PH.D.-THESIS

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THE FORMAT OF THINGS

A Philosophical Inquiry into matters of importance for the conceptualization of future Computer Interfaces

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UNIVERSITET
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The Format of Things

A Philosophical Inquiry into matters of importance for
the conceptualization of future Computer Interfaces

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Submitted Doctoral Thesis

Manuscript for PhD Dissertation Submitted to:
The Department of Learning
The Danish School of Education, Aarhus University.
The Format of Things - A Philosophical Inquiry into matters of importance for the conceptualization of future Computer Interfaces
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2016

Summary

The development of novel interfaces is one of the most important current design challenges for the intellectual, cultural and cognitive evolution of human imagination and knowledge work. Unfortunately, the thinking surrounding this design challenge is heavily mired in conceptions that harbor ontological biases and epistemological assumptions which, to a great extent, delimit what can be thought about interfaces and shorten the imaginative horizon.

The objective of this thesis is to break the hegemony of a particular type of understanding of the world and interfaces, and to make new approaches available. It consists of philosophical considerations on matters of relevance for the design of interfaces. It takes the position that the graphical user interfaces of computers (the Desktop Metaphor or Windows, Icons, Menus, Pointers [‘WIMP’]) that ordinarily come to mind for most people are cognates of much older interfaces that are discussed in philosophy and cognition theory under headlines such as ‘perception,’ ‘cognition’ and ‘representation.’

The conception that is disputed is that the primary way of making sense of the world is to deal with things. In the course of the dissertation this conception is identified as “*the Format of Things*.” The format is embedded in our everyday thinking. In relation to design, it is found in the name taken by the design community, that is human-computer interaction (HCI), and it is mirrored in the desktop metaphor, wherein information is conceived of as the manipulation of objects by a user. This conception of the world is not claimed to be wrong, but in the course of the dissertation it is revealed as accommodating a way of engaging in the world that is expressible with pen and paper. Approaching the world in terms of “things” creates the optimal conditions for speaking, thinking and describing the world in words. In contrast, I claim that the computer is capable of creating dynamic phenomena in relation to which words are superfluous. Furthermore, I explore the possibility that such phenomena can be designed to support knowledge work in a way that matches or surpasses speech and writing. The well from which we draw our design ideas for novel interfaces is therefore needlessly restricted by a format that has outlived its purpose. The objective of the thesis is to dismantle the format of things as well as to sketch out novel paths of inquiry for new interfaces.

The dissertation consists of three articles and an accompanying text that shows the thread tying the three articles together and provides context for the choices made in the three articles. The first article takes on the problem of making the format of things conspicuous. It does so by using traditional dichotomies and the reflexive problems they generate to clarify the conditions of interfacing. The article analyzes and explains how dichotomies can arise from the format of things and attempts to show how the format is responsible for propagating these dichotomies. The second article answers the question of what an interface is. A model is built out of metaphors that both investigate and exemplify the answer given. It concludes that things are *how* we see, not *what* we see, and that philosophical problems of representation and correspondence are an effect of confusing the two. The third article proposes a first step towards a different type of interface or “genesis,” that is, a way of making the world. To *see* differently we have to *do* differently. Analogue computer interfaces are put forward as a different form of working with and creating knowledge that makes use of spatial awareness and our ability to connect the visual with the tactile. It

attempts to answer what digital materiality is and by extension to engage in how it should be utilized as a novel medium.

The entire undertaking is done in a manner where the dissertation itself exemplifies what an interface is. This was deemed necessary for methodological and theoretical reasons. Creating the dissertation without recognizing it as an event in itself would have been to turn a blind eye to the fact that the dissertation is created in the format of things put under scrutiny. The dissertation is therefore very deliberate in its methodological considerations of scope and approach. The choices of how the dissertation was crafted were made to exemplify and illustrate the arguments offered.

The dissertation is based on ideas found in philosophy, Human-Computer Interaction, Cognition theory (enacted, embodied, embedded, extended, situated and distributed), cybernetics, ecological theory, and sociology. The intention is not to take credit for the insight that the world has to be considered in dynamic terms. This is already suggested or explicitly defended in the works of several of the writers taken into consideration in the dissertation. Rather, I explain why, despite available theories to seek alternatives, interfaces continue to be conceptualized in terms of things and point to ways in which this tendency can be subverted.

The goal of the dissertation is to rouse the design community to approach the problem of creating future interfaces from a perspective that is less certain and more exploratory of how meaning is created. On the cusp of virtual reality gear reaching the broad consumer market, the question of how meaning creation turns 3D (or from atoms to photons) is ever more relevant.

Dansk Resumé

En af de vigtigste nutidige design udfordringer er udviklingen af fremtidens brugergrænseflader. Grænserne for vores intellektuelle, kulturelle og kognitive udvikling og vidensarbejde er på afgørende vis betinget af de grænseflader vi arbejder med. Desværre er tænkningen omkring denne design udfordring dybt forankret i forestillinger og begreber der rummer ontologiske fordomme og epistemologiske antagelser, der begrænser hvad der kan tænkes om grænseflader og dermed inddæmmer vores forestillingers rækkevidde. Afhandlingens sigte er at bryde med bestemte forestillinger om verden og grænseflader og samtidigt gøre nye forestillinger tilgængelige. Udgangspunktet er at eksisterende brugergrænseflader såsom desktop metaforen og windows, icons, menus, pointers (wimp) er beslægtede med langt ældre grænseflader der diskuteres indenfor filosofi og kognitionsteori under overskrifter som 'perception,' 'tale' og 'skrift.'

Den opfattelse af verden der bestrides er at verden først og fremmest er givet meningsfuldt i form af vores omgang med ting. I afhandlingen benævnes denne opfattelse som 'tings-formatet.' Dette format er indlejret i vores daglige omgang med verden. I forhold til design ses formatet i det navn design- og forskerfællesskabet omkring computere har givet sig selv - human-computer interaction (HCI) og det kan også spores i skrivebordsmetaforen, hvor information behandles som virtuelle objekter manipuleret af en bruger. Opfattelsen er ikke forkert, men, som afhandlingen søger at udrede, understøtter den en måde at gå til verden på som kan indfanges i det skrevne (og talte) ord. At opfatte verden som bestående af ting skaber de optimale forudsætninger for at tale, tænke og beskrive verden i ord. Heroverfor påstår jeg at computeren er i stand til at skabe dynamiske fænomener der overflødiggør ord. Jeg afsøger samtidigt mulighedsrummet for at understøtte vidensarbejde på en måde der svarer til eller overgår tale og skrift. Påstanden er at den kilde hvorfra design ideerne til nye grænseflader udspringer er unødigt begrænset af et format der har overlevet sig selv. Formålet med afhandlingen er at afvikle tingsformatet, såvel som at skitsere nye veje for fremtidige grænseflader.

Afhandlingen består af tre artikler og en kappe der aftegner den røde tråd der binder artiklerne sammen og kontekstualiserer de valg der er foretaget i dem. Den første artikel søger at gøre tingsformatet synligt som problem. Dette gøres ved at benytte velkendte dikotomier og de refleksive problemer de genererer til at undersøge betingelserne for grænseflader. Artiklen analyserer og forklarer dels hvordan dikotomier opstår på baggrund af tingsformatet, dels hvordan formatet fastholder og videreføre dikotomierne. Den anden artikel besvarer spørgsmålet hvad en brugergrænseflade er. Den bygger en model af metaforer der både undersøger og eksemplificerer det svar der gives. Konklusionen er at ting skal fortolkes som *måden* vi ser på ikke *hvad* vi ser. Filosofiske problemer opstår når vi forveksler de to. Den tredje artikel træder det første skridt til en anden type grænseflade eller 'genese,' det vil sige en måde at skabe en verden på. For at *se* anderledes må vi *gøre* (skabe) verden anderledes. Artiklen foreslår analoge brugergrænseflader som en anderledes måde at arbejde med og skabe viden, der benytter sig af vores evne til at orientere os rumligt og vores sammenkobling af visuelle og taktile stimuli. Den søger at besvare spørgsmålet hvad 'digital materialitet' er og hvordan en sådan materialitet danner grundlaget for et nyt medie.

Overordnet er afhandlingen i sig selv skrevet på en måde der eksemplificerer en grænseflade. Dette var nødvendigt af metodologiske og teoretiske grunde. At skabe afhandlingen uden at anerkende den som en begivenhed i sig selv, snarere end som en ting,

ville have modsagt den grundlæggende problematisering af tingsformatet. Afhandlingen er derfor skrevet under en række meget præcise metodologiske overvejelser vedrørende omfang og tilgang. De valg der er foretaget har alle vægtet eksemplificering og illustration af pointerne højt.

Afhandlingen er baseret på ideer hentet fra filosofi, Human-Computer Interaction, kognitionsteori (enaktivisme, kropslig, indlejret, udvidet, situeret og distribueret), kybernetik, økologisk teori og sociologi. Det har ikke været hensigten at tage æren for den indsigt at verden skal forstås i dynamiske termer. Dette tema er allerede anslået eller forsvares direkte af flere af de forfattere der inddrages i afhandlingen. I stedet søger jeg at forklare hvorfor, til trods for skarp modstand, at grænseflader fortsat konceptualiseres og forstås i form af ting - og pege på hvordan dette kan ændres.

Formålet med afhandlingen er at inspirere design- og forskerfællesskabet til at søge veje i skabelsen af fremtidige brugergrænseflader på en måde der er mindre selvfølgelig og mere undersøgende i sin tilgang til hvordan mening skabes. På kanten af adoption af virtual reality udstyr af en bred forbrugerskare har spørgsmålet om hvordan mening skabes i tre dimensioner (eller hvordan den omdannes fra atomer til fotoner) aldrig været mere relevant.

Acknowledgements

It has been a long journey. I am indebted to a lot of people. There are obviously my former supervisors which include Hans Siggaard Jensen, Finn Olesen, Steen Nepper Larsen and Pernille Rattleff. I would also like to thank the members of the former assessment committees that have provided invaluable feedback: John Krejsler, John Protevi, Søren Brier, Katherine Hayles, David Kronlid and Peer Bundgaard.

I would like in particular to thank Finn Olesen and Jette Kofoed for spurring me on at critical junctures in the process and to Niels Henrik Helms and Karsten Gynther for graciously giving me the opportunity to finish what I started.

I would like to thank my current colleagues at University College Zealand for inspiring talks. Lasse Juel Larsen and Rasmus Øjvind Nielsen have provided invaluable feedback on several parts of earlier versions.

I would like to thank my family for their support.

Finally I would like to dedicate this to: Mia and Storm

Preface

This dissertation began with the ambitious aim of creating a new interface for computers. I was pursuing a very strong intuition I had regarding the future of computer interfaces. Like many others, I believe the computer is a new medium that has not yet come into its own. The idea is, and was, that future interfaces will have to take greater advantage of the intimate connection between what we see and what we do. I personally refer to this idea as a visuo-tactile interface wherein information structures are directly manipulated.[1] While working with different ideas on how to reconceptualize the interface, I was repeatedly frustrated by what I felt was a lack of vocabulary with which to discuss these ideas. I also clearly felt the need to connect my ideas with ongoing discussions in the field of HCI.

However, as I investigated the subject, I grew increasingly puzzled. The theoretical landscape I was attempting to engage in was littered with philosophical flotsam and jetsam. For instance, I found it exhilarating that the discussion of representation versus represented was at the center of a major debate in cognitive science between cognitivists and enactivists. Nonetheless, I was also baffled that this age-old philosophical dispute was still relevant. As I pondered the nature of interfaces, I was struck by how many philosophical issues were simultaneously at play in the simple assertion that: there is an interface between a subject (human) and an object (computer) and that something was going on in between (interaction). Working in a cross-disciplinary manner, I drew inspiration from thinkers such as Gregory Bateson, J. J. Gibson, and Tim Ingold, to name a few, who in their own fields, challenged many existing assumptions.

I thus found myself steadily sliding away from discussions of interfaces and designs towards engaging in philosophical problems. The idea that emerged was to clarify my position on various matters of perception, cognition, and communication and then turn around and apply the findings to the designs I envisioned. As it turned out, this was unsurprisingly overly ambitious. The task of "clarifying my position" on a series of philosophical ideas presented sufficient material to cover a dissertation. Translating the impact of these findings to a community that largely considers the ideas of an interface straightforward and each of the terms in human-computer interaction unproblematic was, consequently, next to impossible. The trouble was not the complexity of thought or the scope of ideas. The trouble was that the well from which I drew my inspiration was immersed in a completely different world than the one inhabited by the community with which I was trying to parley. The problem then became one of making a different world apparent for someone quite content with an existing choice. I therefore looked for ways of jumping that chasm, but this turned out to be an even bigger can of worms. The effort to clarify assumptions – my own as well as those

[1] The idea is, of course, connected with Hutchins, Hollan, and Norman's (1985) idea of direct manipulation interfaces, only without replicating real-world physical information embodiments (paper, writing, equations) or using metaphors (desktop, Windows, Icons, Menus, Pointer). Our hand-eye coordination remains one of our most highly developed skills, one that is already an invisible part of our current interface in the form of the keyboard and mouse; and the recent onslaught of tablet computers has only served to reinforce my intuition that this is the way to go.

embedded in the theoretical landscape – clashed reverberatingly with the attempt to make this new promised land accessible.

The solution presented here has been to stay in the realm of philosophy and deal with problems in a way so that the answers I give will have relevance for conceptualizing future interfaces. The dissertation therefore consists of philosophical considerations of relevance for interfaces and HCI rather than considerations of specific interfaces, models, or designs. The aim of the dissertation is, as will be discussed below, methodological. I find the problems I uncover pervasive, which suggests that they are built into current approaches. Although most interface designers have little patience for philosophical considerations, it is often possible to trace a set of theoretical assumptions in their work. The claim is that interfaces are already implicated in philosophical problems *qua* the assumptions they embody.

The discussion is laid out in three articles, each of which has been submitted for peer-review in international journals and conferences.[2] Each article develops its own line of inquiry, but together, the three also comprise a systematic and methodical approach to solving the problem of "jumping the chasm." The overall idea guiding the different lines of investigation is that *we have to see differently to see a new medium*. Consequently, each article presents its own way of "seeing differently." As will shortly become apparent, this is not a simple matter of changing perspective or worldview. The three articles are summarized and put in context below. Prior to that, the methodology of the dissertation will be laid out as well as its consequences for how the cross-disciplinary collection of literature is approached in the dissertation. I begin, however, with some introductory remarks on why the two worlds are so far apart.

Reading notes

There are four (4) lists of references: One for each article and one for the introductory framework text. Each list is placed at the end of their corresponding text. The three articles are placed as appendices (1, 2 and 3). I will, of course, leave any decision of reading order up to the reader, but note that the order in which the articles were produced was article 1, 2, 3 and finally the introductory text.

In the introductory framework text there are four passages with unusual indentation (p. 16-18, 31-32, 33-34 & 38-39). These have been indented on both the left and the right side. Following standard APA style extended quotes are separate and only indented on the left side throughout the text. Quotes within the four passages have been further indented on the left side. To clearly demarcate the onset and end of the four passages hashtags (#) have been added.

[2] Article 1 is under consideration in "Philosopher's Cocoon Philosophy Conference;" Article 2 is under consideration in "Digital Humanities Quarterly;" Article 3 is under consideration in "Interacting with Computers"

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Introduction

I believe that I have come upon a pattern. I have observed a tendency among theoreticians of many different fields to revisit different phenomena and rewrite the story of how they come to be, that is, to *provide the phenomena with an alternative genesis*. This pattern can be found strewn across many different fields and disciplines and has no common object, topic, or domain to rally around. As such, the pattern is not reflective of a movement; rather, it is a meta-pattern. The tendency is variously motivated. For some, it is a long overdue overthrowing of a pervasive dichotomy of Methodological Trouble such as the subject-object distinction or the representation-reality divide. For some, it is a mediation between the Scylla of constructivism and the Charybdis of objectivism. For others, it is a turn toward practice, materiality, embodiment, and enaction or an expression of an ambition to allow things or the material to speak for themselves, on equal terms, rather than being the object of interpretation. The common thread that binds these diverse ambitions together is a sensitivity towards the enunciation of events and things, that is, an understanding that the *how* and the *what* of events and things that take place are connected or perhaps even not to be distinguished at all. For my own part, all early attempts to comprehend and express what began as a hunch were grounded in the reflexive aspiration to be able to take myself into account, that is, to understand my own part in what was before me.[3]

To give an example of the pattern couched in terms of things, we might say that ordinarily people live in a world of things. They direct themselves at things, are surrounded by things, and "get things done." Indeed, in most cases, they think of themselves in terms of things (a body, a mind, a personality). "Things" are here taken in their broadest sense possible. The genesis implied in such a world is one that considers things as *fait accomplí* (Ingold, 2010, 2012),[4] that is, things are fixed, well-known, and determinable. They either exist or not. They may have been conceptualized as ideas or designs (in our head, i.e., also a kind of thing, although belonging to a different realm) before they were realized. The events that take place around things are concerned with producing, using, or acting upon things, but the things themselves essentially remain unperturbed by what goes on. In this thesis, I attempt to show that there is a radically different version of the world available. In this world, we have directed our attention to how phenomena are generated and come to the conclusion that things themselves have to be considered as events that take place.[5] In such a world, a thing is a much more extensive phenomenon. A thing is a "Thing" as in the old Nordic sense of Thing – an assembly in session (Heidegger, 1971; Latour, 2003). "The [T]hing, by contrast, is a 'going on,' or better, a place where several goings on become entwined. To observe a

[3] What is called in philosophy "the question of enunciation" or to ascertain who is speaking (Descombes, 1980, p. 41).

[4] The entire quote runs as follows: "To view it as an object is to take it for what it is: a complete and final form that confronts the viewer as a *fait accompli*. It is already made. Any further changes it may undergo, beyond the point of completion, consequently belong to the phase of use or consumption" (Ingold, 2012, p. 435).

[5] The claim is related to the idea of the world as "becoming" (Deleuze & Guattari, 2002) and the idea of the world as process (Seibt, 2013). For reasons expounded on below, neither of these can form the basis of the analysis.

thing is not to be locked out but to be invited in to the gathering" (Ingold, 2010, p. 4). Drucker (2013) puts it as a "shift from a concept of things as entities to a concept of them as events, from a notion of *what is* to that *which is always in flux*, from a *literal* to a *contingent* materiality that is exposed by the performative dimension of use" (par. 12). A Thing has fixation points around which the assembly is gathered that still resemble what we normally think of as things or objects. For example, if the Thing is gathered to settle a land dispute, one point of fixation would be the landmarks (the physical wooden posts, the lines on a map, or the stone fences) that demarcate the borders. Many different issues converge in these things (the wooden posts): the authority of the Thing, the vocabulary and taxonomy that it has developed and put to use, the physical acts involved in planting the posts, the embodied and embedded consequences it has for our future actions, and the direct bearing it has on our understanding and enactments of a situation. A "Thing" denotes "anything that in any way bears upon men, concerns them, and that accordingly is a matter for discourse" (Heidegger, 1971, p. 172). This way of seeing things goes against how most of us normally think of things as separate objects in front of us. The contention is instead that we are involved in the things (we are part of their assembly) and that the world is not just the passive recipient of our ideas or a neutral medium we can mold to fit our forms; in a significant way, it enables and constrains what we do (Leonardi, Nardi, & Kallinikos, 2012). We rightly "think through things," as Henare, Holbraad, and Wastell (2007) put it, in a way that collapses the distinction between concept and thing.

In such a world, Things are no longer simply done or undone; they are ongoing and continually accomplished. Things are sometimes barely things, they leak, they vacillate between being one thing or another, they require maintenance (Ingold, 2010), and they endure and persist (Bergson, 2001). In this ongoing effort of Things, the distinction between us and the world can be made, but is of less importance. We (what is traditionally thought of as "subjects") as well as things (traditionally "objects") are part of this ongoing effort, not as elements that together comprise the Thing (subject + object ≠ Thing) but as part of the enactment and enunciation of the Thing in question. In this line of thinking, "the Thing" becomes recognizable as dynamic.[6] This marks an entirely different genesis. The thing is not perceived "out there" and then interpreted "in here." Things do not simply "exist" out there and then given "meaning" in here. Things are *eo ipso* meaning. We conceive (of) things directly in the world, not via representations or ideas in our head; in the words of Henare et al. (2007): "Things disclose themselves not as perceptions but as *conceptions*" (p. 14, emphasis in original).

The dual meaning of "concept" as giving birth and understanding is fitting since this is a genesis that places all beginnings right in front of you rather than hidden or absent. In the

[6] One could choose to say "as acts or processes," but these terms, although they hold dynamic connotations, immediately collapse into a "thing-like" stasis once they have been enunciated. This is easily seen if one considers the commonsense idea that a process produces a result. Although the process and the result are different types of things, we can establish a relationship between them. It makes no sense to talk of a relationship unless it is between relata – even in the case of an identity relation, which is the relationships between an entity and itself.

traditional view of things, all things are created from something, also known as the principle of *ex nihilo nihil fit*.[7] A natural thing comes from a blueprint in a seed; an artificial thing starts as an idea in the mind of a person; a perception is caused by a thing in the world; and an interpretation is based on a string of symbols or spoken words. In other words, *some*thing (existing) always comes from some*thing else*. This cause, blueprint, or idea is often hidden, but it is always presupposed. Breaking with tradition means a collapse of all such separations. There are no blueprints for things in the world; a thing is an idea in itself, not an exemplification of one; things in the world are directly perceived, not accessed via representations, etc.

We are, however, too quickly lost in the particularities of discussion. What a thing is in relation to the subject and object is an important philosophical issue, but in order for the above to be an example of the pattern I have observed, our focus has to be the *shift* in our understanding. In the above example, the shift was this: a thing goes from being *there* (object), as something in front of us (subjects) that we can perceive, interpret, delimit, etc., to being an expression of a process of creation, an enunciation with which we and the world are involved. We suddenly become "part" of the Thing, or we might say that the things and we enter into an assembly.[8] However, for this to actually be a shift, our understanding of the world has to shift radically with it. The two understandings (subject/object vs. assembly) have to be incommensurable, in the Kuhnian sense, not merely two alternative views or proposed theories. The world has to be different. This is not a matter of changing beliefs about the world. It is a different way of making the world, a different genesis. What we *do* matters – in the sense that if we did something else, we would see something else (the world would change into something else). *What* something is is inextricably bound up with *how* it is. The nature of this investigation, and the pattern that I am pursuing, is therefore methodological. It is an enquiry into how different worlds are made.

[7] Which, of course, strictly speaking, means "from nothing, nothing is made," which translates into everything must come from something (else).

[8] Note that it is perfectly possible to interpret the Thing as simply a "big thing," that is, a complex, a socio-material assemblage, a context, or a frame (e.g., Björgvinsson, Ehn, & Hillgren, 2012; Ehn, 2008). Here, the Thing encompasses the activity that takes place as well as the result of that activity. This is *not* what is at stake here. Invoking the concept of the Thing is an effort to make it apparent that the thing (any thing) in front of us is an ongoing effort that we take part in creating and sustaining.

Methodological Trouble

Such an enquiry would be unproblematic if we could just don a methodological gaze and give an account of the two different understandings from the sidelines. However, such an approach comes with a built-in bias. A traditional view of things deals with problems by parsing out things and assigning each thing a place relative to the existing set of things. When we consider different understandings, we think of them as competing answers to the question "what is there?" The well-established academic procedure in this view is simple. Since what is there (whatever it is) must be where it is (where ever that is) (i.e., the thing is self-identical), the understandings (considered as abstract things) *of* the thing cannot *be* in the same place.[9] Since they are different things, they have to be elsewhere, so they are assigned a different place (for instance, "understandings" are either in the minds of the people giving the answers, in an abstract methodological domain, or in a purely theoretical discursive realm). It is a variant of a tried and tested way of settling disputes. We assume that there is a single answer to a question (*one* world, *one* truth, *one* reality) and that all candidates to fill the position are relegated to a different realm (*many* representations, understandings, or methods). In this realm, each candidate is qualified in veridical terms of their *likeness* to the singular reality, and the one closest to reality becomes "the truth." In this way, representations are different from what they represent; concepts are ontologically distinct from the things they refer to; answers and interpretations are about things – not mixed up with them. Representations, concepts, interpretations, etc., are all held to be things whose relationship with the real things is at the center of their being. Placing methodologies in a different realm, in this manner, away from their subject matter, allows for the idea that we can consider each methodology in turn and then pick one, as we would a pair of glasses, instantly transforming the world as we put them on. Needless to say, such an account is nowhere near a shift in understanding. It stays comfortably within a world of things since each method is considered a thing, that is, separate and only related to the thing observing (that is, us) by a relation of observation. In other words, proceeding down this path, we reinforce an understanding of "things" as vehicles for capturing phenomena. On this path, there may be a process whereby the thing is formed or expressed, but once the process is over, the *thing in front of us* captures and encloses a phenomenon separate from us.

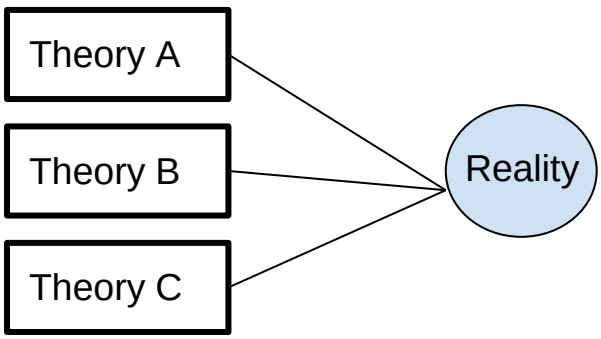

Figure 1. Representations vs. world

[9] Since the law of identity states that each thing is the same with itself and different from another, then the thing that is created has to be different from the thing from which it is created. Otherwise, they would be the same, and the thing would have created itself.

Investigating what a methodology looks like qua an understanding that things *are* concepts engenders a realization that a Thing is *in process*, so to speak.[10] Insofar as you are experiencing things, you are partaking in that process. Whatever thing is "in front of you" (as it were), *it* is the result of an ongoing effort in which you take part. There are unfortunately numerous ways in which this statement can still slip back into a traditional conception of things. We could accept our part in an ongoing process but maintain that the process upholds a fixed and delimited thing separate from the process. We could imagine an arc enveloping an infinite series of expressions of the same thing that integrates into a cohesive and solidified thing. We could assume separate processes taking place for each person engaging with the object (which of course puts the object and the processes in different places). Finally, we could decide that this can simply be read as pointing out a complex thing consisting of a process/activity with a result (the thing). All of these fail to see things as phenomena generated as unfolding events. They fail because they insist at every turn on settling *what is there* (what they are) as something separate in front of them rather than taking what they are as *expressions of how they are*. In other words, to understand in this way means accepting that what you see tells a story of *how you see*. The thing that you see bespeaks what choices are made, what options are dismissed, what is made possible by these choices, and what is rendered impossible at the same time. Once we see things in this way, they are released from their transfixion and set afloat in a sea of choices, influences, and shifting constraints. They become many things rather than one thing.

Take the example of this page. Strong systematic choices were taken in rendering this page suitable for black marks to appear, making the alphabet available, the choice of the English language, and the choice of topic, phrases, words, and style. At the same time, matters that are usually referred to as "contextual" are drawn in, that is, the cultural conventions that have to be in effect for this to *be* a thesis, the circumstances affecting your reading, and the numerous other ways of affecting, altering, and transforming that have to be sustained in order for this thing to be *this* rather than a flyswatter, a conversation topic, or a doorstop. It is in this Foucauldian sense that any and every thing is an *enunciation*. Foucault (1972) appropriates the term usually associated with language use. Like "pronunciation," it pertains to the act of speaking and speaking correctly, but Foucault uses it to signify the unfolding of events. An enunciation is the way statements or sentences are made – not simply sentences in a linguistic sense, but sentences as in a judge sentencing a man to life imprisonment (Foucault, 1975).[11] The *enunciation* is the judge uttering the words "I hereby sentence you…" and striking the block with his gavel. The *sentence* is the immediate "incorporeal transformation" of the accused from a free man to a convict (a Deleuzian term; see Parr, 2005, p. 98). An enunciation thus brings something into the world (or takes something away

[10] Like an assembly is in session. A thing is thing*ing*, we might say, with a nod to Heidegger. This should not be confused with the claim that understanding the world in terms of things should be substituted by an understanding of the world as processes (Seibt, 2013). Such an understanding would still confirm and depend on an everyday understanding of a world composed of things, as it is antithetical to it. Processes are *not* things. More on this below.

[11] Akin to what Deleuze and Guattari (2002, p. 76) have called "order-words" and what Austin (1962) and Searle (1999) famously introduced in the concept of speech acts. See also Drucker (2013, par. 26).

from it). However, this something is not an idea or statement that exists prior to enunciation as a general, free-floating, neutral, and independent sentence, nor is it simply the mechanical manipulation of linguistic elements and rules by a speaking subject.

> At the very outset, from the very root, the statement is divided up into an enunciative field in which it has a place and a status, which arranges for its possible relations with the past, and which opens up for it a possible future. (Foucault, 1972, p. 99)

An enunciation points to the conditions under which a sentence can be uttered. Understanding things this way, we should consider the thing (object) only the focal point of our attention or, in terms of enunciation, as the epicenter of much larger movements that it affects and by which it is affected. It is when we start seeing things as *effects*, rather than causes or conclusions, that they become dynamic because this means that what we do, what others do, and what "it" does have a direct and immediate bearing on what thing it "is."

Remaining cognizant that the aim of this thesis is methodological, the purpose of shifting understanding is not to express a preference for one type of understanding over another. It is solely to make new worlds possible (other ways of seeing made available) and, in turn, bring the pattern I have postulated to light. However, as the example also showed, there is a bias afoot that keeps the traditional understanding of things securely in place. There are assumptions of what it is to scrutinize a process or methodology (both in terms of process and result). There are expectations of what an account of a phenomenon looks like or how a critical discussion of alternative solutions can be had. There are deep-seated beliefs concerning different phenomena and their place in cognitive ecology, for example, feelings, thoughts, interpretations, and opinions all have different codes of conduct and rules for fraternizing. I have chosen to refer to this bias as "*the format of things*" because these examples have no common denominator other than being preconditions and consequences of an understanding that engages the world with the expectation of finding things. Like the sentence, the format does not exist prior to its enunciations. It is not a belief or a convention passed on by its proponents. It is propagated entirely in and by its reproduction. By and in itself, the format is nothing; in each particular thing, the format is engulfed by what the thing is. As such, the format is embedded in our perspective. We parse the world according to it. It is the accepted format in which things are recognized, communicated, and imagined.

Despite the strength of the bias, there is, as demonstrated (insofar as I have succeeded in sketching a different way of understanding above), hope of escaping the format. However, as also shown, the hope cannot rest on a form of analysis that reproduces the format. The thesis therefore develops and relies on methods that attempt to circumvent the traditional format. The approach is detailed in the sections below on methodology and literature review. It is necessary to include the literature review as the methodological considerations also impact how different sources are drawn upon and utilized. Given these initial remarks, the problem statement of the thesis can now be enunciated.

Problem Statement

The object of this thesis is to break the hegemony of a particular type of understanding of the world by making other approaches available.[12] The disputed understanding is that the primary way of making sense of the world is to deal with things.[13] The claim is that this type of understanding is embedded in much of our everyday thinking as well as many theoretical approaches. In the course of the thesis, this understanding is identified as "*the format of things*." The format is important for the human-computer interaction (hereafter HCI) community because it is embedded in vital assumptions of the computer as a communicative representational medium. It is found in the name that the community has chosen (HCI), which confirms and propagates a traditional subject-object divide. It is mirrored in the desktop metaphor wherein we manipulate information objects, and I venture to guess, that it is replicated in the self-perception of many user interface and user experience designers. As such, it stands in the way of developing the computer as a new medium, not because of any fallacious consequences of practicing the format, but because the format serves and accommodates a set of constraints for knowledge creation that does not apply to the computer medium. In plain words, "things" accommodate a way of knowing the world that is *expressible in pen and paper*. When we approach the world in terms of "things," we have created the optimal conditions for speaking, thinking, or recording the world in terms of *words*. The computer is capable of creating phenomena for which words are superfluous, primarily dynamic phenomena and ways of engaging with these phenomena that entirely circumvent the use of words (e.g., swiping on a tablet). What is brought to light by unveiling this format is that knowledge produced with pen and paper creates the image of a static world when a dynamic one is available and desirable. The source from which we draw our design ideas is therefore needlessly restricted by precluding ideas that do not fit the format. Again, in plain terms, *we think in words when we ought to think in dynamic images*. The thesis ultimately finds ways of dismantling the format and outlines a different course for thinking about and designing interfaces.

Reflexive problems[14]

There are several reasons this problem can only be found tangentially in the writings of many individual thinkers whereby neither the thinkers nor their remarks ever coalesce into a movement. The different reasons will be considered more closely in the next section, but the most direct one should be addressed immediately.

Designers, like all craftsmen, depend on an intimate knowledge of the tools of their trade. Most designers in the HCI field can claim insights into the workings of their computer, on different types of software, and some into the workings of the behavior of people. However, fewer would be able to profess a deep and intimate knowledge of the tools they use every

[12] Note that the problem is not articulated as a question, i.e., as a problem to be answered, but as a problem to be solved.

[13] Again, not by substituting the format of things with a format of "process" or one of "becoming."

[14] This section "reflexive problems" and the following "zero distance" consist of slightly reworked material from article 2. The reuse of the text is based on the argument that reflexive problems remain the same in the article and in the thesis text while the format of things is the same.

day in order to make sense of the world around them, to grasp a problem, or to grapple with a solution. The "tools" I am referring to are ideas, concepts, and patterns of thought. In relation to these tools, the designer faces the same difficulty as the philosopher. *The tools they are attempting to examine are the very tools used for the examination.* A philosopher attempting to get a grasp of the tools at her disposal does not have the luxury of being able to step out of her perspective and point to the tool as she would with a piece of software or a paintbrush, canvas, or easel. One cannot see the tools (in the act of) producing the ideas because the idea that would convey such a thought would already be the result of the tool having been used (the production is always over before it can be captured, so to speak), or if we did see it (the act of production), it would eclipse the idea we were trying to delineate. How then can a tool examine itself?

Since representations are traditionally deemed capable of "referring," the consequence of examining the act of referring gives rise to a peculiar "reflexive" condition. If the phenomena we are dealing with are in fact affected by what we do, then it would seem that any current ongoing process (such as the one you are experiencing in this article as you are reading it) not only circumscribes a phenomenon (cognition) contingent upon it (the process), it also defines itself in the process (since it is a cognitive process). The current process (understanding this text) therefore seems contingent upon itself for determining what it is as well as upholding that very phenomenon (*that* it is). If that is the case (and it is a very tentative "if"), whatever it determines itself to be was either the case before it was settled (which violates the premise that the phenomenon is contingent upon the process), or it *became* the case precisely at the moment it was settled (which seems counterintuitive). The conundrum is well-known and well described as reflexive paradoxes, antinomies, or even Buddhist Zen koans, that is, riddles used by Buddhist teachers to allow students to reach enlightenment (Priest, 2014). The theoretical physicist and feminist Karen Barad (2007) masterfully explicates the position of reflexivity in Western thought as a product of representationalism, which, as mentioned above, places her alongside other authors that reject this idea. She uses the term "reflexive methodologies" to denote and denounce the idea that it is possible to reflect on and take into account "the investigator's role as an instrument in the constitution of evidence" (p. 86) in this manner.

> [R]eflexivity is founded on representationalism. Reflexivity takes for granted the idea that representations reflect (social or natural) reality. That is, reflexivity is based on the belief that practices of representing have no effect on the objects of investigation and that we have a kind of access to representations that we don't have to the objects themselves. (p. 87)

Barad places the discussion of this idea in the much broader and more complicated discussion of Bohr's principle of complementarity and Heisenberg's uncertainty principle, which obviously cannot be dealt with here. The popular account of these two principles is, however, quite sufficient to understand the main idea. It is not possible for an instrument to simultaneously measure and be the object of that measurement (p. 161), so an instrument cannot measure itself while measuring. In "interface" terms, this means that it is not possible

to set up an interface that simultaneously creates and reveals itself. The attempt to do so is an ambition harbored by the theorist who dreams of a complete enumeration of the world, that is, one who takes herself into account.

One could argue that studies of language, cognition, or speech achieves precisely that or that communication is self-referential by nature, but that would miss the point. This very line of thought is itself subject to a reflexive condition. If we assume that every phenomenon that arises within a perspective is the result of a "tool" at work, then that includes a perspective that produces the idea of a tool. When we thus answer the question "how was an idea made?" – by presenting the idea of a tool that made the idea – it begs the question ("How was the idea of the tool made?"). If we are to avoid the consequences of the reflexive condition, we are forced to deliver an answer that not only speaks of the solution but also exemplifies it directly without recourse to an underlying phenomenon. This means that we cannot simply say that every phenomenon arises from an apparatus at work and then investigate that apparatus. We therefore have to ask questions slightly differently than the norm. Bateson (1979, p. 39) expresses this idea when he states that "[t]he *processes* of perception are inaccessible; only the *products* are conscious and, of course, it is the products that are necessary."

This is another restatement of the claim that we cannot simply step out of our perspective and investigate "what we do." We have to accept that the "apparatus" at work is only investigable through its consequences. The designer, as well as the reflected philosopher, therefore has to work from the inside-out. If we are to find out anything about the apparatus, we have to look at the phenomena we encounter for clues to their *ontogeny*. This is the biological term for the origin and development of an organism (see Oyama, 2000). It is used here to refer to the *genesis* and development of these phenomena, that is, their unfolding from inception to full-fledged phenomena. We have to ask: "where do ideas come from?" not in the sense of being creative (to get new or better ideas) but in the sense of asking what apparatus is in place in order for ideas to be produced at all, for ideas to become ideas, to be what they are, and to hold any promise. Why are ideas the way they are? Again, not asking in an everyday sense, but in an almost technical sense – why do they have the format they have? What is made possible by conceiving of the world in this way rather than another, and what is made impossible? Can the tools be changed? What happens to ideas and concepts if they are?

There are two consequences to be drawn from the reflexive problem and the genesis of ideas. The first is that the text, as it presents itself here, is *not* to be considered a representation on two levels. On the content level, it is *not* a text that refers to a phenomenon from which it differs and to which it refers. It is rather an exhibit of an interface at work. It showcases an interface rather than represents it. On the form level, it is *not* to be considered simply text to which we have privileged access. The meaning as well as the words, letters, signs, or patterns of syntax on this page are considered as phenomena themselves, which are as much in need of explanation as the phenomena they purportedly describe. In other words, anything we choose to call representations becomes mysterious anew since: *why should anything be anything but itself*? The point is that the text

accomplished here is not separate from the world, and if phenomena are not explained by reference to representations, then representations should not be explained as referents. It also means that phenomena that are not normally considered under the same heading are treated as equals in their need for explanation. Perceptions, maps, objects, speech, thoughts, people, and text are usually juxtaposed in pairs such as internal/external, representation/represented, and subject/object. In this thesis, they are all treated as side-ordered, that is, as phenomena with equal ontological weight and in equal need of explanation.[15]

The second consequence is that the phenomenon you are currently engaged in is performative. Barad (2007) describes it as a direct material engagement with the world:

> A performative understanding of scientific practices...takes account of the fact that knowing does not come from standing at a distance and representing but rather from *a direct material engagement with the world*. (p. 49, emphasis in original)

There is the view that there is no separation between static objects and the things we do with these objects. Rather, we are part of "making" and sustaining the objects as we perceive them and think of them. The world is performed or enacted, if you like. A straightforward analogy is this text. It is not just a piece of paper with marks on it. You are reading it and are thereby part of the performance of the text. The approach requires a different way of *looking at each phenomenon and seeing the interface that gives rise to it*. The Chilean biologist Humberto Maturana recounted a similar shift in approach when he worked out the theory of autopoiesis:

> In 1960 I asked myself "what should happen in the manner of constitution of a system so that I see as a result of its operation a living system?" This was a strange question in a period in which every scientist knew that to know something about something one should go and look what was already there without interfering with it. I was not making a hypothesis about how the system was. I was proposing that the relation between the internal dynamics of the systems and the result of that internal dynamics in the domain in which I observed it, would tell me what the system was. *I had to create the system to know it.* (Maturana, 2002, p. 5, emphasis added)

Instead of asking "what is there" or "how did it become that way?" he asks: "how is what I do connected to what is?" It is one way of becoming aware of what is being done *while* one is doing. In this way, "taking oneself into account" does not mean identifying a subjective "factor" and including it in the equation. It means recognizing one's own handiwork in what

[15] I am appealing to the craftsman awareness of what he is doing as he is doing it, in the same way (although for different reasons) as John Law when he argues that we "need to imagine representation in a different way. Poetry and novels wrestle with the materials of language to *make* things, things that are said to be imaginary. It is the making, the process or the effect of making, that is important. The textures along the way cannot be dissociated from whatever is being made, word by word, whereas academic volumes hasten to describe, to refer to, a reality that lies outside them, They are referential, ostensive. They tell us how it is out there." (Law, 2004, p. 12, emphasis in original) He goes on to ask how we "might imagine an academic way of writing that concerns itself with the quality of its own writing? With the *creativity* of writing? What would this do to the referent, the out-thereness?" (p. 12)

is. Just as a skilled craftsman can see the signs of craftsmanship in ships, houses, spoons, and bicycles and infer what has been done, we should look at perceptions, thoughts, ideas, sketches, and texts and see the evidence of our craft as thinkers.

Zero distance

The perspective I offer aligns itself with these theoretical insights. One extremely important consequence of assuming this perspective is to accept the idea that the distance between one's thoughts and the phenomena one is currently engaged in is *reduced to zero*. This is not as enigmatic a statement as it appears. It simply means that whatever it is that you do in order to experience a phenomenon, you must already have done it since you are experiencing a phenomenon.[16] In fact, you must still be doing it. It is another way of saying that whatever phenomenon you are experiencing (presently) is contingent upon your "experiencing it" (action). It does not mean that you are the cause of it or that there are two phenomena, that is, a process of experience (process) *and* a phenomenon (result). Just as there is a song as long as you are singing, there is a phenomenon as long as you are experiencing. You cannot take the singing away and expect to be left with the song or, for that matter, ask someone to sing but "to dispense with the song" in order to focus on the singing. This does not mean that the tree or house outside my window is not a tree or house until I have interpreted it as such. It means that there is not a tree and *then* my perception of it. There is not a house and *then* my thoughts about that house (the house is perceptible (affords being perceived) in so far as we perceive). Practically, this means that there is not a phenomenon *there* in front of you, which you somehow relate to *here* from the center of your perspective. Just as there is no distance between you and whatever current thought you have *hic et nunc*, there is no distance between the process of a phenomenon and the phenomenon "itself." "No distance" means that what the world is like (ontology), in a very particular respect, is contingent upon what we do (epistemology). This has prompted some authors to state that we, in a sense, create the world in which we exist (Maturana, 1987; Spencer-Brown, 1972), which I agree with, although cautiously, because a less than rigorous understanding of "no distance" either leaves us with classical philosophical conundrums, such as the risk of ending in solipsism, or with the world as an unreachable Kantian ding-an-sich – both of which are avoidable. I will return to these matters.

The idea of "zero distance" is important because it suggests that we might be able to infer what has been done (and currently is being done) from the phenomena themselves. It is a way of investigating what it is that we do without running into reflexive problems.

Perpetuating the Format of Things

It is prudent to ask: if the problem is so grave, why has it not already been addressed and rejected? The overall problem, as demonstrated earlier, is that "a way of thinking" is not something we can simply shed, step out of, and examine; it is embedded in the very enunciation of every thought we think. It is a difficult problem to solve because it is hidden in plain sight. The format we use to think about things is the same format we use to think

[16] To be precise, it is not simply what we do that matters, as will become apparent, nor is it a combination of something "out there" and "in here." The phrasing is simply used to emphasize the performative aspect of the proposition.

about concepts. It is the same format we use to think about thinking. For every topic we can think of, our thoughts have to be formatted, that is, thoughts are patterned, ordered, and structured precisely in order to be thoughts. We cannot form a thought without a format. If we ponder this, we quickly create well-known reflexive problems. A simple example will serve as illustration:

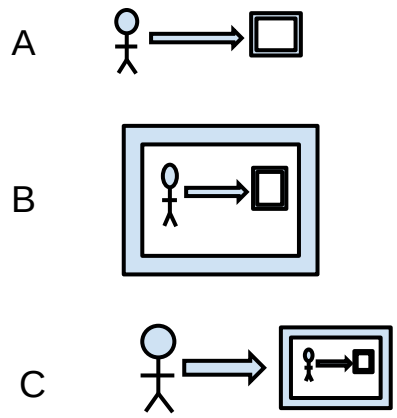

Figure 2. Observing an object

In Figure 2, drawing A represents a person (subject) observing an object. When we make the entire act an object of consideration (i.e., by framing it, B, the frame indicates a new thing), the question immediately arises "from where is that thing observed?" That position, C, indicates in itself a subject observing an object, which, in turn, could be the object of consideration and thereby become a new thing (that would be if C was framed like B), and so on *ad infinitum*. This is of course a well-known philosophical conundrum.[17] From the different perspective, where we are continuously involved in a Thing (Thing Assembly, hereafter TA), A, B, and C exhibit a different likeness. In this view, we have never left "our perspective." We have done the same thing three times and produced three things (images) one after the other. The format of these three things is the same: A thing (object) is produced, and a position (subject) and relation (observation) are immediately posited. From the TA, we can see that in the first perspective, the endless conundrum feeds off the same format (it is the format of things, hereafter FoT). The difference between the two (TA and FoT) can also be seen in the shift of focus. In A, the focus is on the object. In B, the focus is on the action (the frame frames the arrangement with the arrow in the center). In C, the focus is on the newly added subject. Three different things are in focus, but they exhibit the same basic format. There are of course differences between the three. The FoT uses each enunciation (A, B, C) to shift our perspective and at the same time build a sense of "where we are" in the understanding we are compositing. The point is that the FoT needs to express a "thing" in order to consider a phenomenon. We have to focus on and articulate a "process," "an action," or "context," respectively, to "see" such things. In other words, the FoT is like a printer that has to print in order to say something, and it can only do this in its

[17] Readers familiar with the products Droste Cacao, or in a Danish context Ota Solgryn, will recognize this as the "Droste effect" – the picture-within-picture effect (also called mise en abyme – literally "placed into an abyss"). Spencer-Brown (1972, p. 4) calls this a "re-entry."

pre-equipped format. If it was to make sense of its own actions, it would have to print them in that same format.[18]

In the alternative view (TA), every thing (physical object as well as any other thing one is directed at) is by default understood as a Thing (assembly) and thereby understood to be part of an ongoing activity. The *act* involved in the Thing's unfolding is not a different thing but only a different way of approaching the same Thing. The idea that there is a FoT is difficult to grasp because once it has been posited, it (the format) itself becomes the object of inquiry (where is this format? Can we isolate it and observe it?). Within the FoT, this relation is unproblematic. There is a concept or type of "thing," which are realizations or tokens of all the different (real, imagined, linguistic, cognitive, etc.) things. However, if we engage in questions such as "what format was used to articulate this concept or FoT?" we are immediately re-thrust into reflexive problems (why should the concept be treated differently from other phenomena?). It would appear obvious that any articulation of this format was undertaken subject to that very format itself. Is it not odd then that we should somehow be able to utilize this format before the format itself has been settled? Either the format is part of the transcendental conditions of human understanding – in which case we have simply made a description of what was already there – or, counterintuitively, the format was already at work before being settled. The problems become impossibly entangled once we start asking how we knew what to ask about since the question was also articulated using the same format. One could object that stating terms and conditions are not prerequisites for fulfilling them, but it stands to reason that a FoT brought on by the phenomena of speech and writing is a contingent matter, not transcendentally necessary, or an ontic rather than ontological matter, as Heidegger would put it.

A different way of thinking of the FoT is to see it as an expression of a certain pervasively utilized genesis – the *ex nihilo nihil fit* condition. It is the idea that something always has to come from something else. It is found everywhere in our everyday conception of the world.[19] For instance, speech is the realization of thoughts, designs are expressions of ideas, meaning (written) comes from (material) symbols, effects have causes, etc. The TA approach does not recognize the *ex nihilo nihil fit* condition because there is no separation between considering a thing and its cause – in the sense that these are not considered different *things*. Similarly, no differentiation is made between a process and its result, between signifié and signifiant (Saussure, 1986), and a host of other dichotomous pairs. The exercise here is not to enumerate all pairs, but to bring attention to the *genesis* built into the FoT that they exemplify. Whenever we look for a reason, cause, or explanation, the FoT posits a *different* thing (somewhere else or in a different realm) as the reason, cause, or explanation. A causes B. This genesis is rejected in a TA approach. Without this genesis, all things threaten to become simulacra. Baudrillard (1994) uses the concept of simulacrum – a copy without an original – to invoke the idea that reality has been replaced by signs that are

[18] Note that "B" in Figure 2 is equivalent to the interpretation of the Thing as a "big thing" where we have simply framed (i.e., made a thing out of) the activity/process (the man) and its outcome (the square).
[19] It expresses what Deleuze and Guattari (2002, p. 114) call "Interpretosis." It is "a Western disease that traces all becomings back to some origin" (Colebrook, 2002, p. 134).

never exchanged for the real but only for other signs. An example would be paper money, which used to refer to gold or other similar standard for which it could be exchanged at a bank. Currently, money is simply numbers that refer to other numbers. The simulacra maintains a position between reality and representation because signs are supposed to refer. When they no longer refer to reality, they seem artificial. A similar "homelessness" tinges things once we contend that things have no underlying cause. However, the proposition is not that things are created by *fiat*. It is that things are in no need of a genesis that refers to other things. What we identify as a cause is in itself to be found in the assembly that is the Thing. Henare et al. (2007) explain in a parallel effort within anthropology that "the aim is to explore the consequences of an apparently counter-intuitive possibility: that *things might be treated as* sui generis *meanings*" (p. 3).

The genesis of the FoT is a consequence of the incredibly powerful idea that we can capture a phenomenon and hold it encased in a form. We build our world based on this idea. We speak of things, ideas, and emotions in our head and body. We see a world of things. We produce, use, discard, invent, exchange, buy, and steal things. We think in terms of things. The format (FoT) in which we think is recognizable in *every single thing*, but because this is the format in which we ordinarily think, we never see the format, only the things. This is how the format hides in plain sight. In Figure 2, we can clearly see that the image we usually employ to think about the format (or method) is imagined precisely as *stepping out of* our usual perspective and encapsulating (framing) *it* (the perspective or theory) as a *thing* that can be compared to other things (perspectives/formats/methods/theories). This way of thinking about thinking relies on the FoT. In other words, the format with which we investigate the physical world is identical to the format with which we investigate the mental world (or any other world). The detail that makes this line of inquiry extremely complex and bewildering is that even this present discourse in front of you, on the format of things, employs that very format. Once we realize that we cannot treat the articulation of the format differently from other Things, then we see that there is no privileged position (see Law, 2004). There is no "view from nowhere" (Nagel, 1986) or a Kuhnian position (2000) from which to observe paradigm shifts, and therefore, all things threaten to become simulacra. Relative to Figure 1, it is the realization that we cannot *step out* of the frame into an *outermost* outside. The importance of this is subtle but comprehensive. "Stepping out" and getting an overview of a situation is much more than a metaphor. It is part and parcel of our mental toolbox with the FoT. It is what we do in introductions, in breaks between negotiations, and in identifying our means, media, or technology, that is, in our methodology. In these situations, we step out into a corridor that we treat as a "meta-level," which somehow encompasses the activity we have stepped out of. Such corridors carry with them an illusion of neutrality, that is, of being outside the conditions and parameters of whatever it is we have stepped out of. However, in this situation, we cannot step out because what we attempt to step out of are the conditions and parameters of "stepping out" as such. This is crudely evident in "thinking about thinking." We attempt to step out of and examine the conditions and parameters of thinking and do so by *thinking*.

I dwell on these run-of-the-mill transcendental meditations because they are a direct consequence of the FoT; moreover, because once such problems have been raised, the FoT has an ingenious way of protecting itself from being dismantled. The FoT will accept defeat under the stipulation that it is precisely defined and exemplified; that the alleged problems are thoroughly investigated and analyzed; that alternative positions on the matter are given due consideration; and that convincing reasons for adopting a foreign vocabulary and conceptual apparatus are given. Each of these *reproduce* the genesis of the FoT. The phenomenon of the FoT is given by its definition; problems refer to explanations; alternative positions can be compared (in the corridor); and movements require reasons. All of these are the hallmarks of a type of critical-discursive thinking that lies at the root of academic reasoning. Henare et al. (2007) call it the "power of the dualist ontology of difference" in a manner that deserves to be quoted in full:

> The circularity of this position is part of its remarkable power. For, like a Popperian 'closed system' (Popper, 1995), it assimilates all dissent as confirmation – as grist to its mill. Were one merely to contemplate the possibility of a different ontology, one would be forced to capitulate immediately by recognising that such a possibility, by its very virtue of being 'different,' cannot but be an alternative *representation*. Such is the power of the dualist ontology of difference: it exposes all possible adversaries – all putatively alternative ontologies – as merely different *epistemological* positions (artefacts of knowledge). Thus it compasses them within its own terms, much like old-styled Marxists used to do in debate with the bourgeois ('your critique of Marx's idea of false consciousness is just an example of it!'). (p. 9, emphasis in original)

"Assimilating all dissent as confirmation" is the most powerful display of a double-bind possible (Bateson, 1972). Either you protest (and thereby confirm), or you hold your peace (and consent by default). This is the "outside" of critical academic discourse. It is a privileged corridor. It orders every-*thing*. More importantly, it makes one's own activities transparently self-evident: we make sense of the world and order it by placing things (objects) before us (Lt. *objectum*, to throw before). In Figure 2, we have made sense of our methodology by placing the figure (object) in front of us. If you object to this view, you have positioned yourself relative to the figure (an object) and so, by your actions, confirmed it. An enunciation has been forced upon you. The FoT has been confirmed and instated. Transparency is one of the measures in place to protect the format. Another is our fear of a world comprised of simulacra. We have good reason to fear such a world. It signifies the possibility that all things fall away into undifferentiated nothingness.[20] One thing is to fear that we may never find the correct version of reality; it is quite another to question *if* our way of making sense makes sense. What would we do if we could not trust the meaning of

[20] The reasoning is quite transparent. If a sign consists in a signifier (Fr. signifiant) or sound and signified (Fr. signifié) or concept (Saussure, 1986), then words are comparable (the same), primarily relative to being sounds, and differentiate themselves primarily by their concept. If you remove the referent of concepts altogether and allow for the idea that ideas receive their meaning by referencing other concepts, then concepts differentiate themselves in the same way as sounds (by being different from each other). Since the relationship between signifier and signified is arbitrary, the sign becomes doubly arbitrary.

our words or concepts? The fear of paralysis is easily sustained until it is realized that the perspective, from which everything becomes simulacra, itself poses as a view from nowhere that can encompass all things.[21] It is what Law and Benschop (1997, p. 175) call a "naturalizing epistemological account of representation that assumes that there is a common order of things." It is this kind of order that constitutes the privileged corridor from which everything is calmly meditated upon; it is Descartes' territory. Here, we *ad nauseam* differentiate between *res cogitans* and *res extensa* (Descartes, 2008), the things of the mind and the extended things of the physical world, but what is of interest is, of course, that with Descartes, we straddle the border between the two.[22] A corridor allows access to *all* other rooms in the building. The metaphor is intended quite literally. If you will allow a small digression:

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> Corridors are a fairly recent addition to the vocabulary of architects. According to Jarzombek, the first pure instance of corridor was created by the architect Borrimini (1599–1667) in the church Sant'Ivo alla Sapienza (1642–50) (Jarzombek, 2010, p. 737). Up until then, only atriums and galleries suggestive of corridors had been built. The addition of corridors completed a development of interior structures where houses went from single all-purpose rooms over specialized room divisions (reaching one room you would have to go through all intermittent rooms) to corridored and thus functionally efficient buildings. I say "addition," but perhaps the proper term would be "subtraction" in the sense that the space used for corridors is drawn from the rooms. In rooms arranged en-suite, there is already space that serves the purpose of connecting other rooms. By moving this space outside the rooms and in some cases using the same space multiple times (think of a corridor with apartments on both sides), corridors make the overall use of square footage more efficient, that is, they gather a series of variable costs into a fixed overhead expense.
>
> As each room in a building has a function: cooking, working, relaxing, etc., we might be tempted to think of a corridor as another room with a specific function. However, corridors are not simply functions alongside all other functions of a house or a treatise. The corridor does solve a logistical problem, so we could assign it a function such as transport; but the fact that you have to actually physically traverse the space in a corridor or navigate an introduction is incidental to the higher function of *switching* from one function to another.

[21] The view from nowhere is "[t]he perspective of a particular person inside the world with the objective view of the same world – the person and his viewpoint included" (Nagel, 1986, p. 3).

[22] There can be little doubt that Descartes employs the FoT. His occupation of the corridor means simply that the position from which he meditates is one that only recognizes things as existing, and that he can clearly see both types of things from his position: "[J]ust from the fact that I clearly understand myself to be a thinking thing and can have a clear thought of myself as not involving any other substance, whether thinking or extended, it is certain that I as a thinking thing am really distinct from every other thinking substance [res cogitans] and from every corporeal substance [res extensa]. And of course this applies equally to *you* and to everyone" (Descartes, 2008, p. 15, para. 60).

From the corridor, we can access all other functions: the kitchen, the living room, the library, etc. The function of the corridor is thus a meta-function. In the corridor, a particular room's function is brought together in a singular point (the doorway). In Actor-Network Theory (ANT) this would probably be called 'punctualization' (Latour, 1999, p. 184; Callon, 1991, p. 153; Law, 1992). Each point differentiates itself from every other in at least one respect (identity of indiscernibles), so the floor plan that the corridor in fact lays out creates a map of all the rooms and their function.

Analogously, introductions, table of contents, and methodological considerations bring together and provide an overview of subjects, paragraphs, and different methods. The table of contents was the hyperlink of its day. Pliny the Elder credits Quintus Valerius Soranus as the first author to provide a table of contents in a book.[23] In the introduction, a genre serves the same purpose:

> A genre comprises a class of communicative events, the members of which share some set of communicative purposes. These purposes are recognized by the expert members of the parent discourse community and thereby constitute the rationale for the genre. This rationale shapes the schematic structure of the discourse and influences and constrains choice of content and style. (Swales, 1990, p. 58)

In a given genre, you expect a certain layout. Switching genre, you expect a different floor layout. An article or thesis has a certain structure, and certain parts (introduction, literature review, conclusion) are expected. Like a house, we expect different functions to be present and neatly separated (you do not cook in the bathroom. You do not present your main argument in the literature review). Each function is punctualized or "totalized"; as the authors on a book of reflexivity state (as they wrestle with the entire concept of a preface and how to avoid its assumptions of the position of the writer and the reader): "[T]he preface finishes a text by totalizing an object" (Sandwell, Silverman, Roche, Filmer, & Phillipson, 1975, p. 2). Corridors are control structures in the straightforward sense that the function of allowing passage or overview can be inverted. There is an equal possibility of barring the passage and excluding content. For instance, what is often emphasized about Bentham's Panopticon is what Foucault (2002) famously analyzed as the extreme realization of a modern disciplinary institution and the installation of the "gaze" that sees everything. Implicit in this discipline are corridors that are controlled like an irrigation system. Speaking of the church, Sant'Ivo alla Sapienza, Jarzombek (2010) explains how the "staircases at the end allow monitors to control entry and exit. A brilliant solution to the problem of how to allow different classes to spatially co-exist in the same institution" (p. 752) and later how "The corridor was the

[23]Pliny the Elder, preface 33, Historia naturalis, in Henderson (2002, p. 275).

> space of expertise just as it was an instrument of surveillance, channeling and defining people into its spatial regimes" (p. 756). All logistical flows are controlled with the use of corridors (in a sense, all areas in a prison are attempted territorialized as corridors, and even the prisoners' cells become corridors, although prisoners attempt to reterritorialize them as personal spaces). A mundane example is the planning of aisles in a supermarket to control the flow of customers. The corridor "is an antimetaphysical space that cuts soldiers out of the natural order of life and family to reconstitute them into a new social order" (p. 749). Every room is assigned a function. All personnel belong in specific quarters; and all linguistic moves in a thesis have their place. From the introduction, you do not digress into an exposition of the historic origin of corridors without making its relevance immediately clear and distinctly demarcated.
> #

Once we return to the corridor from a room, we are capable of picking up from where we left. By quickly delving into a subject matter and then returning to the problem of the FoT, I have crudely illustrated the idea of the corridor. I have also brought into focus that this introduction in which you are engaged is, in fact, a corridor and that the voice employed in the corridor is what Wertsch (1990) calls the voice of rationality. It is the calm voice of reason that:

> aspires to a view from nowhere. That is, it aspires to a view that gets at the true nature of things because it isn't conditioned by the circumstances of the viewer. It can be transmitted through speech or writing without loss of meaning, and expounded by a generic self that need not have any prerequisite experiences. (Crawford, 2009, p. 162)

In the quote, Crawford is contrasting the theoretician's knowledge with that of the practitioner.[24] A very fitting contrast since the voice of reason is also the voice of theory. In the corridor, we are theoreticians, or observers (from Gr. theoros, spectator), as opposed to practitioners. "Theoros" was, of course, in ancient Greece, the term for official witnesses to a spectacle.[25] With "theory" (/observation), we have triggered the age-old connection between vision and thinking – what Dewey calls the "spectator theory of knowledge."[26] The connection brings us back to pinpointing the primary reason that the FoT can hide in plain

[24] In contrast, he states that "Practical know-how, on the other hand, is always tied to the experience of a particular person. It can't be downloaded, it can only be lived" (Crawford, 2009, p. 162).

[25] For an account of the migration of the term to philosophy and the modern meaning of "theory," see Nightingale's (2004) *Spectacles of truth in classical Greek philosophy*.

[26] "The theory of knowing is modeled after what was supposed to place in the act of vision" (Dewey, 1929, p. 19). For treatments of this association, see Levin (1993) and Grasseni (2007). Jarzombek (2010) gives a very fitting characterization of the connection between vision and thinking: "The corridors that defined these buildings were purpose-driven spaces, every inch focusing on the task of bringing man, building, and nation into a single *optic*. They were spaces in which the modern male citizen's relationship to the state was being molded. In this context, the corridor became quasipublic, stamping uniformity out of diversity and purging the male of societal softness" (p. 751, my emphasis)

sight. The reason is this: the FoT is embedded in seeing. In a certain sense, *things are how we see* (not simply *what* we see), not just when considering the act of perception (we do not look for objects to see; objects are how we see), but also when we consider thinking, or thinking about perception, or thinking about thinking (we do not look for concepts (things) to see in the mind; we conceptualize (make things of) what to think about).[27] As stated earlier, a "way of thinking" is not simply something we can step out of and examine. This still holds true. Calling specific attention to this aspect of the FoT serves to make apparent that when speaking of things and Things, we are not simply targeting physical objects. The FoT is involved in every single enunciation we make – including the methodological self-image we have as readers and theoreticians.

Shadowing one's own thought

The FoT, considered as a way of thinking, cannot be stepped out of because as you attempt to step out, you bring the format along. You therefore have to circumvent the format. Instead of attempting to step out of the format and isolate "it" as a thing, what is now being made possible is recognizing it in every enunciation – in every *Thing*. One thereby attains a type of dual consciousness akin to Husserl's (1982) epoché (or bracketing) wherein the "natural" or everyday way of thinking about and seeing the world (where we "think through things") is observed to express the format.[28] We can, for instance, see that if we have a discussion of perception and first speak of "the object of perception," and afterwards relate this object to "the act of perception," we have used the format twice and are now trying to establish a relation between two "objects" (object and act). Shadowing one's thoughts in this way keeps the mind wary of what is being done *while* it is being done. This idea has a parallel in cognitive science. In an article on mirror neurons in relation to the experience of pieces of art, Freedberg and Gallese (2007, p. 197) propose that a crucial part of a viewer's response to art is an activation of embodied mechanisms that mirror the particular gestures involved in producing the art. They use as an example the artist Lucio Fontana's work *Concetto Spaziale "Atteza"* (*"Waiting"*), which consists of a white canvas with a single straight cut made by a sharp object through its center. The proposition is that the neural response to the work is the observer's recognition (empathy) and imitation (mirroring) of the "actions...suggested by the implied movements involved in its making" (p. 199). In other words, seeing the cut triggers a response that imitates the action that created it. When we see Fontana's artwork, we feel and literally reenact *the movements that created the cut.* It is a type of historic affordance, if you like, or automated reverse engineering.[29] The authors refer to Antonio Damasio when they explain that:

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[27] This is not to be confused with the discussion of whether or not mental content is being reified.

[28] Unlike the epoché, this dual consciousness is in no way privileged. Being able to see that we employ the FoT does not give us a particular insight into the conditions of human experience, only to this particular and contingent way of being in the world.

[29] We are provided a history of things, much like the wear and tear of tools tell a story or an unfinished house shows the carpenter what has been done, the state of the house now, and what remains to be done. In a way, we return to nature's way of telling stories by incorporating them into the living:

Thus, nature is alive in our eyes partly because its shapes are fossils of the events that gave rise to them. History is not merely inferred intellectually from clues; it is directly experienced as forces and tensions present and active in visible shape (Arnheim, 1974, p. 417). The snail's house, the hardened hands, and the crooked tree all tell specific stories of what has happened. A skilled hunter can track an animal for days, and a skilled

> areas of the brain react so as to assume the same state they would have had if the observers of the actions and emotions of others were engaged in the same actions or if they were subject to the conditions they observed. (p. 201)

Kinship with the concept of affordance, is evidenced in the authors' further remark that the "observation of a graspable object leads to the simulation of the motor act that the object affords" (p. 200).[30] The example is a close parallel to what is meant by seeing things as effects or enunciations. Whenever we come upon a text, a drawing, a piece of machinery – any type of knowledgeable work – a large part of our understanding consists in knowing (and as it turns out, reenacting) what has been done based on the result. It is a qualified "guess" of what has ostensibly taken place in order for things to be the way they are, not a guess in the form of propositional knowledge or posture toward the knowledge work, but in assuming the cognitive movements that would produce the same result ("What would I have had to do to have produced that?").

The vigilant dual attention also extends further than the results. The format is not only evident in "settled" things. We are accustomed to focusing on things and objects, but the FoT also works by way of expectations and implicit assumptions about the form of acceptable solutions. It is found in our categories, standards, and rules (Bowker & Star, 1999; Busch, 2011), and it is invoked each time we decide to cut out a part of reality and call it a separate thing. Thinking of the FoT is a way of asking "why did you make the incision there?" – a question that is otherwise never asked. "Why did you choose to include this and not that as part of the phenomenon?" – is a question of definition, but underneath this question is the meta-question "how can you separate *anything* from anything else?" Simply tracing an outline of a thing begs the question. When we separate a thing from its environment, we do not question that we can do so (we may question where, why, how, etc., but the fact that this is what one does when differentiating a phenomenon in the world is not questioned).[31] The FoT is not part of the act. It *is* the act. Its execution is so ingrained in our thought that it is not in itself considered of any consequence. When, for instance, we speak

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art critique can tell if a painting has been done by the master himself, and so forth. The restrained thing bears witness to the restraining skill. It could also be called a post-factual affordance.

[30] This would indicate that the concept of affordance could be adjusted to include a temporal aspect. Affordance is not simply "what you can do" (action capabilities) but also "what has been done." Freedberg and Gallese (2007, p. 202) write: "[O]ur brains can reconstruct actions by merely observing the static graphic outcome of an agent's past action."

[31] A different way of pondering the same question is to question the outline. What is it? And what does it separate? Barad (2007) has two wonderful quotes from Feynman et al. and Gayatri Spivak, respectively, that deal with the same issue: "What is the outline? ... It is not something definite. It is not, believe it or not, that every object has a line around it! There is no such line" (Feynman, Leighton, & Sands, 1964). "If one really thinks about the body as such, there is no possible outline of the body as such" (Spivak, 1988, taken from Barad, 2007, p. 153). Deleuze (1981) also raises this question in the course of a series of lectures on individuality: "The true question is: where does an action stop? Does everything have an outline? Bateson, who is a genius, has written a short text that is called "[why] does everything have an outline?" Take the expression "outside the subject," that is to say "beyond the subject." Does that mean that the subject has an outline? Perhaps. Otherwise, what does "outside the limits" mean? At first sight, it has a spatial air. But is it the same space? Do "outside the limits" and "outside the outline" belong to the same space"?

of competing alternative theories or methodologies, we assume that methodological considerations have no impact on the theories' content,[32] but their comparability relies on the assumption laboring in the background that they are both *things* that speak about the same Thing (subject matter) and so they can be compared. This is how methods become representative of different interpretations and thus subject to a representational search for the truth that corresponds to reality.

Notwithstanding, although inconspicuous, the thing is not unconscious or simply mechanical. There is constant work that goes into establishing a thing. The Thing, the assembly, performs a labor of division, a term coined by Robert Cooper (1997) that highlights the creative act of making a thing and suggests that it is significantly bound up with the act of seeing. As Henare et al. (2007, p. 15) put it: "Seeing things requires acts of conceptual creation." Seeing is not passive reception, but as the enactive approach (examined below) says in relation to perception: "*What we perceive* is determined by *what we do*...we enact our perceptual experience; we act it out" (Noë, 2004, p. 1). The enactive approach aims at perception. The concept of the labor of division applies more widely in relation to thinking, painting a picture, writing, speaking, dancing, etc.; in fact, all types of human expression answer to this sensitivity. The concept is obviously a wordplay on "division of labor" and expresses all of the "work" that has to go into (and already has gone into) distinguishing one thing from another.[33] It is much more than tracing an outline. Like Fontana's cut, we see the work that has gone into carving out things from their environment – each with their unique position – and in the process, creating ecologies (e.g., the oven belongs in the kitchen, and the topic of politics is part of dinner conversations). The labor of division is part of the code, rules, measurements, translations, and transformations that have to be in place for things to be meaningful parts of a discourse, a way of thinking (e.g., scientific data) or recognized as a "move" (e.g., the dance style "B-boying" has recognizable patterns, rules for engagement, and ways of deciding a winner). Latour (1986) draws out how the various ways in which different articles (or inscriptions) become part of a homogenous language as a way of mobilizing allies and winning arguments. The labor of division is the common ground that allows an argument to take place at all, and it is also the way of "making the incision" into the world that allows us to see "what is there." When we accept that things are labors of division, we see enunciations rather than things. We see the cutting in the cut. Seeing enunciations for things reveals the labor of division that goes into creating the things. With this insight, we are set free to not simply perform the labor, but question it. Speaking from a point of view that attempts to resist the normalizing effect of a corridor, Law and Benschop (1997) analyze different paintings to show that if you discard the idea of an immediate comparability between all pictures, then "the labour of division is no longer backgrounded to produce an ontological effect that seemingly resides in the order of things" (p. 170). If this is possible, then there is hope that we can meet a world wherein the power of "things" has subsided and placed back into a multiplicity of different ways of encountering the world. Here, it becomes possible for a "painting [to] resist producing a

[32] Or their impact is comparable so that *ceteris paribus* the methods and theories can be brought into the same optical consistency.
[33] The concept is related to Strauss' idea of articulation work (Corbin & Strauss, 1993; Strauss, 1988).

hidden ontology that comfortably grounds an epistemology (that may become naturalized). Instead the contingency of entities – and the labour of division in which they are generated and distributed – is made visible" (p. 170).

Henare et al. (2007) note that Latour (2003) has worked to shift the emphasis of things from "matters of fact" to "matters of concern." Notably, actor-network theory is (in-)famous for its insistence on a generalized symmetry, a democracy of non-human and human actors alike. What is claimed here runs along the same lines, but it is emphasized that the symmetry also applies to the drafts, sketches, daydreams, and fantasies or what Deleuze and Guattari (2002) would call monsters. What is most obvious is the potential that different worlds are to be found in things – we can see *enunciations in things*. Nevertheless, most of the time, we live and breathe in the same – singular – world that is established qua the format of things. With these cautionary notes, we are now able to move on to a discussion of a methodology that does not necessarily rely on the FoT.

Methodology

As should be apparent from the introduction and problem statement, the aims of the thesis are both methodological and theoretical. Solving the problem of dealing with the format of things cannot be straightforward for the above-stated reason. There are other reasons. These tie into considerations of method as well as how to approach literature. This methodology section first outlines six approaches that are subsequently rejected. The remainder of the section describes the alternative approach that has been taken in the thesis and how it relates to the three written articles. The methodology section also provides much of the argument for the particular approach taken in the literature review or "state of the problem" as I have called it.

What is a thing?

Presented with the problem of the FoT, the first conventional academic design would be to consider the format or concept of a thing. It would be to ask: "what is a thing?" or "what is the format of things?" We would then present Heidegger's (1971) famous analysis of a jug and Mauss' (2009) equally famous article on gifts to consider exchanges, discuss views of reification, and so on. We would also have confirmed the format in the process. Consider the following questions: what, if any, are the characteristics belonging to things as things, rather than the characteristics of this or that particular thing? Can we say that a thing is always clearly demarcated, or that it is countable, or that it is a discrete entity? Is a thing always situated? Is a thing clear and distinct as Descartes would have it? These are all perfectly legitimate questions, and they all make use of the FoT. However, the point of the introduction was to make it obvious that the format is incessantly at work. Problems have been pointed out that make a straightforward investigation of the method questionable (we cannot step out into a privileged corridor and capture our method as things). A straightforward investigation of what a thing is suffers doubly under this objection. If there ever was an example of when the FoT was displayed as an expectation rather than an actual thing, it is in the question "what is a thing?" If we have done anything in asking, it is to reaffirm the FoT. Thus, we cannot rush unreflected into stating and answering the above questions.[34]

Seemingly left with no tools to clarify how to proceed with the investigation, we could invent new tools. We could start by acknowledging that whenever we think, most of the time, we have already couched our enquiry in the format of things. We then discard a general and abstract treatment of the concept of thing since it would only examine what a general and abstract thing is. Instead, we take it that any theoretical concept of a thing should be side-ordered with all other things (including the imagined, the broken, the unfinished, etc.). This produces a flat ontology, one in which no thing is excluded. A flat ontology makes it apparent that we can only ever exemplify what a thing is (words and concepts about things are also things). Garcia (2014, p. 21), in an attempt to bring out the thing seen across all things, uses the term "the no-matter-what" for the thingness of the

[34] The investigation into the FoT is not to be confused with the anthropological/archaeological call to "take things seriously" (Webmoor & Witmore, 2008).

thing. He tries to see the thing as a *thing* proper instead of being occupied with what the thing is. It does not matter that it is a bike, a tree, an idea, or a sentence. It matters that it is a thing. Thus, we should forget the question "what is it?" and look at the thing without seeing what it is. We try to see it as a thing before it becomes a *some*thing. It is in this way that we attend to a "no-matter-what." Garcia is thus looking for the "thinnest possible thing," so to speak.

The above only exemplifies the deeply fascinating philosophical issues that would spring from such an investigation.[35] However, as the line of reasoning develops, it becomes clear that the entire undertaking is developing into a separate philosophical treatment of the FoT. Moreover, in its own way, it inadvertently provides impetus to the idea that the FoT can be neatly separated as a thing (a topic, a problem, a format, a concept). The purpose of the thesis is to break the hegemony of the FoT in our everyday thinking. A separate conceptual treatment of "the thing" is not a viable option in this endeavor.

Switching format

Dissatisfied with the FoT and seeing no way out of answering pressing ontological questions, we can attempt to switch format. There are impressive philosophical bodies of work dedicated to providing a new place to stand from which to move the world. One option is to provide a new genesis for things; another is to switch the basic unit of the world from "thing" to "process."

The first option can be found in the philosophy of difference, as developed by Deleuze (2001) and Derrida (1997, 2002). Both formidable thinkers in their own right, they draw on such iconic radical thinkers as Nietzsche, Tarde, Bergson, and Heidegger. All of these thinkers follow different approaches and deal with many unrelated subject matters. One common focus, though, is to invert a classical distinction between difference and identity to the point at which identity is subordinated to difference instead of vice versa. Multiple consequences cascade from this inversion. Most important among these are 1) the dissolution of identity as the origin and ordering principle of meaning and identity and 2) the displacement of a logocentric metaphysics that centers on an original, irreducible form that the logos (literally, the word or the act of speech) represents and reproduces. Where traditional metaphysics conceives of difference as arising from between two entities that have their respective prior identities, a metaphysics of difference starts with movement or, in Deleuzean terms, the intensive that results in the extensive, that is, in things. Deleuze (2001, p. 231) uses the term "the intensive origin of extension" to signify that the identity of each thing arises from difference, and any subsequent comparison that yields a difference happens within a horizon of identity. The repetition of such a term is dead or empty in the sense that it adds or subtracts nothing. We might as well buy two newspapers to check the

[35] For instance, there is a debate in realism built into considering the origin of the FoT. Grosz (2009, p. 126), for example, states that "...things as such do not exist in the real. The thing is a certain carving out of the real, the (artificial or arbitrary division) of the real into entities, bounded and contained systems, that in fact only exist as open systems within the real." My treatment of constraints in the articles would go against such a view as there would be no separate (social) sphere from which the "real" could be carved into pieces.

contents of one in the other.[36] As such, identity only affirms a postulated unity without ever answering what the thing is.

The second option is found in process philosophy (Rescher, 2000; Seibt, 1990, 2013), which similarly draws on Nietzsche, Bergson, and Heidegger but also heavily on Whitehead, Hegel, and pragmatic influences such as James and Dewey. Process philosophy parallels the philosophy of difference in criticizing substance metaphysics as the prevalent idea in Western thinking that being is static and that change is explained as either illusory or accidental (as opposed to essential). Instead, process philosophy starts from the ontological claim that being is dynamic and that the primary unit of analysis is not *what there is* (things) but *what occurs* (becoming). It is not that there are no "temporally stable and reliably recurrent aspects of reality" (Seibt, 2013, para. 2) (i.e., things), but these are taken to be effects of the behavior, organization, and interaction of processes. Process philosophers do not expect things to be the basic unit of investigation. What is of interest is "becoming." As such, it is also a different kind of genesis; however, not only is there no creation *from* anything... there is no creation *of* anything. In a sense, there is only the creative act. Johanna Seibt (2013) explains it thus: "[B]ecoming is both the mode of being of different kinds of dynamic beings *and* the process that generates different kinds of dynamic beings" (par. 4, emphasis in original). In wording and intention, process philosophy aligns with the aim of this thesis. Process philosophers seek to resist a vocabulary and a perspective that predisposes one to think in terms of things. This is particularly vivid in the case of movement and becoming when we seek to capture them with static means. Grosz (2009) expresses the problem thus:

> The moment that movement must be reflected upon or analyzed, it yields objects and their states, distinct, localized, mappable, repeatable in principle, objects and states that become the object of measurement and containment. The depositing of movement, its divisibility, and its capacity to be seen statically are the mutual conditions of the thing and of space. (p. 126)

We deposit or place movement and thereby force it to sit still. We do so by using gerunds (e.g., becom*ing*).[37]

Although most of the thoughts in this thesis owe some debt to the philosophy of difference, and despite the shared agenda with process philosophy, both were discarded early as unsuitable paths for the thesis. This is so first and foremost because of the risk of being engulfed by the antithetical stance toward thinking based on identity, substance, or static things. This thesis also has a positive ambition, an ambition that would have been largely corrupted if the dominant effort had been to explain why some way of thinking is erroneous. Furthermore, the rejection of something can, in some respects, also serve as its

[36] Wittgenstein's famous example from *Philosophical Investigations* (1997, pp. 94e, §265).
[37] There is one respect in which process philosophy differs from what is said in this thesis. It is that "things are considered as secondary effects, constructions, or illusions at the intersection of several events or vectors of being" (Garcia, 2014, p. 10). There is no claim that things are not real in the investigation of the FoT.

confirmation. For instance "processists replace the descriptive concepts of substance metaphysics with a set of new basic categories. Central among these is the notion of a basic *entity*...often labeled 'process'" (Seibt, 2013, para. 4, emphasis added). The suspicion arises that the FoT is still at work when words like "entity" or "category" are used (although such a claim requires a more in-depth analysis). Moreover, if the FoT is still functional, then at least this particular article is written from a corridor. Reinterpreting the world based on either "difference" or "becoming" calls up a scenario whereby, in Garcia's terms, a substantial ontology is juxtaposed with vectorial ontologies (2010). In one, everything is a thing; in the other, no thing is a thing.[38] At best, we find ourselves in a situation where we have to argue "for" or "against" an ontology. At worst, we propagate the FoT endlessly in a vocabulary intent on explaining "what there is" relative to a thing (or a non-thing). Similarly, in trivializing a reading of "difference as becoming," we could see difference as something that is always "in-between," as in Deleuze's (1990) example of Alice who simultaneously becomes larger and smaller – as if Deleuze was speaking of a difference *between* a small Alice and a large Alice.[39] There is precisely no*thing* between a smaller Alice and a larger Alice (and it is a complete misunderstanding to understand difference as *between*). Proposing a paradigm shift on the backdrop of a different paradigm invites methodological or theoretical comparison – one that would be conducted in a corridor.

A conventional approach

Conventionally, a thesis demonstrates mastery of an existing field, isolates one or two unresolved problems, and proposes solutions to those problems, thereby contributing to the community of scholars. This of course assumes that there is a field, that there is an array of agreed-upon problems, some of which are unsolved, and that the conventions and vocabulary that raise and settle problems are relatively stable. In the present case, the community of scholars is the cross-disciplinary field of HCI researchers (including, but not confined to, philosophers, sociologists, cognition scientists, UX/UI designers, science and technology researchers, anthropologists, etc.). The domain is interface research, and the problem is the methodological problem of the format of things. Ostensibly, the thesis is able to conform to this template. When we look closer in order to demarcate the domain and isolate a problem area, we are, however, at a loss. The claim was that the FoT is an integral part of theory building, in a certain way of thinking, to the extent that the social technology used to evaluate and change the theoretical tools one employs (methodological considerations) is based on the format. The solution is obviously not to enumerate all the examples that can be found to exhibit the format. It may very well be that *I* see the FoT

[38] The vectorial model is somehow dependent on things as points that are never reached: "The [vectorial] model consists not in distributing being substantially, but vectorially. One thus conceives of trajectories of being, identified with events, facts, powers, intensities, or intentionality. These vectors of being are primary. They carry, support, and displace being, but without ever obtaining an end point or objective consistency" (Garcia, 2014, p. 9).

[39] Deleuze (1990) affirms that events are ontologically primitive, and by his famous example, he shows that substances (the substance we would normally think of as Alice) are derivative of events. "When I say 'Alice become larger,' I mean that she becomes smaller than she is now. Certainly, she is not bigger and smaller at the same time. She is larger now; she was smaller before. But it is at the same moment that one becomes larger than one was and smaller than one becomes" (p. 1).

ubiquitously reflected in the design of different interfaces, or replicated in theoretical discussions of this or that metaphor, or unconsciously propagated by designers who see themselves as human-centered. Notwithstanding, all of these examples are pointless relative to whether they are seen as things or enunciations. One does not necessarily contradict the other. As stated earlier, when we accept that things are labors of division, we see enunciations rather than things. The obverse also holds true. When we are inattentive to the labor of division, we do not see their enunciation. We see things. A further complication is that "a way of thinking" is not confined to a specific problem area, a specific phenomenon, or a specific type of inquiry. Following conventional boundaries, it would require conceptual clarification whenever examples were drawn across different fields, disciplines, or discursive modi (e.g., if I were to draw examples together from systems theory, the philosophical problem of representation, methodologies from organization studies, design considerations from design-based research, etc.). This would call for a super structure, that is, a systematic account of the interrelations of the chosen fields, disciplines, methodologies, etc., and a consistent argument that supports their compatibility and incompatibilities in a way that renders their association better, more worthwhile and, not least of all, theoretically justified (e.g., can difference philosophy be combined with cybernetics, ecological psychology, and enactive philosophy of mind?). This is perfectly understandable since the "things" in question (their "meaning") in these different endeavors are obviously not the same. However, what is claimed here is reversed. The question is not "how do all of these theoretical perspectives and theories fit together?" It is "how is it that we are capable of handling all of these very different phenomena with just one single format?" What the perspectives are "about" needs to be aligned only to the extent that it sheds light on the format. The scenario resembles that of Maturana and Varela's (1980) proposal of the theory of autopoiesis, claiming it to be valid for all living systems. To preempt demands of proof for considering living systems autopoietic systems, they state:

> The assertion that physical autopoietic systems are living systems requires the proof that all the phenomenology of a living system can be either reduced or subordinated to its autopoiesis. This proof, obviously, cannot consist in enumerating all biological phenomena and presenting cases of autopoietic systems that exhibit them; rather it must consist in showing that autopoiesis either constitutes or is necessary and sufficient for the occurrence of all biological phenomena, if the proper non-determinant contingencies are given. (p. 88)

Mingers (2006) expands on this perspective by stating that one does not solve the problem of "what is the living?" by "specifying a list of necessary characteristics which any living organism must have" (p. 32). This would constitute an entirely descriptive and non-explanatory approach. "It works by observing those systems which are accepted as living and noting some of their common characteristics" (p. 32), and thereby, it begs the question. In other words, to show that all living systems are autopoietic, we do not start at one end – describing bacteria or a handful of animals – and work our way through the list to compare and show that all living systems exhibit traits that would satisfy such a theory. Similarly, attempting to show that the FoT is part and parcel of the HCI community's basic conceptual

apparatus by analyzing interfaces or conference papers and submitting that as evidence would only yield comparisons of arbitrary similarities between, metaphorically speaking, "wings" and "forearms" (or apples and oranges) of different interfaces (or theories). A systemic argument relies on systemic evidence. What is compared are not first-order traits of different phenomena but second-order isomorphisms between structures of theory-making and, in particular, between the chosen unit of analysis.[40] A small example will illustrate the difference:

Consider for instance the following four quotes:

> Social aggregates are... the object of...a performative definition. They are made by the various ways and manners in which they are said to exist. (Latour, 2005, p. 35)
>
> [T]he object of a performative definition vanishes when it is no longer performed. (Latour, 2005, p. 37)
>
> Observing means making a distinction and indicating one side (and not the other side) of the distinction. (Luhmann, 1995b, p. 85)
>
> Our perceptions are caused by the action of things on us, through their effects on our bodies. (Nagel, 1986, p. 14)
>
> [T]he larger material arrangements enacts a cut that resolves the inherent ontic-semantic indeterminacy through which the 'subject' and the 'object' emerge. (Barad, 2007, p. 143)

One quote stems from social theory and speaks about performative definition. Another hails from social systems theory and states how an observation is made. The third comes from philosophy and takes a well-known position on perception. The last opens an inspiring route to agential realism and talks of cuts. Anyone familiar with at least two of these thinkers can find similarities and differences that would justify a composition (e.g., the significance of observation for the performance of social aggregates). The trouble is not that we cannot do this; the problem is that we can do this *whichever way we want* and, in their subject matter, find no way of addressing the format of things. Not all of them speak of things, and some speak of objects in different ways. Some focus on the act and others on the result. The concepts of "perception" and "observation" are not even close to being comparable as they are used, and so on, and so forth.

What ties the quotes together is not what they say but the position they have on the kind of problem they solve. Each provides a genesis of something. However, it is not the same genesis, and they are not different "types" of geneses. DeLanda (1998) provides a very

[40] Incidentally, we can note that the argument that Maturana and Varela consider valid is one that adheres to the *ex nihilo nihil fit*. It is either a genesis ("constitutes") or a condition (necessary and sufficient).

illuminating account of Deleuze's view of the relation between the actual and the virtual as a kind of problem-solving. He writes:

> To take an example from physics, a population of interacting physical entities, such as the molecules in a thin layer of soap, may be constrained energetically to adopt a form which minimizes free energy. Here, the 'problem' (for the population of molecules) is to find this minimal point of energy, a problem solved differently by the molecules in soap bubbles and by the molecules in crystalline structures (which collectively minimize bonding energy). (p. 30)

The point of DeLanda's example is that the soap bubble and crystalline cube look nothing like each other and share very few, if any, characteristics, save for the fact that they "minimize free energy," that is, they solve the "same" problem. Applying this idea, the quotes are comparable, not because of any shared characteristics or domain, but as a result of solving "the same problem" (a problem that, if phrased in the respective theoretical vocabularies, would appear as dissimilar as the answers). Their similarity is one of second-order isomorphism (Edelman, 1998), that is, not the first-order similarity between one thing and another but the second-order relation between one thing's relation to another thing vis-à-vis another thing's relation to another thing. Bateson and Bateson (1988) provide an example that clears up what is meant by a second-order isomorphism:

> I think the first person who actually saw this clearly was Goethe, who noted that if you examine a cabbage and an oak tree, two rather different sorts of organisms but still both flowering plants, you would find that the way to talk about how they are put together is different from the way most people naturally talk. You see [...] we talk about 'things,' notably leaves or stems, and we try to determine what is what. Now Goethe discovered that a 'leaf' is defined as that which grows on a stem and has a bud in its angle; what then comes out of that angle (out of that bud) is again a stem. The correct units of description are not leaf and stem but the relations between them. These correspondences allow you to look at another flowering plant – a potato, for instance – and recognize that the part that you eat in fact corresponds to a stem. (p. 27)[41]

Anyone attempting to compare a potato and the stem of a flower on the basis of their appearance alone would find very few things to go on. Similarly, in relation to the quotes, Luhmann's "observation" is the "distinction" between Barad's "cut" and "material enactment." Notwithstanding, they are by no means the same "things." They are positioned differently and have enormously different ecologies, etc. In terms of the position they hold, "observation" and "cut" are incredibly similar. When compared, it is not a matter of looking

[41] The designer David Pye calls this "an arrangement" and goes on to note how arrangements are always embodied, that is, they are always comprised of first-order differences, although they pertain to second-order differences or isomorphisms (Edelman, 1988): "It is really rather remarkable that, while anyone can tell whether a thing is a pocket-knife because, presumably, anyone can recognise the principle of arrangement which constitutes the similarity between all pocket knives, no one can visually abstract that arrangement. We recognise it when we "see" it embodied, we can describe it disembodied, but we cannot visualize it disembodied" (Pye, 1964, p. 20).

for which one of the quotes is “nearer to the truth” or provides “the better answer.” They are compared like the anatomies of different animals. One would not think of arguing that the anatomy of a horse was “more true” than that of a tortoise.

A conventional approach assumes that a critical discursive theoretical treatment of a subject stays within the parameters of the established labor of division. Before the objection is raised that many writers attempt to revise or critique a field’s conceptual apparatus, I will note that the parameters to which I refer hold *precisely* the option of revising and “swing[ing] the balance of power and turn[ing] an incredible statement into a credible one” (Latour, 1986, p. 17). “Staying within the parameters” does not entail agreeing with the established opinion. It refers to the manner in which agreement and disagreement are reached, that is, the labor of division. Two theories in disagreement agree on the format of their disagreement. If they do not, they are not in conversation. In the earlier assessment that one cannot step out of the FoT into a methodological “corridor,” where its use can be compared to other “methodologies,” the main problem was, and is, that this corridor performs the same labor of division as any of the “rooms” and thereby establishes the same FoT. This thesis does not employ a conventional approach. It does not attempt to develop a critique of the existing field in order to lead the reader to see the inadequacy of the current conceptual framework to a problematic and to adopt a new framework as a better approach. The object of the thesis is to *break* the hegemony of the FoT and to make other approaches available. This is done by making the format noticeable and comparing examples across borders of fields, disciplines, domains and problems – not in order to pick out the true or the best but to see the pattern that connects them, to use a Batesonian term. Other approaches become available as the consequences of the FoT no longer being exacted by way of a hegemonic vocabulary, epistemology, ontology, or genesis.

Reflexive problems

The FoT is either noticeable in *every*thing, or it is nowhere to be found. As stated earlier, there is no privileged enunciation where we can conceptually or methodologically isolate the format. Instead, different variants of reflexive problems have been produced to make the format visible. Figure 2 brought out the paradox of observing observation. The corridor established the methodological problem of “getting behind oneself” in order to see what one is doing. Yet a third reflexive problem is that of examining what a thing is without already having assumed *that* it is. These are all variants of well-known classical philosophical paradoxes such as Achilleus and the tortoise, God as the unmoved mover, the problem of movement, the liar’s paradox, the problem of beginning, the sorites paradox, and so on. It is therefore tempting to engage in a discussion of the reflexive nature of these problems. After all, they are prime examples of *effects* of the FoT. As in the case of a conceptual discussion of “the thing,” “the process,” or “the difference,” a separate treatment of the reflexive problems of paradoxes could easily give the impression that the problem of the FoT lies with its paradoxical effects. However, these are incidental to the much more fundamental consequences of only thinking within the limitations of a single format. The use of paradoxes is a way of showcasing the format as its expressive limits are tested.

#

The limits are seen, for instance, in Luhmann's (1995b, 2002), ideas on observation, blind spots, and re-entries. Luhmann has made a specific paradox the cornerstone of his entire oeuvre. Obviously, his conceptual apparatus can only be suggested here, but a sketch of how the paradox can be put to use is possible. Luhmann is interested in how phenomena begin. He is inspired by Maturana and Varela's (1992) biological concept of autopoietic systems, which he applies concept to social systems. Just as a biological system needs to differentiate itself from its environment, a social system needs to make distinctions in the world. Luhmann therefore starts with observation, which he calls "crossing," as the basic unit of a social system. He borrows this term from the polymath Spencer-Brown (1972). We can think of it as the crossing of the border of a thing (so in a sense, it is what I have called an enunciation here). Luhmann's point is that we can either see the thing, or we can look at the act that distinguishes the thing from its environment (the observation), but we cannot do both:

> Observation is the use of a distinction to designate one and not the other side. To draw a distinction is to mark a border with the consequence that one can reach one side from the other only by crossing the border. Spencer-Brown calls this 'form.' "Since the use of a distinction is the presupposition of every observation, this distinguishing is itself not distinguishable in its operative use ... The distinction that is operatively used in observation but not observable is the observer's blind spot" (Luhmann, 2002, p. 190).

We can either observe, or we can observe an observation, but we cannot observe our own observation. This is the blind spot. The concept of the blind spot thus covers what I have called the "labor of division" here. Luhmann contends that we can either see the thing *or* the work that goes into seeing the thing. This contention creates a reflexive loop. If you are looking at the work that goes into seeing the thing, then some work must have gone into seeing that, which you can then choose to see, and so on, *ad infinitum*. The blind spot keeps moving. Whenever you turn to see it, it moves with you. Just as there is no outermost corridor, there is no final view where you finally catch the blind spot. This is what Spencer-Brown (1972) calls a re-entry. The phenomenon is known as the Droste effect – or mise en abyme in art. A picture that appears within itself.

But is there a blind spot in this statement that suggests that all views have a blind spot? Have we not exactly caught it here? One commentator on Luhmann's philosophy summarizes the problem beautifully:

> The claim that the above assertion makes – that there can be no final, all-encompassing overview of a complex system – is contradicted by the form

> that that assertion takes. The statement itself is an all-encompassing claim about complex systems, maintaining, in a seemingly authoritative manner, that all-encompassing claims about complex systems cannot be made ... The system acknowledges this and thereby gives the paradoxical impression of having at last fully observed itself as a system that cannot be fully observed. (Rasch, 2000, p. 47)

Finalizing the problem gives one the impression that the problem has stabilized. Admitting the impossibility of a final view provides a final view. This is analogous to the case of examining the thing whereby you have to assume the thing (and thereby employ the format) in order to examine the thing. Here you have to employ the distinction in order to create the problem (all observation creates a blind spot; if you look at the blind spot, you create a (new) blind spot). Again, a double bind threatens. Either you observe (and admit a blind spot) or you make no observation (and see nothing). Note how the above objection can easily be avoided. Luhmann can simply state that the problem with the all-encompassing claim is part of its blind spot.

You have to assume that all observation has a blind spot in order to create an unobserved blind spot. You have to assume the concept of a thing in order to examine it. In every case where iterative or recursive phenomena occur, it is the certainty of your present enunciation that maintains the reflexive problem. A case in point is your observation of the above problem: does it (your observation of the problem) have a blind spot or not? Suddenly, you become part of the problem. We can also interrupt the problem. If we state “you are observing a description of a problem,” suddenly, you are no longer part of the problem.
#

The above is an example of the use of reflexive problems. We can investigate what happens in the course of an unfolding problem. To do so, we need to simultaneously uphold the passing moments of the problem and maintain an awareness of the invariants that characterize the movement. It is like looking at an unfolding Mandelbrot fractal image and then noticing a similarity in the recurring patterns. For instance, when we decide to frame a situation in Figure 2, we note that we can frame the situation indefinitely because for every new frame, a subject position appears relative to the frame that now has taken the place of the thing (this new position in relation to the frame can also be framed and so on).

When we follow unfolding paradoxes, we quickly come to the skeptic’s conclusion that there are only three possible outcomes. Either the paradox goes on indefinitely (infinite regress), the paradox bites its own tail (circular argument), or we simply decide to stop (axiomatic solution). The infinite regress leads to paralysis. If we accept it, there is no way out. We can find no safe foundation to stand on. There is no outermost position that oversees everything, and there is no innermost base that reveals the fundamental unit of the

world. The next best thing is to make a virtue out of necessity. In relation to cognitive science, Stewart (2010, p. 27) writes: "it is important to note that cognitive science is a reflexive enterprise: doing cognitive science is itself a cognitive activity, and so cognitive science applies to itself." Stewart, Gapenne, and Paolo (2010) call it a "fruitful circulation" while Varela, Thompson, and Rosch (1991, p. 3) write of "a fundamental circularity in the mind of the reflective scientist."

#

As mentioned earlier, Maturana and Varela (1980) coined the term "autopoiesis" for a biological organism. They did so to explain how an organism obtains information about its environment and how it structures itself in the process (p. xvi). A key concept is the idea of operational closure, that is, the idea that a system does not receive information from the outside environment, but the nervous system only operates on signals it generates itself.[42] The world is reduced to a triggering role. The world triggers different signals but provides no information. Anyone familiar with the problem of solipsism can raise the issue of whether or not we, as conscious creatures, are then isolated in our own head, so to speak. However, this is countered by the assertion that we (our minds) are not in a separate realm, precisely because we are biological phenomena (we have bodies; our minds are part of our body). The problem has been flipped on its head. Information is not "out there" (in the world) but "in here" (our system) while "in here" (our mind/body) is not separate from the world but is "out there" (part of the physical world).

The circularity of the argument rests on our continued use of the terms "in here" and "out there." When we speak of information about the world (we want to know something), we retain a separation between the world and what we know and our traditional perspective of looking out at the world. Speaking only of information (signals in the nervous system), the system is discussed as "operationally closed" (i.e., information is "in here"). Speaking of "where" the system is, it is identified as a biological phenomenon and hence "out there." Again, a difference between "in" and "out" is maintained, but note that in both cases, an answer is provided to the question "*where* is the information?" Circularity arises because the information on the outside world is "in here," and the information on the system is "out there."

Dissatisfied with circular solutions, we might attempt to find a contingent solution that, although not final, is able to fend for itself within its own limits. An axiomatic solution would be one that would consider its answers self-evident on the premises stated. The early Wittgenstein (2005) gives an example of this:

[42] "Operational closure ... that is, the states of neural activity always originate from and lead to other states of neuronal activity in a recurrent, self-referring manner" (Peschl & Riegler, 1999, p. 10).

> I am my world. There is no such thing as the subject that thinks or entertains ideas. If I wrote a book called *The World as I Found It*, I should have to include a report on my body, and should have to say which parts were subordinate to my will, and which were not, etcetera, this being a method of isolating the subject, or rather of showing that in an important sense there is no subject; for it alone could not be mentioned in that book. The subject does not belong to the world: rather, it is a limit of the world. Where in the world is a metaphysical subject to be found? You will say that this is exactly like the case of the eye and the visual field. But really you do not see the eye. And nothing in the visual field allows you to infer that it is seen by an eye. For the form of the visual field is surely not like this. (pp. 5.621–5.6331)

Wittgenstein is not simply giving up on the idea of finding the subject as a separate entity. He is making the case that the subject is the very condition (the limit of the world) of the world as it is. Every part of the world is thus evidence of the subject, but it is not possible to encapsulate the subject "itself" in the format of a thing. This is a case of the world becoming transparent. We see the world, but "through" the world, we also see the subject.[43] A different version of transparency is often ascribed to Heidegger. Although Heidegger himself never used the term, the concept of breakdown is unmistakably unfolded in *Being and Time* (1962) in the form of the extensively quoted distinction between ready-to-hand (Zuhandenheit) and present-at-hand (Vorhandenheit).[44] Our primary involvement in the world is the non-reflective, enacted, and situated being of everyday living. The skilled carpenter does not ponder his hammer (it is ready-to-hand). But once the hammer breaks down, it suddenly appears (it becomes present-at-hand). It has thus been deduced that when the skilled carpenter *does not* ponder his hammer, the hammer has become transparent in use (e.g., Winograd & Flores, 1986, p. 164). Therefore, it is as if we are still looking at it, but now, we are looking *through* it (and as we know, everything is a nail when you have a hammer). Transparency is a form of self-evidence. Usually, a thing is substantiated by something *else* (the ex nihilo nihil fit principle). When something is self-evident, it provides its own support. An authority coincides with herself (why? because I say so!).
#

[43] A parallel effort is made in *A Stroll through the Worlds of Animals and Men* (Uexküll, 1957). Jakob von Uexküll develops an early idea of an animal having an Umwelt, that is, a specific perceptual world in which an organism exists. He imagines each animal surrounded by a soap bubble. Uexküll's idea is quoted in full below. The soap bubble Uexküll speaks of is obviously transparent, and here it is being used in the sense rejected earlier, wherein a perspective, methodology, or theory could simply be put on or taken off and examined like a pair of glasses.

[44] See Koschmann, Kuutti, and Hickman (1998) for an account.

Following unfolding paradoxes provides a wealth of information about the enunciation that establishes and maintains these paradoxes. However, this strategy is only followed cautiously. To maintain the paradox, you have to maintain the enunciation in question (e.g., in order to find the investigation of the concept of things paradoxical, you have to look for a thing in the process). The purpose of providing the image of the corridor was to break the hegemony of the FoT. This also entails breaking the authority that the FoT has in the corridor. It matters what methodological view we have, not because of what is stated but simply because "the methodological" is not a special view; it is the same view applied to itself (and it becomes "transparent" in the process). This is why the authors of the book on reflexivity quoted earlier shy away from writing an actual preface. Any preface pretends to give an overview of something on two pages that, in an article, is only given arduously in two hundred. It feigns an authoritative author and a submissive reader who need instructions on how to read and how to begin. Being in opposition to corridors and prefaces is a way of giving up "the image of the author as a translucent guide-book to his own work. That is a transcendental… image which we could well do without" (Sandwell et al., 1975, p. 2).

Reconciling dichotomies

The greater deal of the inspiration for this thesis has been drawn from writers who attempt to overcome dichotomies they have perceived to dominate their field. These dichotomies are often well-known and awe-inspiring conceptual pillars such as: representation-reality (Barad, 2007; Varela et al., 1991), subject-object (Barad, 2007; Clark, 1998; Hutchins, 1995a; Varela et al., 1991), nature-nurture (Oyama, 2000), theory-practice (Suchman, 2007), and mind-body (Chemero, 2009; Lakoff & Johnson, 1999). Other incarnations can also be found, such as map-territory (Turnbull, 1989), knowledge and things (Baird, 2004), perception and environment (Ingold, 2000), vision and thinking (Arnheim, 1974), animal and environment (Gibson, 1986), mind and nature (Bateson, 1972), meaning and things (Henare et al., 2007), action and perception (Noë, 2004), mind and action (Wertsch, 1989), and social and material (Orlikowski, 2007). This list is obviously not exhaustive. There is, however, method to the madness of listing all of the above. As stated earlier, the purpose of the thesis is not to construct an all-encompassing account of these problems. They are not the "same" problem, nor do they secretly harbor the "same" structure. At most, they will, upon examination, exhibit a Wittgensteinian "family resemblance." So there is no proposition to be granted or denied. There is the overall attempt at finding a way to establish second-order isomorphisms as if comparing the anatomies of different animals. When these different resources are drawn together, there is an assumption of comparability, as when we state that all mammals share the same bodyplan. This does not mean that they display the same characteristics (the forelimbs of bats are wings; they are hands on humans) or solve the same problems (e.g., occupy the same environmental niche). They show characteristics that occupy comparable positions and solve parallel problems of internal consistency, explanatory power, and granularity while, at the same time, having wildly different structures, mechanisms, and units of analysis. Finding the FoT in all of these different "animals" is not a way of proposing that there is a universal format to which all must adhere. It is a way of inviting all present and future contributions into the same conversation, into the same Thing.

From such a vantage point, it is possible to trace patterns (examples of which were given above in three different types of reflexive problems). The tendency to provide phenomena with new geneses, which I spoke of in the preface, is such a pattern. Although I have the greatest respect and admiration for the thinkers mentioned above, there is good reason that the thesis does not just consist in showing how these dichotomies might be consequences of the FoT and in picking out the preferable way of overcoming them. Tracing the pattern of overcoming these dichotomies also enables one to trace the pattern of how they arise and consequently how they are preserved and propagated. As I claimed above: to maintain the paradox, you have to maintain the enunciation in question. Although many of the theorists claim to have at least laid the foundation for overcoming their choice of paradox, they have, in the simple act of conjuring the paradox (and attempting to overcome it), in fact affirmed the format. In the words of Ingold (2012) on the dichotomy between subject and object:

> The obverse of the material object is, of course, the historical subject, and while falling over themselves in their attempts to overcome a subject/object dichotomy that is widely perceived to be discredited, theorists of all persuasions seem only to have reproduced it in the process. (p. 436)

We think we have left the problem behind us, but as the proof rests on the FoT, we have first and foremost affirmed the format. To believe the proof that dislodges the consequences of the FoT, you have to affirm the FoT, and you have thereby set the scene for creating new dichotomies. Proving this to be the case calls, in itself, for a critical discursive treatment of the theories in question. In the end, very few people would be convinced of the need to change allegiance by such a treatment. Chemero (2009, p. 16) poignantly says aloud what most of us think: “Books by philosophers almost always begin by arguing that everyone else is incorrect...nobody believes these arguments.”

Instead, I opted (in article 1) to ask the question: Why are dichotomies so pervasive and resilient despite many efforts to overcome them? I also attempted (in article 2) to employ metaphors in a way that allowed each one to enter the same conversation. More on both of these measures below.

A new approach entirely?

It was not possible to talk of “things” as such; to switch to talking of difference or process; to approach this conventionally because corridors are established; to settle the reflexive problems that arise; or to overcome the dichotomies that are a consequence of the FoT. Unable to enclose a “problem” in a conventional sense, I have moved further and further away from talking about “it” and closer toward enacting “it” and showing “it.” It would be preferable to simply invent an entirely new approach. The masters who were able to do so inspire awe in every philosopher. Heidegger invented entirely new ways of thinking by making language do things it had never done before. Nietzsche crafted tools with which to break down stale conventions out of almost visceral images of thought. Bergson introduced concepts that made it possible to think previously unthinkable thoughts. Wittgenstein, with

his terse prose and aphorisms, tried to make his readers think by doing. All of these were dissatisfied with the state of thinking in their time and considered it an error even to enter the fray. Disagreeing with this or that position and arguing against it would take place on erroneous terms and only serve to propagate the same fundamental errors. The basic assumptions had to be questioned. The solution was (implicitly) to shock the reader into a new reality – or create an entfremdung (alienation) – by their novel language use.[45] I do not flatter myself in their company, but I have followed their example in the case of the FoT.

Entering into an analytic discussion on the FoT is futile. However, this also leaves us with the problem that is probably the most conspicuous in the thesis. How can you avoid using the FoT if it is ubiquitous? How can you be engaged in breaking the hegemony of the FoT and create a novel approach to user interface design if your patterns of thought are heavily mired in the use of the FoT? The answer is of course that I cannot avoid the FoT. As explained in relation to the epoché, the answer is rather to maintain the FoT and, with each enunciation, circumvent the format to bring out what is *also* being said. Things are *how we see*, not *what* we see, so we have to see what is also said when we see things. For example, the concept of enunciation is a way of bringing attention to the labor of division that goes into differentiating a thing. This strategy is subversive. The modern author that I most admire in his employment of such a strategy is Gilles Deleuze, including his collaboration with Felix Guattari, particularly in their masterpiece *A Thousand Plateaus* (2002). Deleuze is positively indifferent to the borders of academic disciplines, fields, and problems that supposedly have a set place in a methodology of theoretical scholarship. He appropriates vocabulary, images, tools, and concepts from mathematics, biology, systems theory, and a host of other sciences without introductory remarks or attempts at explaining their conceptual coherence. Claire Colebrook, in an introduction to Deleuze's thinking, explains that he criticizes conventional thinking and invents new styles of thought:

> [H]e wants to show that thinking takes different forms. Philosophy, science and art are distinct tendencies or powers, so it makes no sense to try to come up with some unified picture of the world – for there are as many worlds as there are ways of thinking or perceiving.... we do not study philosophy or science to get to the truth of literature...nor should we use literature as some form of document, example or evidence to support claims in history, philosophy or psychology. (2002, p. 7)

Instead, disregarding conventional borders is a way of seeing all disciplines as rhizomes of thought patterns. If an image, model, concept, etc., exists in a field or science, then we know that it has been thought about and that it is possible to think that way. What, other than convention, should prevent us from trying out these ways in fields in which they do not "belong?" To invoke an image that is comparatively easier to visualize, we can liken ways

[45] Gross (2010, p. 200) on using Deleuzean concepts in the article, Shock Value on horror movies, contends: "The goal of philosophy, science, and art is not to reduce experiences to mere oppositions but to render experience more complex, opening up new and vital possibilities for us .... [W]e are not working within a closed system of thought but are using tools that open up on the world and lead to innovation and construction."

of thinking with the many ways a body is capable of moving. Think of all the different types of sports in existence. With them come all kinds body types perfected to engage in these sports as well as all kinds of movement.

Figure 3. Body types (Source: Schatz, 2002)

The idea, that it is possible to take a type of bodily movement from one sport and attempt to use it in another (as when football players are exposed to ballet training) may be impractical, but no one would think of saying that it is impossible. In contrast, we can see how using topology as a thinking tool outside the field of mathematics has to be presented as a "metaphor" before it can be accepted in a different field (DeLanda, 2002). When we allow different patterns to defy scholarly borders, we create processes of pollination. We might consider the following example:

> #
> In everyday conceptions, a human being is seen as composed of parts. We can see that a human has arms, legs, a torso, etc., and we can identify each of these parts. It is straightforward to think of a human organized as a unit composed of parts. To open a different way of thinking about the human body, we may be inspired by the study of ontogeny, that is, the origination and development of an organism from fertilization to its mature form. From ontogeny we take the idea that organization is not a combination of parts but the continual

differentiation of a whole. The fertilized egg (the whole) is continually split (no cell is added, but the existing cell is divided) until we reach the mature individual consisting of millions of cells. It is still the same whole, now only split millions of times. DeLanda (2002, p. 24) uses the concept of symmetry-breaking transitions from the field of topology to explain the splitting. The idea is that the process is a continual loss of topological invariance. Greatly simplified, we can think of a sphere that starts out as perfectly symmetrical. A split occurs wherein left and right are "defined," then top and bottom, front and back, etc., each splitting loose parts of the original symmetry.[46] However, the whole system has, in the loss, gained the information of what is up and down, right and left, etc. When the whole system is finished, it is no longer perfectly symmetrical, but the symmetry that is retained is "full of information."[47] Based on this idea, a body is not "composed" of parts. An arm is not a part attached to other parts. An arm is a part that has been differentiated (split) from the whole. Similarly, the upper arm is differentiated from the lower arm, the hand from the lower arm, each finger from the hand. This is why Deleuze and Guattari (2002) write:

> The shock of the hammer and the anvil broke his arms and legs at the elbows and knees, which until that moment he had not possessed. In this way, he received the articulations specific to the new human form that was to spread across the earth, a form dedicated to work .... His arm became folded with a view to work. (p. 41)

One might object that it matters little whether the body is "put together" by parts or "split into" parts – the result is the same. However, there is a great difference in the genesis proposed. In one, information is added. In the other, information is gained by subtraction of possibilities (i.e., restraints, cf. Bateson, 1972, p. 406). The perfectly symmetrical sphere can, in principle, become anything. It only becomes something specific and individual by submitting to a series of choices that, at the same time, make it capable of some things and limit its potential to do other things. These are entirely different worlds. If we apply this thought to how we perceive the world, we can see the contours of the same argument. We often think of perceptual objects as *added* to our perception. What if we were to think of the appearance of perceptual objects as the result of a process of subtraction? The tree outside your window did not

[46] Bateson (1979, p. 177) describes how an unfertilized frog's egg does not contain the necessary information to achieve bilateral symmetry. It has to have information from the outside world in order to decide "which shall be the future median plane of symmetry of the bilaterally symmetrical frog. Epigenesis cannot begin until one meridian is made different from all others." He goes on to explain how the information is provided by the entry point of the spermatozoon.

[47] Arnheim (1993, p. 17) uses this precise idea in relation to design: "[A] topological shape stands for a whole range of possibilities without being tangibly committed to any one of them. Being undefined in its specifics, it admits distortions and deviations. Its pregnancy is what the designer requires in the search for a final shape."

> "appear" in your view. Something was *detracted* for the tree to become the tree.
> #

The transposition of thought patterns from different disciplines is a general appeal and argument for the abandonment of the separation of domains when it comes to innovations of thinking. Great theorists such as Tim Ingold, Andy Clark, and Bruno Latour are examples of thinkers who are able to draw on many different domains, albeit in a less dramatic way than Deleuze. Again, a conventional approach would seek to isolate a particular problem as the focus and develop arguments, raise support, and counter objections in the existing literature. This is not a viable approach for all of the above-stated reasons and would only serve to confirm the format of things. A methodology is not separate from an inquiry, and it is certainly not innocent, neutral, or something to be dispensed with prior to the "real discussion." It is not possible to speak *about* a methodology only to showcase it. Importing images, concepts, and arguments from other fields is an important part of the thesis. However, the thesis does not dwell on their exploratory possibilities. There is no attempt at a "theory-of-everything," but there is an internal consistency at work in each article and across them. The focus that binds the thesis together is an unveiling of the FoT and showing that there is great potential in abandoning this format in favor of a search for different geneses (it is tempting to use words like "building blocks" and "units of analysis," but all words I can think of are pre-formatted in the FoT). In order to not simply be a "negative theology" of what is *not* possible, the remainder of the methodology section clarifies the approach that has been taken in the three articles to provide a positive way of recognizing the FoT, dismantling the FoT, and displacing the FoT.

The approach of the thesis

The format of things is an extremely efficient and successful generative and explanatory principle (a genesis), the use of which to a large extent dictates the boundaries of our current understandings and aspirations. To paraphrase Wittgenstein (2005), the limits of the FoT are the limits of our world. If we want to develop our grasp of the world beyond this format, we will have to understand the limits and mechanisms of this principle in much greater detail. Such an undertaking cannot be carried out by examining things or by examining an abstract concept of the format of things or the reflexive problems generated by things. It cannot be clarified "in advance" in a separate "methodology" section. Thus, as Sandwell et al. (1975) ask, is the suggestion that we find a non-method?

> In fact we feel nervous in even raising the question of whether a non-methodic reflection on method is possible or whether it is a contradiction in terms. Even so: how far would that contradiction take our thought? For today, in our age of suspicion, the most urgent sociological task is to Unthink Method. (p. 5)

The suggestion is not that we dispense with methodology or attempt an approach that somehow escapes reflexive problems. The brief discussions of the epoché and the simulacra exemplify the idea of showing that methodology resides in every*thing*. *Things are how we*

(usually) see, to repeat this point yet again. The strategy is to treat every theory and every phenomenon as enunciative. A computer scientist would probably say that methodology resides in the data structure. A thing is, like Wittgenstein's subject, a limit and an enabling constraint. Things embody a genesis, and as such, they are themselves articulate in their method. The approach is therefore to treat all text as empirical material and all theories as enunciative. Very importantly, however, the approach is also to treat all other phenomena – perceptions, practices, sketches, daydreams, metaphors, and drafts – as equally enunciative, not as enunciative *of* something, but in themselves expressing and articulating *how* they are – like Fontana's cut. Ordering all of the different enunciations side by side is a way of straining and overloading the FoT to show itself rather than hiding in plain sight.

The task of looking for enunciations challenges the reader. Although the discussion here has made use of a conventional corridor, it has (hopefully) also succeeded in showing that the corridor is not privileged but needs to be side-ordered with all other phenomena. The corridor is not privileged in the sense of being a reflexive place wherein we can assume transparency and intimacy between a sender (writer) and a receiver (reader). It is not a place wherein we establish the unit of analysis, encapsulate the problem, and agree upon the field of science. It is not a representational passepartout capable of referring to everything. The thesis is opposed to the basic figure of traditional critical theoretical thinking, that is, the representational relationship between the many texts and the *one* truth or reality. This figure embodies the acceptance of the *ex nihilo nihil fit* principle. It purports to provide a neutral "view from nowhere" from whence a problem can be presented and in which we exchange argumentative blows. It upholds what Deleuze and Guattari (2002, p. 374) call the "image of thought" that tells us *what* it is to think and what is *legitimate to think*. The image of thought is the self-image of a scholar in a study withdrawn from the world. It is also the methodological space that absorbs all enunciations as "positions" or "arguments" that can be ruled in or out of a domain but that can always be *placed* relative to other positions. The figure and corridor are rejected, not because they are wrong or useless (on the contrary they are very productive), but because they are helpless in the attempt to examine themselves (or what they do in themselves) and because they mistake ever finer and "more nuanced filters through which to pass phenomena" (Henare et al., 2007, p. 7) for greater understanding while leaving fundamental methodological issues unresolved.

Abandoning the corridor also means giving up simplistic ideas of communication that are alive and well in the corridor. There is no information that has been transported from my field of view to yours. Rather, you (what is traditionally thought of as a subject) and the text (what is traditionally thought of as an object) have taken part in, and continue to be part of, an enunciation, a Thing. One could say that it is a way of making "the reader co-responsible for listening to and hearing the tradition so that in his reading (as hopefully, in our writing) he can accomplish a principled violence – a retrieval – upon the source works of that tradition" (Sandwell et al., 1975, p. 4). However, it is not just an effort to re-establish a symmetry between writer and reader. It is a different style of thought whereby *authority* is not placed anywhere in particular. The writer is not particularly authoritative on what has been written. The text is not singularly authoritative relative to the reader in "what is being

said." No example, thing, or piece of text is more or less authoritative on what is being enunciated.

Thinking in this way does not mean that we abandon notions of "right" and "wrong." Such questions are merely sidelined. The proposition is to look for second-order isomorphisms or patterns in the sources and voices brought together. What is sought is whether or not they are in conversation with each other. In a sense, all sources are treated as if *everybody is right in their own way*. We have "given reason" to use a notion from Donald Schön[48] for every single enunciation. Giving reason means that we assume that everybody can make their own viewpoint coherent. Because of that, it is possible to receive all kinds of different views/theories/positions, not on the basis of what they say but *what has to be the case* in order to say it. The question is not whether the source is wrong, right, or different from this or that theoretical position. The question is *how* has this become right (or wrong)? Speaking of the analogous anthropological problem of not interpreting other cultures on the researcher's own terms, Henare et al. (2007, p. 15) state that "[i]t has to do with how *we* must think in order to conceive a world the way they do" (emphasis in original). To read a text with the supposition that *it is* meaningful makes the reading an unsolved problem until it *does* make sense – very likely with the consequence that *I* will have had to make changes in my presuppositions. Thus, the question of how a text is right is answered by the reproduction of the text as right (making it consistent) and observing what you have done differently (from what you would have otherwise done) to make it right.

The difference in approach is quite literally *in* the thing. In a critical-discursive theoretical space, theories and arguments have positions because they are extended (Descartes' *res extensa*). Things occupy positions relative to a Cartesian coordinate system. Their place is defined from their distance from the origo (the view from nowhere). The origo is of course at all times your present position. You are trying to make your position as coherent as possible. Other views are more or less correct depending on their proximity to your view. In the alternative TA sketched out here, things are not copies of each other, so there is no space extended; rather, each thing is to be considered *a space unto itself*. The "likeness" of each thing with another is reached not by comparison but by deformation: "What do I have to do differently to reach (or see) this thing?" Just as a topological shape can shift from a donut to a cup without cutting or gluing; two things (ideas) can be said to be homeomorphic when they can be changed into one another by deformation. What you have done (the act or process) to make one shape or another can be separately articulated (such as in this sentence), but up until such a point of articulation, it would not be different from seeing the thing. This type of sensitivity is a form of "skilled vision," whether it is about learning to tell cows apart (Grasseni, 2007), midwives learning to tell the normal from the abnormal in CT scans (Sandell, 2010), or seeing atoms with the aid of a microscope (Ian Hacking

[48] This is described in the first article. Part of Schön's research team analyses video material and judges one boy as not being particularly bright. Later, it is discovered that his actions were triggered by an error in communication from another boy. Suddenly, the boy's effort are retrospectively transformed from stupid to rather ingenious. The researchers coined the term to "give someone reason" to indicate the assumption of intelligibility while interpreting their behavior (1983, p. 67).

referenced by Barad, 2007, p. 51). However, it is also about realizing that seeing is a form of doing, and the idea of "things are how we (currently) see" entails that it is possible to see a world without things (or rather, a world wherein things play a different role, although they can always be enunciated). Things play a dominant role because they are the format of our thoughts and ideas (of writing and speaking). They dominate because we have conferred upon part of them (i.e., words) the role of referring or representing all other things. Last but not least, they rule because we are constantly occupied with sorting out what things there are and their different relationships rather than engaging in looking at "the format of the thing."

The three articles presented below develop answers that deny that things can represent other things, that deny that meaning can be transported, that deny that an interface is a relationship between two different things, and that deny that words and things are fundamentally different things. These claims are not pursued as separate problems; they are presented as consequences of becoming aware of the FoT. First and foremost, the articles find ways of affirming that there are ways of challenging the format. Second, in different ways, they demonstrate that all phenomena accomplish their own genesis or meaning-making (without the intermediate translation of symbols or language). Third, they make good on the promise that there are resources available for inspiring novel interfaces that do not require the FoT. The three articles can be read separately. They each state a question, present an answer, and employ a particular methodology in order to answer.

The three articles in overview

Taken together, the three constitute a progression through and a solution to the problem of breaking the hegemony of the FoT. All three present challenges to the confident implicit application of the FoT with which theoretical problems are parsed. It is this confidence that, for many in the HCI field, makes the leap into solving, for instance, the human-computer interaction problem straightforward. It harbors an inconspicuous certainty of the idea that things and ideas are captured as things – so much so, that introducing the notion that perhaps the problem of the interface is not properly formatted will, for a hardcore proponent of the FoT, at most elicit a curious affirmation of the format in the form of counter questions such as: "what is it then?" or "how else would you describe it?" Jumping the chasm from the FoT to the possibility of different formats requires the realization that the FoT is at work. It requires an understanding of what it does so that it can be recognized. Finally, it requires viable examples that there are alternative formats and modalities available. In a sense, challenging the confidence in the FoT is a move from "belief mode" to "design mode" in Bereiter and Scardamalia's (2003, 2006)[49] terms. The critical discursive theoretical space (what I have called the corridor) needs, aside from positions, arguments and interpretations to be supplemented by a direct awareness of the craftsmanship involved in producing ideas *as they take place* rather than as an afterthought or a methodological side note.

[49] "When in belief mode, we are concerned with what we and other people believe or ought to believe. Our response to ideas in this mode is to agree or disagree, to present arguments and evidence for or against, to express and try to resolve doubts. When in design mode, we are concerned with the usefulness, adequacy, improvability, and developmental potential of ideas" (Bereiter & Scardamalia, 2003, p. 2).

I. The format of things – how are dichotomies possible, and why are they so pervasive and resilient despite many efforts to overcome them?

The first article brings attention to the FoT. It does so with the knowledge that realizing that one's thoughts are given in a certain format is a reflexive problem. Attention to the format is created by way of dichotomies. The article asks the question: How are dichotomies possible, and why are they so pervasive and resilient despite many efforts to overcome them? The dichotomies in question are well known, such as subject/object, representation/reality, and theory/praxis. The question is purposely directed at asking *how* the dichotomies are possible rather than engaging in efforts to "solve" any of the dichotomies. As such, the article follows the stance taken in the section "overcoming dichotomies" above of not engaging in overcoming any dichotomy. Rather, a meta-question is posed, one that seeks to bring attention to the genesis of dichotomies. If we can see how dichotomies are created, then we might catch our first glimpse of the format of the thought that produces it.

At the outset, the position is taken that there are different cognitive modalities available for humans to make sense of the world, for example, linguistic, mathematical, visual, and mechanical. This is to suggest early on that there may be other ways of making sense of the world. It also serves to place the preceding analysis within the linguistic modality. Next, an analysis of dichotomies is offered that provides an economical "solution" to the problem of dichotomies. The two sides of a dichotomy are shown to be two different ways of capturing a phenomenon, which are then juxtaposed in an infelicitous manner. The analysis of the format allows us to revise the everyday conception of what a thing is. The novel idea is that "things are not *what* we see but *how* we see." Once this pragmatically and enactively inspired link to things is established, the two different ways of capturing a phenomenon are exposed as an effect of the recursive application of the format of things within a linguistic modality. Part of the analysis is also undertaken to explain why the dichotomies persist. The proposition is that the requirement for establishing dichotomies is the acceptance of the format that creates the problem. Once the format is instated, there may be valiant attempts at overcoming it, but inevitably, the format wins the war. For instance, accepting a dichotomy as the starting point of your inquiry may allow you to come up with a good solution to why the dichotomy should be overcome, but in the process, the format has been affirmed. The reason for this is that you have to affirm the format to have a dichotomy to overcome. The acceptance of the dichotomy as a starting point is thus a Trojan horse that propagates the format. The final part of the article is dedicated to opening up a line of theoretical inquiry that is sensitive to the idea that there are other modalities and formats available. To avoid the dismissal of the argument as simply theoretical, the dichotomy between theory and praxis is analyzed. An example is then provided of ways of considering practice that are not based on linguistic terms. Through the analysis, the very clear implications of the format of things are brought out, partly in terms of how we reason about different ways of making sense of the world and partly in relation to how we manage relationships between different modalities.

The article, to some extent, utilizes the strategy of attempting to strain and overload the FoT to reveal itself. The reflexive problems that follow from dichotomies are allowed to unfold without entering into a specific discussion of either. There are no "solutions" presented of any dichotomies. None of the dichotomies brought up are "revealed" or reduced to being the same phenomenon, shown to be inextricably intertwined, or to being two sides of the same coin, etc. This requires an exercise of dual consciousness mentioned above whereby the problem is maintained as problematic, and at the same time, the effects of maintaining the problem are followed.

II. What is an interface? Introducing metaphors as an analytical tool. Why is the question of an interface set up as a representational problem, and what is an interface?

The three articles can be read separately. When read together, it is possible to see that the second article picks up where the first one ends. It retains a meta-perspective with the question it poses: Why is the question of an interface set up as a representational problem, and what is an interface? Unlike the first article, it does, in fact, engage directly with a dichotomy that is very much alive and well: the contra-positioning of human and computer interposed by an interface in the field of human-computer interaction (HCI), but still not from a perspective that considers the problem pedestrian. The article is directed at the HCI community (designers and theorists) and challenges the hegemony of the FoT in the form of a typical model of human-computer interaction implied by the title of the field. The problem is how to investigate the properties of the FoT without making the format itself the conceptual focus of inquiry. A traditional critical discursive investigation would seek to flesh out a separate concept of which a scientific community would demand strict definitions, proof-positive of its applicability, and thorough tracings in the existing literature. Alternatively, the discussion could attempt a methodological turn toward "what we do" and become engulfed in reflexive problems. As discussed earlier, this poses a reflexive problem. Because we seemingly cannot examine the tools (with which we examine the world) using the tools themselves, we have to find a different means through which we can "see what we do." The intention has been to show "what it is that one does when one does it," to be able to see it directly qua the things (and Things) one is engaged in. The meta-perspective is thus retained to keep the discussion rooted in the phenomena wherein the FoT makes an impact while, at the same time, allowing a questioning of the question that is posed.

The article proposes a theory of interfaces. It does so while taking the reflexive and methodological problem mentioned earlier into consideration. Because of the reflexive problems posed in entering into a discussion of an interface, and because any dichotomy has been shown in article 1 to harbor the FoT, I opted, as stated in the preface, not to press forward with analyses of computer interfaces, *per se*, but rather to concentrate on theoretical and philosophical assumptions dominating the field in the form of interaction considered as a human vis-à-vis a computer. The article therefore introduces the use of metaphors as an analytic method. Instead of attempting a direct exposition of a method, I present a series of

metaphors that together elucidate a model. The model as a whole produces phenomena and at the same time attempts to provide explanations of said phenomena that are not separate from the phenomena. As such, they demonstrate the idea of things as *sui generis* meaning. They come with their own genesis. The use of metaphors takes Lakoff and Johnson's (2009) assertion seriously that metaphors are "conceptual in nature" (p. 159) and that "a given metaphor may be the *only* way to highlight and coherently organize exactly [certain] aspects of our experience" (p. 156, my emphasis). However, these metaphors are not taken as "something for something else." They are employed in an *ostensive* or *expressive* way where the emphasis is on what the metaphor itself exemplifies or expresses (Goodman, 1978), not what it says about something else.

The model proposed is built by repeating the same pattern. First, a question is introduced that guides the development in that particular step. Second, a metaphor is introduced that functions as an explanation. Third, through the explication and discussion of the image, a principle is reached, which leads to further questions, and so on. Six metaphors are presented. Together, they answer the question of why interfaces are thought of as representational problems, what an interface is, and how it comes to be (its genesis).

The article details what was only hinted at in article 1, that the two phenomena in the dichotomy of the HCI model – human and computer – are two different ways of capturing the same phenomenon. It is claimed that phenomena cannot represent each other. For phenomena, e.g., words and things, to be related, they have to be *transforms* of each other. The "mechanics" of how they are brought forth and linked are closely demonstrated. As a consequence, the article is able to explain what an interface is and how it has become quagmired in a dichotomy. Among the more notable implications of the theory, it is claimed that phenomena cannot represent each other, yet a (non-representational) transformational connection between words and things is put forth. It is also refuted that meaning can be transported. Traditional models of communication make use of the FoT. The purpose and effect of communication are to interfere (create changes), not to create things (words, ideas, pieces of information). The article is the most direct of the three in its approach to treat all things – perceptions, practices, sketches, daydreams, metaphors, and drafts – as equally enunciative. Metaphors are not considered denotative of something else; they are expressive in their own right. The hold that the primary metaphor of human-computer interaction has on the field of the same name is thus broken through the use of metaphors.

III. Analogue computer interfaces. Introducing constraints as the foundation of the design of interfaces. Where should we find inspiration to redesign the computer as a new medium?

Whereas the first article is designed to stir misgivings on the matter of a format that is hidden in plain sight, and the second article is devoted to examining the genesis and ontogeny of an interface, the third article attempts to provide the impetus and direction of a fruitful new path of exploration for the design of new computer interfaces. If the existing format creates unseen barriers for developing novel ideas, then how can we possibly think

truly novel thoughts, and what format should we look for in redesigning the computer as a new medium? This article, like the others, starts out by problematizing the assumptions at work in our thought patterns. It directly states something that was present, but premature to discuss, in the other articles. It is the idea that our current way of making sense of what goes on with a computer – that is, our interfaces – is linguistic or hybrid-linguistic. This means that the assumptions on which interfaces are built cater to an understanding of the world that can be verbalized or written down as information. What is proposed runs parallel with Ong's (2002) famous claim that writing restructures consciousness. He states that "[p]ersons who have interiorized writing not only write but also speak literately, which is to say that they organize, to varying degrees, even their oral expression in thought patterns and verbal patterns that they would not know unless they could write" (p. 55). In relation to the FoT, the order is turned upside down from how we ordinarily think of expressions. We would usually say something to the effect that we find a format with which to express an idea. What is said here is that the format strongly predisposes us to ideas that fit the format. Because we think in a certain format – that is, definitional descriptions, logical syllogisms, and analytical categories – we organize our ideas and the world according to the format. Things are how we see the world and ourselves. The trouble is that descriptions are ill-suited for the task when it comes to fundamentally re-imagining and creating novel representational forms.

In order to develop new representational forms, the article suggests that there are alternative cognitive styles and formats available, for example, a mechanical understanding of the workings of a machine that renders any description auxiliary. Naturally, an article that champions a fundamental change of format should not rely on description. Rather, non-linguistic examples of meaning-making in the form of analogue computers are considered as a possible way of developing user interfaces. The article introduces vocabulary and a series of theoretical considerations of relevance on how to approach this problem. It first explains why the claims in the article should not be confused with technological or media determinism and proposes constraints as a viable course for explaining and re-imagining the possibilities of the computer as a new medium. The article then proceeds with a discussion of what type of medium the computer is and whether it is possible to speak of digital materiality. After these preparatory remarks, examples of analog computers are introduced. These are considered a type of scaffolding that offloads computational tasks into the environment or embeds them into technology. The analysis of these examples shows how constraints can act as explanatory principles of the genesis of interfaces. The analysis thereby becomes a way of showing how and why the computer is to be regarded as a new medium. Finally, an outline of requirements for redesigning the computer as a new medium is drawn up. A new computer interface should on the one hand render novel cognitive styles possible. On the other hand, it should match and possibly surpass the advantages of writing and the ubiquitous desktop metaphor.

Together, the three articles bring attention to a problem, elucidate it, and present an alternative. The thread connecting the articles has been traced out in this corridor. It is the idea that it is possible to infer *how* we see from *what* we see and, in fact, that the two are

transformations of each other when considered separately. It becomes obvious from the treatment that we see things everywhere, and in fact, things are how we see. Things are what we do (we thing (verb) with an allusion to Heidegger). Because we look *with* things in the world, in our minds, or in the abstract,[50] we propagate the belief that we can (and we do) capture a phenomenon and hold it encased in some form. It makes us believe that the format of things is the format of the world by default. All three articles actively oppose the FoT – each in its own way. To dispense with the expectation of things, it is first necessary to make the problem apparent. Second, it is necessary to see the format 'in its natural habitat' – at work in different problem complexes – instead of treated as a separate conceptual analysis. The use of metaphors is a way of demonstrating that all phenomena are enunciative and strain the expressive capabilities of the FoT. Once we are able to recognize the FoT in its making, we can suggest novel approaches that no longer look to establish things but put things back in their place as one way, among many, to render the world meaningful and engaging. As such, the three articles accomplish the objective of breaking the hegemony of the FoT, making other approaches available.

[50] Processes, patterns, and actions are also "things" when they are demarcated and held out to be encapsulated phenomena or concepts.

State of the problem

The methodology section and "state of the problem" are closely linked. The various reasons for the overall approach given above, as well as the methodological and theoretical choices made in the articles, have been stated. Given these reasons, an ongoing difficulty has been what literature to review or what art to give a 'state-of-art' of. The choice of venue and conversational partners for a thesis depends, of course, on the problem being solved. To reiterate, the thesis is clearly delimited by the problem of how to break the hegemony of the FoT. It is fueled by a desire to create novel interfaces. The problem thus falls within HCI. However, straightforward questions such as "what is an interface?" were explicitly rejected as the basis of the thesis because they assume that the task of answering them is equally straightforward. The thesis has precisely raised the objection that an interface is not a "what" (a thing). It attempts to raise the methodological issue of becoming reflexively aware of assumptions (the FoT) at work in our current ways of conceptualizing and imagining interfaces. This problem is not recognized or even stated in the HCI community. There can be no literature review because there is no literature on the subject of the format of things. An alternative strategy would be to "prove" the problem exists in the field as such. I have, after all, claimed that the FoT afflicts thinking in the entire community. However, this claim cannot, as argued, be substantiated by showing that all articles in the field are indeed connected with the FoT. Rather, the "proof" presented consists in a principled argument that counteracts assumptions in the field, such as the acceptance of the *ex nihilo nihil fit* doctrine, and makes it possible to identify the FoT in standard practices such as referring to "users," "system," "interface," "document," etc.

To shed light on the problem, the thesis reaches into the domains of philosophy, cognitive science, and other disciplines for patterns and figures of thought. A natural suggestion would then be to take, for instance, the philosophical problem of difference, or becoming, or the mind-body problem, as discussed in cognitive science, as the point of departure for a review. The issue with this approach would be that these discussions are in themselves fully mature in their respective fields and, *in toto*, not particularly pertinent to the problem at hand. Engaging in a review of any of these would mislead the reader into thinking that the thesis is a contribution to a particular discussion in question within philosophy or cognitive sciences. Each of the larger discussions touched upon in the thesis, that is, the discussion on the nature of difference (how do we cut the world), the representational problem, the genesis and concept of things, and so on, are interesting only because they tell us something about how they are generated and, therefore, how similar problems are generated in the field of HCI. For these reasons, a different type of literature review is offered.

The approach to the literature revolves around not what is said explicitly about the problem of the format (because this literature does not exist) but what is said about the problem *qua* what the literature *does* and *does not* say. Along the lines of Fontana's cut, the cuts[51] found in the various resources are taken to mirror the conceptual decisions made in their making.

[51] By "cuts" I mean the focal points, the units of analysis, the concepts employed, etc.

This *modus operandi* is employed throughout the thesis. It is characterized by the idea that it is possible to draw upon resources cross-disciplinarily and cross-medial. “If it has been thought in domain X, then it can be thought elsewhere.” This means that actual interface designs are as much in dialogue with literature as vice versa. It also means that the HCI literature is in dialogue with philosophy, cognitive sciences, anthropology, design, etc., because comparable choices and assumptions have been made, not because they speak of the same issues. This approach provides not a state-of-the-art but a “state of the problem.” It consists of:

- Examples from the HCI literature of how interfaces are perceived and actualized
- Key theoretical resources and insights of importance for the thesis’ approach, which are taken from philosophy, cognitive science, Gibsonian ecological psychology, Bateson’s ecology of mind, and pragmatism
- Design examples as they are envisioned or realized from available resources such as YouTube and Vimeo.

In the following video examples are indicated by numbers in bracket. These are listed separately in the literature section.

Examples from the HCI literature

Designating human-computer interaction (HCI) as a field or community is misleading. The association for computing machinery (ACM) lists 37 special interest groups (SIGs) whose interests range from artificial intelligence over hardware design to interaction and interface design. There are multiple disciplines that vie for a place at the table (see Figure 4 below) and many subfields that consider themselves part of HCI or have overlapping interests (e.g., Computer Supported Collaborative Work (CSCW), Computer Supported Collaborative Learning (CSCL)). At best, HCI can be considered a fragmented discipline (Diaper & Sanger, 2006; Hinze-Hoare, 2007; for an overview of HCI, see Dix, Finlay, Abowd, and Beale, 2004 Schneiderman, Plaisant, Cohen, and Jacobs, 2014; for a history of HCI, see Carroll, 2015; Grudin, 2012; Myers, 1998). Similarly, there is no such thing as an HCI researcher or designer. The below map gives an indication of the many disciplines that have a stake in this “community of communities,” as Carroll (2015, para. 9) puts it.

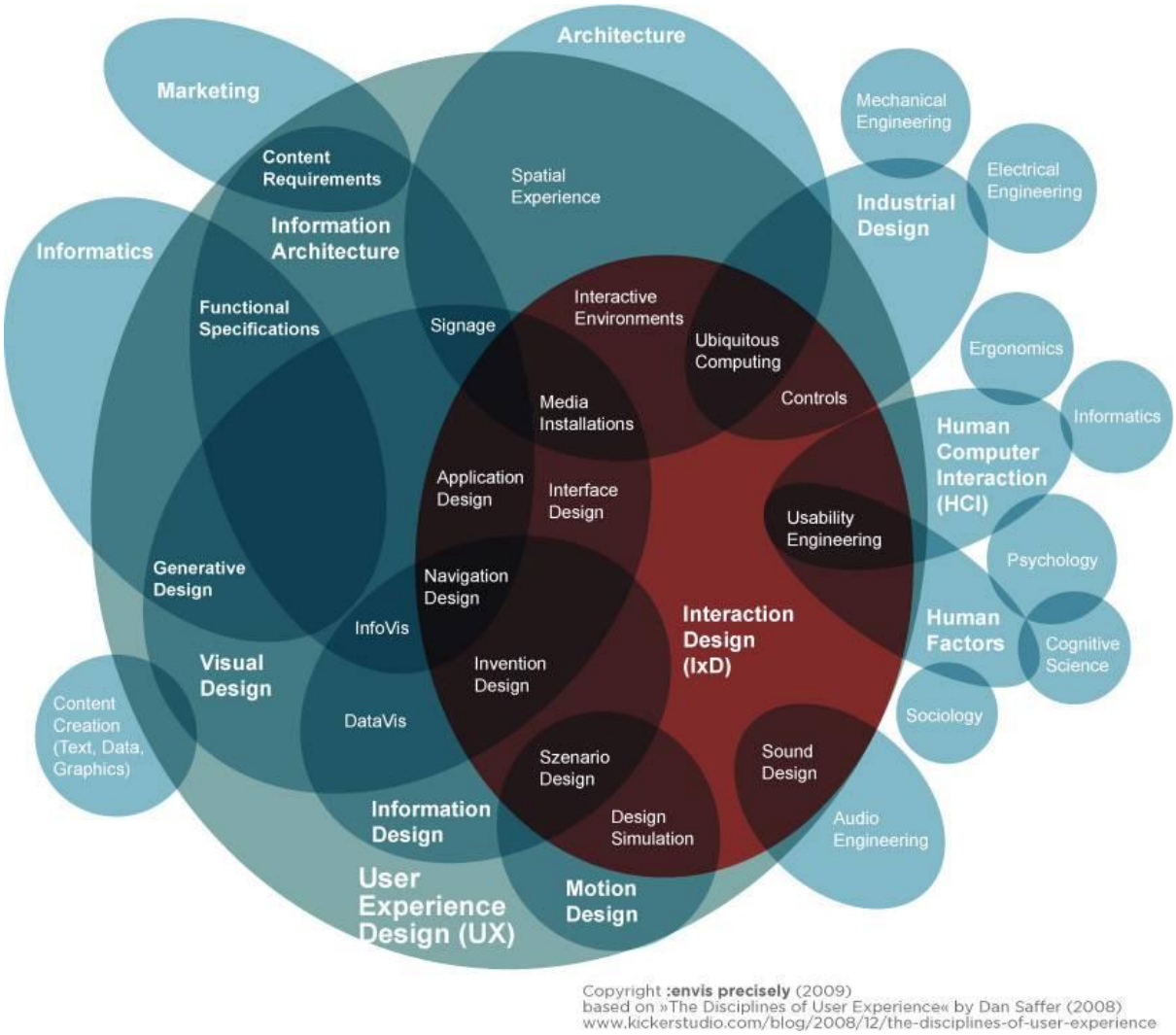

Figure 4. Map of disciplines invested in interaction design (Source: Envis Precisely)[52]

One would think that the most obvious place to look for thoughts with affinities to the problem of the thesis would be in interface design even though many adjoining disciplines are potentially affected by what is proposed in the thesis. However, anyone with cursory insights into the field will quickly agree that such a search is riddled with problems. First, there is no established or generally accepted definition or model of what an interface is. Second, the articles discussing the concept of interface are few and far between (e.g., Bannon & Bødker, 1991; Grudin, 1990, 1993; Janlert & Stolterman, 2015), and these often exhibit a compilation of uses of the term hitherto rather than a conceptual discussion of what an interface is (notable exceptions include Drucker, 2011b; Kerne, 2002). Third, the field sits uneasily between theoretical aspirations and design recommendations, a fact recognized throughout the community. Books and research articles on HCI are often written for designers, engineers, programmers (e.g., Butow, 2007; Galitz, 2007; Sandom & Harvey, 2004; Tidwell, 2011), or engineers (e.g., Lauesen, 2005). As such, they quickly pass over theoretical questions to reach the more directly applicable insights (how to design/optimize/break down/develop an interface; or they present a sourcebook on existing solutions or recommendations, e.g., Nielsen, 1993). Beneath these issues lies the

[52] http://www.envis-precisely.com/blog/tag/information/

observation that interfaces are ubiquitous and that we might not have a formal definition; however, for all intents and purposes, we have a working understanding of what an interface is. In the machinic origin of computers and interfaces built by engineers and programmers, Agre (1997, p. 13) sees a single work ethic: it has to work. In their everyday work, user interface (UI) designers and user experience (UX) designers do not need to grapple with the foundational problem of "what an interface is." The result of ignoring this and other basic questions is that most articles present a bastardization of many different ideas, models, and types of theory that are mixed and matched to explain or simply confirm existing assumptions about what an interface is. Consequently, any hope of a stringent analysis across different definitions at work is buried in the complexity of figuring out relations between the different ideas applied. In the following section, ideas are therefore mainly identified and compared from different sources. There is no attempt at deciding on their "proper" relationships or veridicality.

According to Galitz (2007, p. 4), "Human-computer interaction is the study, planning, and design of how people and computers work together so that a person's needs are satisfied in the most effective way," and "user interface design" is a subset of HCI. We should take note that the two categories of entities – people and computers – are taken as fundamental for the entire HCI community. This is clearly evidenced in the use of the terms "human" and "computer" as part of the overarching label "HCI." We are therefore, from the outset, as discussed in articles one and two, deeply embedded in the format of things. The third part of the acronym, the "I," designates what supposedly ties the two together, the interaction, which is usually equated with the interface.

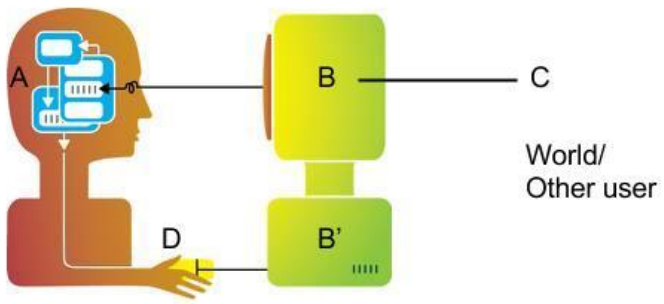

Figure 5. Typical model of a human-computer interface (source: http://mkhares.kau.edu.sa/Pages-cpis354-e.aspx reworked)

As discussed in article two, there are many different variations on how to interpret this relationship. To quote in full from the article:

> In this model, we could read the distinction between subject and object (A vs. B), the mind body divide (A vs. D), the pairing or entanglement of man (A) with technology (B/D); the computer is also often referred to as a communicative medium – where the user is either communicating with the computer through the interface and vice versa (B' behind B) or communicating through the computer with another user somewhere else (C via B); then there are numerous versions of representation vs. represented; the

mind (cognition, A) representing the world (B or C) – either the mind in relation to a computer (B) or directly in relation to the world (C); the computer as a (external) medium (B) representing the world (C) – where the computer (B) is understood as a representational medium on par with language (text and speech), and the world (C) is what is referred to – or the computer (B) represents externalizations of thoughts or cognitive content (A); or even the special case where (B) is understood as the interface representing the computer (B') – the outward appearance of what is going on inside.

There are bound to be variations that are not included here (for an overview of models in HCI, see Carroll, 2003). The first point to note is that all of the above configurations entail a distinction between at least two entities, sides, or regions. This follows the dictionary definition of an interface as a common boundary between two regions. All the implicit or explicit definitions encountered differ in their choice of entities and types of relations, except for the words "between" or "through," which are used consistently. The entities identified on one side are variously "human," "user," "system," "schema," "model," "representation," and similar. On the other side, they are "computer," "machine," "environment," "world," and the like. As in the case of the acronym HCI, the three-fold assumption of relata vis-à-vis (human and computer) and a relation (interface or interaction) remains unquestioned. This can also be witnessed in resources that recount the history of HCI and the graphical user interface (GUI) (Carroll, 2015; Grudin, 1990, 2005, 2012; Myers, 1998; Reimer, 2005). These often trace a progression from a command-line interface to GUIs, detail the desktop metaphor, and then look ahead towards a yet to come post-GUI era. Occasionally, analogue computers or other early antecedents are brought up (e.g., Ullmer & Ishii, 2001, p. 579 use the abacus as an example). What ought to draw attention is that HCI theorists do not skip a beat in connecting the dots between these different interfaces (for a very thorough treatment, see Merkle, 2001), despite the fact that the processes by which meaning is created are wildly different. Analogue computers, such as the abacus or the slide rule (article 3) rely on manipulation and perception of materially scaffolded invariant relations. The command-line interface is linguistic; the GUI is metaphorical and visuo-tactile; and post-GUI interfaces have no other commonalities than the ambition to think outside the (GUI-)box. The primary reason that no eyebrows are lifted is that in all scenarios, the figure of the human vis-à-vis the computer (or some variant of the two) is easily recognized. The interface definitions that can be found all focus on answering the following three questions: What is it; where is it; and what does it do (what can you do with it)? The "how" of the interface is taken to follow from the answers to the first three questions and is not taken as a fundamental question of the genesis of phenomena in or by the interface. In what follows, five different ideas, each with an impact on conceptions of what an interface is, are laid out and exemplified. They are artificial constructions and not "pure." Rather, as mentioned, each of the authors quoted mixes and matches ideas taken from the different answers as they see fit. The ideas are: the computer/interface as artifact, machine, tool, medium, and system. The order in which they are presented should not be considered integral to the idea of an interface. The ideas have simply been aligned with an observation made by Grudin (1990, p. 261) that "[w]e can plot the trajectory of work in human-computer interaction: the location of the 'user interface' has been pushed farther and

farther out from the computer itself, deeper into the user and the work environment" (see also Grudin, 1993). We therefore start with the thing, or object, that for most people stands at the center of the information age, the computer. From the computer, we move "toward" the user and "interaction."

The computer is an artifact

The first idea of a computer that comes to mind for most people is one seen from a bird's eye view. Here, "the computer" is considered a whole, without any real thought on its proper demarcation. Surely, it is different from the printer, but is the mouse, keyboard, or screen part of the assemblage? What about the internet or the electrical grid? Are they part of the computer? What about modern smart-phones, tablets, smart-TVs – are they computers? The computer has been black-boxed or "punctualized," as it has been called in actor-network theory (Law, 1992). "The computer" – whatever it is – has been gathered in a single point that glosses over any of the above considerations. With such a general concept, it is no wonder that so many disciplines partake in the HCI community. The computer is a boundary object (Star, 2010; Star & Griesemer, 1989), if there ever was one. Given the recent proliferation of devices equipped with considerable computational power, it would perhaps be more fitting to, for instance, adopt a term such as "digital artifacts" (Murray, 2012; Raptis, Kjeldskov, Skov, & Paay, 2014), however, to maintain the focus on "interface," the term "computer" is used here, given its long-standing association with interface.

Considering the computer as a whole goes hand in hand with assuming that this whole can be parsed into parts. Often, computers are divided into hardware parts (motherboard, graphics card, mouse, etc.), different functions (memory, CPU, etc.), or levels (bits, operating systems, compilers, software, etc.). Once parts have been identified, interfaces are given as the *surfaces of contact* between these parts or their *edges*. Mingers (2006, p. 67) describes edges as "the first and most primitive form of boundary" by which he means "simply the limit of the extent of some entity or substance" (p. 67). The interface is literally taken as the boundary where parts *face* each other. Harrison, Tatar, and Sengers (2007) call this the first paradigm of HCI or "Human Factors."

> When applied to HCI, human factors conceptualizes interaction as a *form of man-machine coupling*. The goal of work in this paradigm, then, is to optimize the fit between humans and machines. (p. 3)

> According to Brenda Laurel the interface is "the place where contact between two entities occurs." (Laurel, 1990, p. xii)

> "In engineering environments, a computer's architecture included many internal 'interfaces.' Since the interface to the users was one of many interfaces that had to be discussed, labelling it 'the user interface' was an obvious and noncontroversial choice." (Grudin, 1993, p. 112).

This is consistent with a more colloquial use of "interface" where, for instance, a problem can lie at the interface between two fields of research, or the political system interfaces with the economic system at certain points. Janlert and Stolterman (2015) see the "surface of contact" idea hailing from the tradition of industrial machine-making (see also Harrison et al., 2007). They reason that in the beginning of design interest in computers, it was the "fitting" of user interfaces to users who drew attention "similar to how a piece of software should be made to fit the shape of *its* "users" (p. 511). From this idea follows that "the user" is considered the "other half" of the two sides of that interface. For this reason, user interfaces are seen from the perspective of the user:

> The *user interface* is the part of a computer and its software that people can see, hear, touch, talk to, or otherwise understand or direct. (Galitz, 2007, p.4, emphasis in original)

> The interface includes such things as the keyboard, mouse or joystick, the display screen – menus and windows – that is seen, heard, touched or pointed to. (Macredie & Coughlan, 2004, p. 236)

It is noteworthy that both quotes specify the interface across a hardware/software boundary with elements that do not necessarily belong to the same partitioning (e.g., keyboard and mouse are mentioned together with menus and windows). When we think of the computer *in toto* in this fashion, the interface is not yet considered a thing separate from the whole. It is still part of the whole. As Shedroff and Noessel (2012) explain in their account of science fiction movies that inspire interaction design, at the beginning of the movies, there are no interfaces depicted because there existed very few interfaces in "real" life. When you live in a mechanical world, there is no separation between process and result. Pushing a lever *is* working with the object. Thinking of interfaces as surfaces of contact is consistent with a design thinking approach. The designer Christopher Alexander uses exactly the concept of "fit" to characterize design problems:

> It [a general way of stating design problems] is based on the idea that every design problem begins with an effort to achieve fitness between two entities: the form in question and its context. The form is the solution to the problem; the context defines the problem. (Alexander, 1964, p. 15)

However there are productive, operational, communicative, and representational connotations of the concept of interface that are not addressed by treating interfaces as adjacent parts. Once the interface has been identified as the part of the computer facing us (the users), we embark on the well-trodden path of establishing its relation to other parts.

> Physically, the interface is the visible part of the computer system with which users have first contact. (Macredie & Coughlan, 2004, p. 236)

The interface becomes the exterior and the rest of the computer becomes the interior. Such a distinction aligns with the age-old divide between appearance (*Gr. phainomenon* – that which appears) and substance (*Gr. hypokeimenon* – that which lies beneath or the underlying thing).[53]

> The user interface is the part of the system that you see, hear and feel. Other parts of the system are hidden to you, for instance the database, where information is stored. Although users don't see the hidden parts, they imagine to some extent what is going on 'behind the screen.' (Lauesen, 2005, p. 4)

The last sentence in the quote from Lauesen hints at the historical remnants of engineering reasoning. Grudin (1990) convincingly recounts the development for the first computer users who, as engineers, required a "relatively full understanding of the hardware" (p. 263). As the complexity and capability of the hardware increased, the need arose for an access point to manipulate the computer, which did not depend on such an intimate knowledge. This establishes a trajectory that culminates with the shift to a focus on a non-programming user (naïve or discretionary users as Bannon, 1991, calls them) and the graphical user interface (GUI) that requires no insight into the workings of the computer. On this trajectory, we become further and further removed from the original "source." Each interposing layer becomes a translation of the one underneath. Thus, we find the origin of Lauesen's assumptions that when using the computer, the user is in fact attempting to figure out what lies beneath the interface.

The computer is a machine

The need to understand the "source" sees computers in the lineage of machines. When an interface is considered a step *away* from the computer (and thus away from something we are required to understand), it is because the problem for a computer engineer is first and foremost to make the computer *work* (Agre, 1997, p. 13). Making someone else understand *how* it works is secondary. The interface is the solution to how the non-professional is made able to understand what is going on. As Grudin (1990, p. 261) puts it: "Ironically, 'user interface' is a technology-centered term: the computer is assumed, the user must be specified. And indeed, consideration of the history of that interface goes more smoothly if we position ourselves at a distance and think of the 'computer interface' to the user and the world." Creating a specific user interface happens for the sake of the user. The computer does the work regardless.

[53] The distinction can be further hypothesized as having a direct connection with the subject/object dichotomy. The Romans translated the Greek terms *Hypokeimenon/phainomenon* into subject/object. The Greek *phainomenon*, "that which appears or is seen," – in the sense of covering – is translated into the Latin *objectum* as "thrown in front of" – in the sense of facing. The Greek *hypokeimenon*, "that which lies beneath," or "the underlying thing" is translated into *subjectum* in Latin, to "throw under." But instead of the sense of "underneath" that *hypokeimenon* conveys, the meaning of "subject" is to "face" or "be exposed to." Add to this the Modern Greek word for thing, *antikeimenon*, which seems to be a "translation back" from the Latin "object" – in the sense of "against" or "opposed to." The suggestion is that the "subject" changes place from Greek to Latin. Instead of being underneath or inside the thing (an ontological distinction), the subject is opposed to the object (an epistemological distinction).

> All machines do their job by physically transforming energy and/or raw material into some product, effect or event. (van den Boomen, 2007, p. 2)

> The earliest computers were dedicated machines, whose programs were encoded in their wiring. Interacting with the computer meant rewiring it to configure it for a new task. (Dourish, 1999, p. 2)

Relative to types of boundaries, the boundary of a machine is best described as what Mingers (2006, p. 68) calls an "enclosure." "An enclosure or container is different [from edges] in that it consists of specific boundary components that both mark a separation and keep in that which is included, or, equivalently, keep out that which is excluded." The enclosure is still part of the artifact, but it is starting to be something else. For this reason, one can find various phrasings that set the exterior (or surface) in opposition with the interior of the computer as one of translation or explanation. Janlert and Stolterman (2015) speak of designing the exterior of an object to "express certain characteristics or properties of the machine" (p. 515) and how the "interface becomes a manifestation of what can be done with the machine" (p. 514).

> The screen displays visual representations of the inner state of our computer, ordered by pictorial icons, textual menus and plane subscreens (windows) – the so called graphical user interface (GUI). (van den Boomen, 2007, p. 2)

This is particularly evident in the frequently used distinction between "Use end" (or front end) and business end (or back end) illustrated in Figure 5.

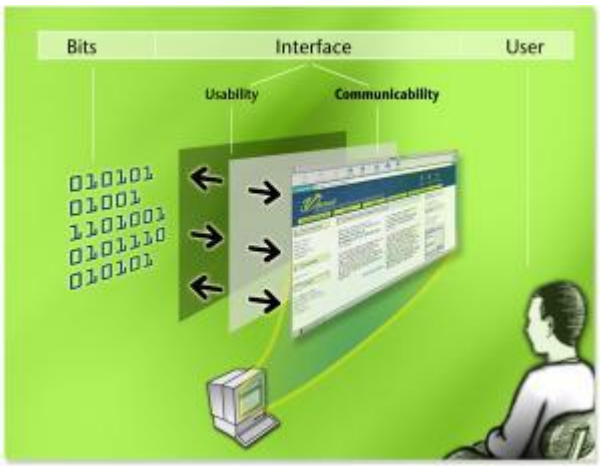

Figure 6. From bits to browser (source: http://www.nosolousabilidad.com/articulos/comunicabilidad.htm)

The two terms vis-à-vis each other (computer(bits) and user) correlate with the subject/object distinction. The user in Figure 5 is, according to this understanding, *actually* trying to understand the underlying bits but needs the interface to translate and mediate. This would of course equate to saying that the driver of a car is *really* trying to understand the propulsion system of the motor through the steering wheel and dashboard. Nonetheless,

the image has endured in the HCI community and in the public imagination, possibly because of the perception of the computer (and reference to it) as a machine that does work.

A machine transforms

The image of a working machine evokes the idea known from popular accounts of the industrial age whereby raw materials enter one end of the factory and exit as finished products. The input/output metaphor dovetails perfectly with perceptual and cognitive theories that work with such conceptual pairs as efferent/afferent (nerve-)signals, impression/expression, and the internal/external divide. Harrison et al. (2007, p. 4) call this the second paradigm of HCI or classical cognitivism/information processing. The idea is that "human information processing is deeply analogous to computational signal processing" (p. 4). This paradigm is most often associated with Card, Moran, and Newell's (1983) famous Model Human Processor. In this model, the "perceptual system carries sensations of the physical world detected by the body's sensory systems into internal representations of the mind by means of integrated sensory systems" (p. 25). Their model constitutes a standard representational version of cognition. The work of the mind (perception and cognition) is then supplemented by the work of the hand, the output. "Thought is finally translated into action by activating patterns of voluntary muscles" (p. 34). In this system, input and output are connected in the most mechanical of ways: "In the simplest tasks, the cognitive system merely serves to connect inputs from the perceptual system to the right outputs of the motor system" (p. 35). A similar model is proposed in the general interaction framework (Dix, Finlay, Abowd, & Beale, 2004, p. 128), which works with four concepts: the system, the user, the input, and the output. In both cases, the system and user seem to end up in a situation where the output of one becomes the input of the other and vice versa:

> The user interface has essentially two components: input and output. *Input* is how a person communicates his or her needs or desires to the computer… *Output* is how the computer conveys the results of its computations and requirements to the user. (Galitz, 2007, p. 4, emphasis in original)

> When you use a computer, you give it orders, usually by means of the mouse and the keyboard. The computer replies, usually by showing something on the screen or making sounds. Sometimes the situation seems reversed the computer gives you instructions and you have to reply. In both cases we talk about *human-computer interaction*, and we call the system an *interactive* system. (Lauesen, 2005, p. 4)

In this line of reasoning, the interface becomes "the boundary of the object, wrapping it up" (Janlert & Stolterman, 2015, p. 512). The interface is pushed towards the exterior of the object until it coincides with its border or surface. The line of demarcation is not just charged with the responsibility of "keeping the object together, protecting what is inside from disturbing external influences, protecting the surroundings from potentially disturbing influences from the inside" (p. 512), but more importantly, it mediates "functionally

important interactions of the object with the surrounding world" (p. 512). We will return to the idea of a system-environment relationship shortly.

The interface is a tool

Pushing this tendency to its logical conclusion, the interface eventually separates, if not physically, then conceptually, from the computer and becomes a separate entity, a tool. For instance, the cyberneticist Klaus Krippendorff agrees with Grudin (1990) that the use of computers by non-specialists "brought into being another kind of artifact, one that mediates between complex technological devices and their users: human-machine interfaces" (Krippendorff, 2006, p. 8). Input/output devices move front and center and become part of the interface that sits between the computer and the user:

> The interface is what the user sees and operates; it sits *between* the machine and the person, like the knobs and dials on a toaster, or the icons on a computer screen. (Murray, 2012, p. 10, emphasis added)

There is no distinction between the "interface" as a whole and the devices it is made up of:

> Graphical interfaces make a fundamental distinction between 'input devices,' such as the keyboard and mouse, as controls; and graphical 'output devices' like monitors and head-mounted displays, for the synthesis of visual representations. (Ullmer & Ishii, 2001, p. 579)

Once separated from the computer, the task of understanding shifts. The user is no longer first and foremost tasked with understanding the computer. What should first be understood is the interface and how to use it, hence such phrases as "user-friendly interfaces" and the later term "usability." Understanding changes character accordingly. The user needs to develop a type of functional or goal-oriented understanding whereby each icon, sign, and button has a function or purpose to be discerned. Understanding the function is crucial to the task of working the device:

> The interface is seen as a means to control an artifact, steering it toward a set goal, which may also involve problem solving. (Janlert & Stolterman, 2015, p. 514)

> The displayed graphics may function as buttons to give commands to the machine. This is comparable with the pedals in a car, as with a desktop icon for starting your mail program, or toolbar icons for commands as 'save' or 'print.' They also may be feedback signs, indicators of how the machine is working – comparable with the speed display in a car, as with an icon indicating you are connected to the Internet. (van den Boomen, 2007, p. 2)

The purest expression of this thinking is reached when anything functional connected with a computer becomes part of the interface by default. For instance, in an attempt to come up with a practical demarcation of interfaces, Shedroff and Noessel (2012) settle on an abstract

definition of an interface as: “All parts of a thing that enable its use” (p. 3). Their definition allows them to consider the hilt of a lightsaber as an interface on par with a traditional GUI. In a similar abstract line of thinking, Drucker (2011a, p. 10) states that:

> A book is an interface, so is a newspaper page, a bathroom faucet, a car dashboard, an ATM machine. An interface is not so much a ‘between’ space as it is the mediating environment that makes the experience, a ‘critical zone that constitutes a user experience.’

Drucker’s statement blends the interface “as a tool” with a conception of the interface as a medium (which will be treated momentarily). Still, it is the enabling or functional aspect of the medium that is at stake. From such a position, all things have suddenly become equipped with an otherwise imperceptible interface. It need not even have a specific function specified. All it takes is that we are able to perceive it. “Seeing” the thing becomes “using” the thing.

A tool works

Once the interface has been separated as an entity on its own, it becomes a tool proper. Tools have purposes that lie outside their own use. In a sense, they can be said to be “indirect” things as opposed to things that are purposes in themselves. They have one very simple operating condition; they either work or they do not. If you understand the interface, you can make the machine work.

> Any machine which can be operated by humans in variable modes comes with a so called user interface: a specific arrangement of switches, buttons, and other operating tools. This mediating switchboard provides operational access to the machine. (van den Boomen, 2007, p. 2)

> Brenda Laurel (1990, p. xiii) defines interface as “a contact surface” that “reflects the physical properties of the interactors, the functions to be performed, and the balance of power and control.

Santhanam and Batra (1998) divide human-computer interaction into four major components. The user component (including cognitive style, experience with computer, and knowledge level), the task (measured by complexity, application domain, and effort required for completion), the work environment (including management policies, system documentation, and training facilities), and lastly, they designate the interface as “the locus of interaction with the computer and to the user this ‘is the system’” (Norman, 1986, p. 61). They then proceed to specify the interface as consisting of two parts: input and output (Santhanam & Batra, 1998, p. 25). Clearly, the interface is the tool that renders the user capable of completing tasks in the work environment. The computer itself has taken a backseat.

This understanding of interfaces as enabling also goes for hardware interfaces. Kay and Goldberg (1977) maintain that:

> [o]ther input devices include a typewriter keyboard, a 'chord' keyboard, a pointing device called a 'mouse' which inputs position as it is moved about on a table, and a variety of organ-like keyboards for playing music. New input devices such as these may be easily attached, usually without building a *hardware interface* for them. (p. 33, emphasis added

Building a specific interface for a piece of hardware is a way of controlling it or, in this case, connecting it with other pieces of hardware. The teleological conception can be expanded – considering the intentions of the user, the artifacts involved, and the different types of purposes (extrinsic, intrinsic) – but the means-end relation remains the same.

> [The] *user interface* of a computer artifact should be understood in relation to intentions of the use activity. Hence, functionality of a computer artifact is a relation between the user and the artifact, something that is found in the use activity, not just a property of the artifact. (Ehn, 1988, p. 164)

With the interface serving a purpose and assuming a mediating role, it can split into an assortment of disparate components without losing its coherence. Each component still partakes in the user interface as long as they can be said to advance the user's grip on the situation. An example is Bowman, Kruijff, LaViola Jr., and Poupyrev (2005) who do not offer a definition of an interface but instead list components of an interface:[54]

> Modern computer users have become intimately familiar with a specific set of UI components, including input devices such as the mouse and keyboard, output devices such as the monitor, interaction techniques such as drag-and-drop, interface widgets such as pull-down menus, and interface metaphors such as the desktop metaphor. (2005, p. 4)

Similarly, Lauesen (2005) is able to, without further ado, include novel types of devices as part of the user interface as long as they can be assigned an input or output status. Note the interaction between the user and the computer *through* the interface:

> The interaction with the computer takes place through the *user interface*. In a standard PC, the user interface consists of the screen, keyboard, mouse, and loudspeaker. In more advanced systems, the interface may include voice input through microphone; special buttons, lights and displays; electronic gloves that can feel the movements of your fingers; and eye sensors that can detect where you are looking at the screen. (p. 4, emphasis in original)

[54] A different way of breaking up the design equation would be the human factors approach, which divides the human and system, respectively, into "factors" to be considered in the overall design. "Factorization" is also a mathematical concept whereby an object is decomposed into a product of other objects (factors).

The computer is a medium

Closely connected and running in parallel with the idea of a computer as a tool, the computer is simply often cast as a medium for communication (Licklider & Taylor, 1968). The metaphor of language as a tool is also a factor in their intertwinement. The physical or material aspects that constitute the tool fit neatly into a linguistic separation of the sign as a double entity between the sound pattern (signifiér) and the concept (signifiant) (Saussure, 1986, p. 66). The computer is considered a special machine: "it is both a physical processing machine and a symbol processing machine" (van den Boomen, 2007, p. 2). Information – like meaning attached to physical symbols – is inscribed in this machine "on electronic bits rather than clay tablets or printed books, and its transmission across space and time through binary codes rather than analog waves" (Murray, 2012, p. 9). The interface, and thus the computer, by way of metonymic reasoning (pars pro toto), becomes a medium as a whole. The computer carries meaning and/or content. The model that lies implicit has variously been called the conversation metaphor (Hutchins, Hollan, & Norman, 1985), the transmission model (Shannon & Weaver, 1949), and the conduit metaphor (Reddy, 1979).

> Altogether, the interface provides the necessary information channels for the user and computer to communicate. (Macredie & Coughlan, 2004, p. 236)

> In order to enable humans to read specific parts of this memory the computer needs a sophisticated device: a screen which shows both output and input in human readable form. (van den Boomen, 2007, p. 2)

As should be evident, it becomes progressively easier to recognize the mixing of several different ideas in a quote such as the last. The interface (equated with the screen) is a device (a tool) used for communication (the information is read); the device works as a machine (input/output), and the end purpose is that humans (end users) are able to understand the source (memory of the computer – the back end).

A medium mediates or enables communication

We have returned full circle to the user confronted with an artifact. However, instead of facing a computer, the user is now facing the interface that has delimited itself as a medium, assuming the status of a medium, "the interface" is immediately associated with such complex concepts as "representation," "communication," "language," "sign," "code," and the like. There is a process of transfiguration whereby "what the computer does" shifts from material to symbolic:

> The exchange between the physical and the symbolical is accomplished by the common language of digitality, as the electronic circuit states and the human readable signs can both be translated into digital code. Digital code embodies specific instructions (programs) for the machine, enabling it to load, read and write entities in its memory. (van den Boomen, 2007, p. 2)

> With the advent of stored program computers, and of batch processing, interaction with machines typically took form of punched cards and line printer output. Interaction become symbolic rather than electrical. (Dourish, 1999, p. 2)

Murray states that the digital medium is "the medium that is created by exploiting the representational power of the computer" (Murray, 2012, p. 8). However, the interface did not "just" turn into a communicative and representational medium. It retains its association with machines. As a tool and a device, an interface is also to be considered a "medium" in the sense of "in between" or "mediating." Any action undertaken in or with this medium is *simultaneously a communicative act and an instrumental act.* Bannon and Kuutti (1993) speak of a demarcation between programmers and psychologists, which separates the "interface" from the underlying "functionality" of the system. The importance of this dual parentage cannot be overestimated. I will return to it shortly. It is seen in the following quotes on interaction:

> Q. 1. What is a Graphical User Interface?
> Ans. An interface between the user and the computer via graphics is called a Graphical User Interface. It provides a very easy and convenient mode of interaction with the user. (Arora, 2006, p. 9)

> We also need to design an 'interface' between the machine and the person – knobs, dials, displays, controls, so that they can interact at some level. (Bannon, 1991, p. 31)

> Interactivity refers to the action-response sequences, command and execution cycles, or *the give and take* that is inherent to the human use of machines. (Krippendorff, 2006, p. 9, emphasis added)

> Plotnick, in a historical technological perspective, investigates push-button interfaces and buttons themselves "as objects that mediated between users and electrical machines of the late nineteenth and early twentieth centuries." (2012, p. 818)

The term "interaction" fits easily with any of the prior senses of "interface" mentioned. It can be equally taken to be action with an artifact, machinic transformations or exchanges, tool use, and communicative dialogue. At any rate, it retains its place "in between" as *inter*action. The term, in this sense, becomes synonymous or even replaces "interface." According to Diaper and Sanger (2006) the "I" in HCI changed from "interface" to "interaction" somewhere in the 1990s. With "interaction" as the main focus, we have reached one possible polar opposition to the computer considered as an artifact: the computer as pure process. Going even further, we detach ourselves from any material grounding. Janlert and Stolterman (2015) step off this particular cliff when they state:

> *Interaction* does not necessarily require an *interface*. (p. 523, emphasis in original)

They allow themselves to do this because they restrict the term "interface" to "real surfaces and surface-bound interaction" (p. 253). However, there is an immensely strong impulse toward *situating* interaction and interfaces in particular. In a comment to Janlert and Stolterman, Paul Dourish (2015, p. 542) asks: "If interaction is faceless...then what is the site of interaction?" He goes on to answer himself: "It lies not in the computer but in the world, and not on the screen but in our social engagements mediated by technologies of all sorts" (p. 542). Without being bogged down by any actual physical artifact, surface, or specified medium, the interface becomes everything because it turns into a verb. We *interface* when we interact – sometimes, directed at a surface or artifact, but just as often as part of a work practice of context where only part of the activity is surface directed. In such a world, interfaces are truly ubiquitous because interaction, as a type of social engagement, is everywhere and nowhere in particular (cf. Bannon, 2011, p. 56).

Transparency

Just shy of complete free-floating interaction, the metaphor of transparency is freely applied by authors of both tools and media (see Bardram & Bertelsen, 1995). The archetypical example of this idea is the blind man's cane vigorously discussed in philosophy and cognition theory (Bateson, 1972; Descartes, 1998; Donellan, 2015; Ingold, 2000; Malafouris, 2013; Merleau-Ponty, 1962; Noë, 2004; this is also discussed in article 2). "Transparency" is used metaphorically to indicate what does and does not catch our attention in an interface. Bødker (2006, p. 5) states that "[i]n much of ubiquitous computing it seems to be an assumption that the computing and hence the interaction can simply be made to disappear, once and for all, from the attention of the human user." Norman (1998) touts the "invisible computer"; Fishkin, Moran, and Harrison (1998) speak of "an invisible user interface"; and Ishii and Ullmer (1997) urge us toward a seamless interface between people, bits, and atoms where "computing is truly ubiquitous and invisible" and the world itself is changed into an interface (p. 2).

> transparent: a good interface should not call attention to itself, but should let us direct our attention to the task. (Murray, 2012, p. 10)

> In working with people, we establish domains of conversation in which our common pre-understanding lets us communicate with a minimum of words and conscious effort. We become explicitly aware of the structure of conversation only when there is some kind of breakdown calling for corrective action. If machines could understand in some way people do, interactions with computer would be equally transparent. (Winograd & Flores, 1986, p. 164)

> Humans tend to 'see through' interfaces into an underlying meaningful state of affairs and development. (Janlert & Stolterman, 2015, p. 511)

According to this idea, we do not see words, but meaning, and we do not see hammers, but nails (Winograd & Flores, 1986, refer to Heidegger's oft-quoted idea of "breakdown," as discussed above and in article 2). The idea of transparency only serves to reinforce the

impression that the computer is somehow a new medium or perhaps even a whole new type of digital materiality (discussed in article 3).

> All things made with electronic bits and computer code belong to a single new medium, the digital medium, with its own unique affordances. (Murray, 2012, p. 2)

Because the medium is free-floating and/or transparent, *interface* designers turn *interaction* designers (Carroll, 1991). As such, we focus on an (now) unobstructed consideration of the relation between the user and the computer. The interface has been extended from its "middle" position "in between" the human and the computer to engulf both sides. The two are now considered part of the same *system*. In a historical perspective, this means that when UX designers claim that they have started "including people" in the design of interfaces, they seem to miss that people were never absent from the equation.

> [T]he scope of the interface is seen to stretch beyond physical boundaries with inclusion of the people responsible for shaping interactions with the interface such as management. (Macredie & Coughlan, 2004, p. 236)

The computer is a system

On the surface, the step from artifact/machine/tool to system seems insignificant, but obviously, the relationship between the human and the computer is the main reason that questions of the interface parallel so many conundrums within philosophy and cognitive science (subject/object, mind/body, internal/external, representation/reality, etc.). Thinking of the human and the system as part of the *same* system, as opposed to two separate entities joined by an external relation, carries deep implications relating to how we think of each of them and their relation.[55]

> For about forty years, the discourse of AI has been organized around a particular metaphor system according to which the mind is a space with an inside, an outside, a boundary, and contents… A better starting point is the complementary metaphor system organized by the notion of interaction. (Agre, 1997, p. 27)

While Agre speaks of the field of AI, it also holds true for HCI as a whole. The shift has been called the second wave in HCI (Bødker, 2006; Kaptelinin et al., 2003) or the phenomenologically-situated third paradigm (Harrison et al., 2007), the first two being human factors and classical cognitivism. As Figure 4 indicates, there are many different ways of approaching the problem of figuring out human-computer interaction relations in order to meaningfully create an overview of the many examples that can be found. It can,

[55] The extension of the frame to include both human and computer in the same system does not mean that either of these "goes away" in these theories. They are assigned new roles in the production of meaning (for instance, the brain-body-world are considered structurally coupled in the theory of autopoiesis (Maturana & Varela, 1980; Varela et al., 1991), or they are seen as a by-product of the interaction that has taken center stage, e.g., Barad's (2007) agential realism inverses the ontological order. Subjects and objects do not come together to interact. The two emerge from intra-actions of the material-discursive apparatus that produces meaning. "[T]he larger material arrangements enact a cut that resolves the inherent ontic-semantic indeterminacy through which the 'subject' and the 'object' emerge" (p. 143).

however, be suggested that the proliferation of examples supports one of the main claims of the thesis – that the many different ways in which theoreticians and designers approach their problems harbor philosophical assumptions. I therefore turn to a more in-depth consideration of some of the theoretical sources of the third paradigm.

A caveat

First, however, a caveat is in order. In many ways, the term "interface" is already transparent. The concept appears "self-evident" since everybody can point to an interface (e.g., a computer screen). However, the mixing and matching of ideas and terms with which interfaces are described, exemplified above, muddles the concept, so much so that it appears that "interface" itself functions as a boundary object (Star & Griesemer, 1989; Star, 2010) for theoreticians, programmers, engineers, and "users" alike. The problem is exacerbated by theoreticians who use the term "interface" in a perhaps technical but, for the HCI community, non-specific way:

> A representation forms a kind of abstract *interface*, regulating the interactions between system and environment, in such a way that the system is able to maintain a stable identity. This process of regulation or steering can be conceptualized as an internal processing of information coming from the environment. (Heylighen, 1990, p. 144, emphasis added)

> David Chalmers writes in the foreword to Clark's *Supersizing the Mind*: "It is natural to hold that perception is the *interface* where the world affects the mind, and that action is the interface where the mind affects the world." (Chalmers, 2011, p. xi, emphasis added)

> Further, Long has created a social interface theory where "a social interface is a critical point of intersection between different lifeworlds, social fields or levels of social organization." (Long, 2001, p. 243)

Conversely, writers within the HCI community are not afraid to draw directly upon philosophical or cognitive theories in a way that implicitly or explicitly informs their take on interfaces or interaction, for example, theories of perception or representation:

> [Humans] form sense-making models of what they perceive and experience, and those rather than superficial phenomena of the interface, such as the traffic of pixels and key presses, are what drive and guide their interaction. (Janlert & Stolterman, 2015, p. 511)

> Our media make us human by externalizing symbolic thought so it can be shared. (Murray, 2012, p. 16)

The quotes reveal HCI's philosophical inheritance and deep roots in cognitive science. Adopting the idea that there are (internal) cognitive models or schemas that can be externalized, for instance, belongs to a discussion about the nature of cognition, with

obvious implications for what an interface is and can be. These and similar ideas are ubiquitous, but there is no single set of propositions that are universally held to be true in the community. Using such claims as explanatory scaffolding for a particular view of interfaces requires the theoretical discussion that I have opened in this thesis, which connects cognitive and philosophical claims with ideas about the nature of interfaces in the field of HCI. I consider the following series of sources obvious parts of such a discussion, which have been instrumental in forming my own views.

Theoretical sources that shed light on interfaces

The first wave – or second paradigm – in HCI is alive and well (Bødker, 2006; Harrison et al., 2007; Kaptelinin et al., 2003). It stems from classical cognitive science. It has variously been called symbolism, computationalism, representationalism, or simply cognitivism. Its primary claim is that the mind works like a digital computer, either considered on a "high-level" – where cognition is thought to be computations of symbolic structures akin to natural languages (Fodor, 1975; Newell & Simon, 1976; Putnam, 1961) – or on a "low-level" – where cognition consists in multiple, distributed groups of simple processing units from which higher level cognition emerges (Edelman, 1998; Hinton, McClelland, & Rumelhart, 1986; for a more detailed description, see article 1). The different takes on computers and interfaces examined above (artifact, machine, tool, and medium) are easily situated within the parameters of cognitivism, as is the idea of the computer as a system. However, I have set this idea apart as the cue for the second wave or third paradigm. The reason is that the shift from things (artifact, machine, tool, medium) to systems constitutes a shift from finding meaning, interpreting meaning, or assigning meaning to the *creation of* meaning. It marks a shift from identifying things to allowing meaning to emerge from within a Thing (a system or assembly). Seeing both the human and the computer as elements of a larger system alters the problem from one of *localizing* meaning (e.g., if meaning is in the world, how can it transfer to the mind or vice versa?) to one of explaining how meaning (the world as we experience it) can arise from the interactions of the elements of the system. Our everyday world becomes a different kind of mysteriousness since it is no longer a world given to us that has to be explained; rather, we have to find a way to the world, as it appears to us, as the endpoint or the culmination (we know the result; we are trying to figure out how we got there). Each "thing" in the complex of the system is relieved of the responsibility of harboring meaning in isolation. Instead, meaning emerges within contextual relationships between parts of the system. The following sources of inspiration all have something to say about the genesis or production of meaning.

Curiously, this problem has parallels in biology where the distinction between the living and the non-living and the problem of how the former emerges from the latter remains the holy grail of the field. It is perhaps then not surprising that all of the following theories are inspired, directly or indirectly, particularly by Maturana and Varela's (1980) theory of the living as autopoietic systems. The theory of autopoiesis (treated below) forms a direct link to the dual parentage of the interface (it is both a tool and a medium). In his book *Realising Systems Thinking*, Mingers (2006) presents some fundamental observations about the nature

of living systems in the works of Maturana and Varela. Observations ii and iii are as follows:

> ii) Living systems operate in an essentially mechanistic way. They consist of particular components which have various properties and interactions. The overall behaviour of the whole is *generated* purely by these components, their properties and their relations through the interactions of neighboring elements. Thus any explanation of the living must be a purely mechanistic one.
>
> iii) All *explanations or descriptions* are made by observers (i.e. people) who are external to the system.... Observers can perceive both an entity and its environment and see how the two relate to each other. Components within an entity, however, cannot do this but act purely in response to other components.
> (p. 34, emphasis added)

I quote these two observations to bring out their second-order isomorphism (Edelman, 1988) with the dual parentage between tool and medium, the Saussurean distinction between signifié and signifiant (1986), and the 4EA's insistence on a world enacted (treated below). In all of these, there is a mechanical component that takes care of actualizing the act in the world (the tool, the signifiant, the enactment, or the process) while the meaningful component (the medium, the signifié, the meaningful world, or the result) is what is created by this act. They also share an emphasis that there are, in fact, not two entities, but the two in question are one and the same. In Mingers' (2005, p. 52) words, "acting is knowing, and knowing is acting." It is the same idea expressed in the phrase "zero distance" used above. An interface is thus at the same time the expression of a genesis (the creation of life or transition from non-living to living and from meaningless to meaningful) and is also involved in the concrete meaningful enunciations made within the interface – that is, in terms of interfaces, the general question of how a computer is meaningful at all and the more specific question of how movements of a mouse or a wiimote become meaningful in the whole. These theories shed light on interfaces because they all, in different ways, answer the question of how a (meaningful) world is brought forth. The duality involved is advantageous for a community that wrestles with reconciling the "hard" technical language of programmers and engineers with the "soft" intentional language of UX designers and users. Moreover, it provides an easy solution to the question of whether an interface is a thing or an (inter-)action. Part of the appeal is therefore that seemingly novel insights can be brought to bear while the basic format (the FoT) is maintained. The computer becomes, in the word of Agre (1997, p. 2), "a bit of metaphor attached to a bit of mathematics and realized in a machine whose operation could then be narrated using intentional vocabulary." The following treatment extends the literature reviews in articles 1 and 3.

1. Bringing forth a world

In this first part, an array of loosely coupled theories is presented, which go by the acronym 4EA (e.g., Protevi, 2010; Reinhardt & Loke, 2013; Ward & Stapleton, 2012) and can all be counted as part of the third paradigm. The acronym covers the terms "embodied, embedded,

extended, enactive, and affective." To these I also count "distributed" and "situated" (for an overview of these theories, see for instance Menary, 2010a; Pasquinelli, 2004a, 2004b; Ward & Stapleton, 2012). The theories have one common feature that should be singled out in relation to interfaces. All of them, each in its own way, promote the idea that *meaning is created not found*. In terms of cognition, this is the question of how a meaningful world arises or is "brought forth." This particular phrase is an allusion to Maturana (2002, p. 31) who states that we "continuously bring forth the world and worlds that we live" (see also Varela & Dupuy, 1992). The everyday world we experience may seem given, but it is in fact the *end point* of our perception and cognition, not the starting point. Fritjof Capra (1996) expresses it in this way:

> There are no objectively existing structures; there is no pregiven territory of which we can make a map – the map making itself brings forth the features of the territory. We know that cats or birds will see trees, for example, very differently from the way we do, because they perceive light in different frequency ranges. Thus the shapes and textures of the 'trees' they bring forth will be different from ours. When we see a tree, we are not inventing reality. But the ways in which we delineate objects and identify patterns out of the multitude of sensory inputs we receive depends on our physical constitution. As Maturana and Varela (1980) would say, the ways in which we can couple structurally to our environment, and thus the world we bring forth, depend on our own structure. (p. 271)

But it is essential to understand that theories are not answers to a general question of how things come to be. Rather, their claim is that the world (meaning) as we know it is shaped, in a non-trivial way, by particular constraints, dependencies, and conditions because these *are part and parcel of its (the world's) enactment*. To paraphrase Capra (1996), we see the world as we do because we are human (and the world is the world). The world emerges through the consummation of actions in the face of constraints particular to us. As Capra writes, "we are not inventing reality." (p. 271)

It is difficult to provide a strict demarcation of what to include in the second wave, and it is even more difficult to find commonalities in what one includes. The theories overlap to a great extent on various points, but it is far easier to characterize what they are opposed to than that in which they are united. For instance, Bødker (2006) counts situated action, distributed cognition, and activity theory as part of the motley crew of theoretical ideas that challenge cognitivism. Several of the authors referred to could easily fit under more than one header. Most of the authors writing under any of the headings include parts or all of the other approaches in their review of the relevant literature (e.g., Sutton, 2006). Harrison et al. (2007) recount a telling story of their problems in finding an appropriate name for the third paradigm. They tried "embodied and situated," "meaning-making," "post-cognitive," etc., before settling on "third paradigm." The trouble is that, as with any other antithetical endeavor, it is a lot easier to identify the elements in cognitivism that these various theories oppose than it is to identify commonalities across the alternative answers and approaches they offer.

In very broad terms, all of the theories touched upon can be said to lend support to the rejection of two elements of cognitivism. The first is the placement of cognition and perception *inside* an isolated mind or a singular subject. The second is the rejection of "the idea of a world or environment with extrinsic, pregiven features that are recovered through a process of representation" (Varela et al., 1991, p. 138). Rejecting one of the above automatically puts the other into question, but there is no set way in which the rejection of either (or both) plays out. The only certainty is that the interface is not to be considered a border between two separate entities. In Bateson's (1972) words:

> The mental world – the mind – the world of information processing – is not limited by the skin. (p. 460)[56]

While Bateson uses the word "mind," for this purpose, "meaning" is more suitable. His statement is the rejection of the proposition that meaning originates from the mind of a subject (social construction) or from the objective world (objectivism). In fact, it is a misunderstanding to enclose meaning "inside" entities at all. Meaning is what is produced, created, or what takes place when borders are *crossed*. Thus, *interaction* in relation to HCI means the production of meaning. In addition to the two aforementioned points, other themes can be found that vary in emphasis: the opposition to the representational aspects of cognitivism (e.g., Chemero, 2009; Varela et al., 1991); the view that man's body is an essential part of cognition (e.g., Lakoff & Johnson, 1999; Shapiro, 2011); the idea that meaning is always bound to a specific situation (Clancey, 1997; Suchman, 2007); and the premise that cognition is always enacted (Noë, 2004; Varela et al., 1991). Throughout, there is a strong philosophical influence from phenomenology and hermeneutics (Heidegger, 1962; Merleau-Ponty, 1962), sometimes indirectly, but often directly by philosophically trained thinkers (e.g., Dreyfus, 2002; Mingers, 2001).

Enaction

The first constraint to consider is the performative aspect itself. This constraint is crucial because it turns our assumptions on the head. The world is something we enact or perform rather than "the something" we do something with or to. Barad (2007, p. 49) states that knowing is the result of a direct material engagement *with* the world. Tweaking this statement, we should say that the world *is* the result of a direct (or active) material engagement.[57] The crucial thing to point out is that perceiving, meaning, and knowing are not *about* the world. They are not separate phenomena that take place in a realm different from the result. Rather, the phenomena resulting from them are *ongoing* and only exist *qua* their enactment. "The meaningful is not in our mind or brain, but is instead essentially worldly...we do not store the meaningful inside ourselves, but rather live and are at home in

[56] The quote can be read in a variety of ways. I tend to read it along the same lines as Ingold (2000) where the statement brings the entire question of "placing" the mind anywhere into doubt: "If mind is anywhere, then, it is not 'inside the head' rather than 'out there' in the world….The mind, Bateson had always insisted, is not limited by the skin" (p. 3; see also note 24).

[57] There is a growing contingent of research on the significance of matter and materiality (see Carlile, Nicolini, Langley, & Tsoukas, 2013; Leonardi et al., 2012; Malafouris, 2013).

it...the meaningful *is the world itself*," as Haugeland (1998, p. 231) puts it. This is important for something as trivial as our assumptions about the relationship between a process and its result. In articles 1 and 2, I argue the case that phenomena cannot represent one another and that such pairs as process/result and map/territory are in fact commutable versions or transforms of each other. The point is not that there are *two* phenomena that can be exchanged for one another; it is that there is only a single phenomenon that is captured (described) in two different ways (process and result) and *then* attempted and compared. We can capture the phenomenon in both ways, but that does not mean that we end up with two phenomena. When we consider an enactive or performative process, we are therefore not considering something (a process) different from the result. Rather, we consider the enaction because *it matters what we do in relation to the world we encounter.* The world is enacted. This is what is meant by "performative" and "enactive" (Stewart et al., 2010; Varela et al., 1991). The small prefix "en-" allows us to discern the reference to "something" that is acted out. We might say that just as there are no "neutral," pregiven features or objects in the world, there are no neutral processes that simply carry information. "Organisms do not passively receive information from their environments, which they then translate into internal representations. Natural cognitive systems...*enact a world*" (Di Paolo, Rohde, & De Jaegher, 2014, p. 39). There are differences in how you perceive the world when you are bicycling as opposed to walking or flying – in the dual sense of being different processes – and seeing different things (e.g., a bump on the road has different affordances relative to your mode of transportation).

Enactivism is obviously indebted to pragmatism, as developed by William James, Charles Sanders Peirce, and John Dewey (see Hookway, 2015 for an introduction).[58] It has been proclaimed that there has been both a "Practice Turn" in sociology (Nicolini, 2013; Schatzki, Knorr Cetina, & von Savigny, 2001) and a "Pragmatic Turn" in cognitive science (Engel, Maye, Kurthen, & König, 2013). This glove has been picked up in HCI (Kuutti & Bannon, 2014), and Peirce (1878) is credited with coining the maxim that makes the connection with enactivism:

> Consider what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of those effects is the whole of our conception of the object. (p. 293)

Like Fontana's cut, we recognize processes in their consequences. Seeing a thing is not simply the observation of, say, a physical object. A thing is itself a consequence of an act, and we recognize the act in it. The same idea can be found in Leonardi et al. (2012) who explicitly attempt to understand technologies in terms of their consequences. Just as the world is not simply there prior to action, our actions are not "there" to be applied prior to our meeting with the world. The material informs us, the actors, of our capabilities.

[58] There are also obvious affinities with the late Wittgenstein's (1997) parole "meaning is use" and speech act theory (Austin, 1962; Searle, 1999) that are not considered here.

> Rather than being simply constrained by structure, as the typical conventional interpretive understanding wants us to believe, human choice and agency are made originally possible through the very resources that objects and structures dispose. (p. 10)

Pondering the idea that what you see is a product of a process allows the reflexive realization that the process that allows you to see what you see now must have already taken place. The enactive approach is therefore the most direct route to the reflexive problems discussed above as well as the idea of "zero distance." Being able to see what is in front of you as the result of a process that has already passed or is still in progress is a way of reverse engineering the processes of your thought. It is a way of recognizing what is in front of you as the endpoint of those processes.

Relative to interfaces, this idea translates into the conception that interfaces are not located anywhere in particular but are instead "anywhere" meaning is created. Drucker (2011b) creates the link to phenomenology and hermeneutics when she defines interface as "a space that supports interpretative events and acts of meaning production" (p. 3).

The Perceptual Robotics Laboratory is a bit more heavy-handed in scoping out the aim of the ENACTIVE Network that structures the research on enactive interfaces:

> *Enactive Interfaces* are related to a fundamental 'interaction' concept which is not exploited by most of the existing human-computer interface technologies....enactive knowledge is a form of knowledge based on the active use of the hand for apprehension tasks. (Percro, 2015, para 1)

Interaction here becomes synonymous with the "active use of the hand." In this framing, the "enactive approach" is about a particular type of knowledge that is set apart from traditional symbolic or iconic knowledge. The case can be made that the hand "possesses its own know-how" (Radman, 2013, p. 384) and that there are particularities to our world that are entirely dependent on humans having hands (Wilson, 1998). However, with the above quote, we have drifted away from considerations of enaction toward examining another type of constraint. In a generalized way, "the hand" becomes a metonymic term for the idea that our world is always constrained by the fact that we all have bodies, something most of us can agree on.

Embodied and embedded

Wilson and Foglia (2011, para. 23) succinctly sum up the connection between enactment and embodiment:

> [T]he world that is given and experienced is not only conditioned by the neural activity of the subject, but is essentially enacted in that it emerges through the bodily activities of the organism.

Embodied cognition (Chemero, 2009; Lakoff & Johnson, 1999; Mingers, 2001; Shapiro, 2011), sometimes referred to as embodied embedded cognition (EEC) (e.g., Haugeland, 1998), posits that cognition depends on having a body (e.g., sensorimotor capacities) and, furthermore, that the body (these capacities) is embedded in a larger context (social and natural environment) such that consciousness and intelligent behavior emerge in the interaction between the brain, body, and world. The pivotal idea developed by Merleau-Ponty (1962) is that perceptions are inherently meaningful to us because we have bodies (Mingers, 2001, p. 112). In terms of process and pattern, this is a way of saying that the body puts restraints on the cognitive processes in a manner that is discernible in the resulting patterns of perception. An example is Gibson's (1986) idea of affordances, examined below, whereby the scale of the body, say the length of the legs, puts constraints on how high a step one can take and, consequently, the perception of what is "step-up-able" (Warren, 1984).

Embedded or environmental constraints are relatively straightforward to understand. We can see that different environments look, feel, and impact us differently (put different strains on us). We are able to trace the body in the meaningful world we engage in. A puddle of water is "jump-over-able" relative to our physique. Most people will also be able to follow a more complex version of the Darwinian idea of environmental pressure that drives the development of different body types.[59] It is a bit more difficult to comprehend the idea, let alone translate it into design ideas, that if you had a different body, the world would literally appear different. To make matters worse, there are many different conceptions of embodiment, embeddedness, and what a body is (Ziemke, 2003). As the different ideas find their way into the HCI environment, the reception of the embodied-embedded perspective takes equally disparate forms. For example, Dourish (1999, 2001) traces the philosophical roots of embodiment and argues for a better understanding of human interaction with a system as a fundamentally embodied phenomenon. In a bachelor's thesis from the University of Gothenburg (Weschke & Börman, 2009), Dourish's ideas are given a very literal interpretation as a transition from "traditional interaction" with a desktop environment, to a broadening of scope, to "interaction with everyday objects such as interactive whiteboards, furniture, spoons, cups, or even digital jewellery" (p. 1). This interpretation is not "wrong." Dourish's philosophical ideas are just somewhat removed from a "design mode" that speaks of creating "more natural interfaces by incorporating social and/or physical skills in order to create a more meaningful interaction space, allowing participants to engage in systems in a more natural way" (p. 2). A different example is Hurtienne (2009), who employs concepts such as "image schemas" and "mental models." This is surprising since such concepts go against the non-representationalist aspects of the 4EA literature. The fundamental notion at stake here, that bodily and environmental

[59] There is a more complex meaning of embeddedness at stake. When we engage in the world, the material "kicks back" informs us of our own capabilities. "[W]ork materials are more than mere stimuli for a disembodied cognitive system. Work materials from time to time become elements of the cognitive system itself. Just as a blind person's cane or a cell biologist's microscope is a central part of the way they perceive the world, so well-designed work materials become integrated into the way people think, see, and control activities, part of the distributed system of cognitive control" (Hollan, Hutchins, & Kirsch, 2000, p. 178). This sense is investigated in article 3.

constraints have an effect on the meaningful world we experience, becomes somewhat obfuscated by the fact that different constraints can be accepted in different ways and without buying into the entire 4EA package. There are very innovative ideas in circulation in the HCI community that start from embodied interaction (e.g., Williams, Kabisch, & Dourish, 2005), but no clear direction from applying the approach has emerged.

Extended

One reason that the different theories have not been united under an acronym and do not cluster under a single headline is that their sometimes overlapping ambitions have very different foci. The embodied-embedded position points to cognitive processes that are constrained by intrinsic bodily dynamics as well as external structures that constrain and mold the cognitive process at play. The extended cognition thesis (Clark, 1998; Menary, 2010b; Noë, 2004) says basically the same thing, albeit with respect to breaking down the strict separation of the mind and world. The mind is not limited by the skin, as Bateson (1972) maintains. It extends beyond the limits of the skull, the skin, and the body. Conversely, the environment is not just an "outside" we meet from inside. It is implicated in our cognitive processes in an indispensable way. Clark (1998) borrows the term "scaffolding" from the Soviet psychologist Lev Vygotsky (1986). Together with Chalmers (2011), he gives the example of the game Tetris wherein the physical rotation of a block with a button can be executed more than three times as fast as the "same" action performed in the mind as a "mental rotation." In other words, the mind is designed to work with an environment, not to make representations of it. This makes sense from an "economical" standpoint. It is very inefficient to create a system with the responsibility of creating authentic copies or representations of the world. A much better idea is to create a system that takes advantage of the world's features and allows it to carry the burden of processing. As Brooks (1990, p. 5) famously said, "the world is its own best representation." Clark (1989) calls this the "007 principle":

> In general, evolved creatures will neither store nor process information in costly ways when they can use the structure of the environment and their operations upon it as a convenient stand-in for the information-processing operations concerned. That is, know only as much as you need to know to get the job done. (p. 64)

This is an important transgression of the traditional border between the subjective and the objective. Instead of having two separate "areas" or things, each responsible for different effects on the meaningful world that appears to us, the two are inextricably co-conditioned. This idea is indirectly what article 2 is about. Clark and Chalmers (2011) provide an analogy:

> The extraordinary efficiency of the fish as a swimming device is partly due, it now seems, to an evolved capacity to couple its swimming behaviors to the pools of external kinetic energy found as swirls, eddies and vortices in its watery environment. These vortices include both naturally occurring ones (e.g. where water hits a rock) and self-induced ones (created by well-timed tail flaps). The fish swims by building these

> externally occurring processes into the very heart of its locomotion routines. The fish and surrounding vortices together constitute a unified and remarkably efficient swimming machine. (p. 225)[60]

The main point to understand is that it makes no sense to separate the system from its environment using an arbitrary border (the surface of the skin). Deleuze and Guattari (2002) speak of the same issue when they consider the emulation of the female wasp's sex pheromones by an orchid. Going against a framing that sees it as a case of mimicry, they speak of the wasp becoming-orchid and the orchid becoming-wasp (2002, p. 10). The two do not constitute or determine each other. They nonetheless evolve together. Bateson (1972) uses the term "complement" to describe the relation:

> A shark is beautifully shaped for locomotion in water, but the genome of the shark surely does not contain direct information about hydrodynamics. Rather, the genome must be supposed to contain information or instructions which are the complement of hydrodynamics. Not hydrodynamics but what hydrodynamics requires, has been built up in the shark's genome. (p. 134)

The mind (like the fish) is "shaped" *qua* its body and the environment it swims in. Relative to interfaces, this insight is interesting since it also applies to tools and technology. Tools co-evolve with cognition as forms of culture (Wertsch, 1989). As in the case of the environment, the 007 principle applies. It makes little sense to take on the entire task of processing information. It is much better to delegate part of the task and responsibility for accomplishing it to the tool. This is also examined in article 3.

> This point may be expressed more clearly using a different example of form: an axe. An axe is a tool which has been perfected over thousands of years, to achieve the most efficient shape. Its blade is "designed" just so for its purpose. Any slight change in its shape would make it less effective. Its metal is hardened steel, and its handle is made just right for the human hand. Thousands of years of trial and error were required to identify just the right materials and shape for the axe. That time of trial and error (and the wisdom gained) is manifest in its form. (Frehley, 2005)

A tool is not something that can be separated from the human physique or simply added to an existing task. When technology enters, it transforms the task as well as the human physique. A straightforward example of changed physique is the different bodies of elite athletes that have adapted to different tasks and tools (e.g., Wertsch, 1989 gives the example of pole vaulting). It is a form of double adaptation:

> The basic idea is simple enough. Consider a familiar tool or artifact, say a pair of scissors. Such an artifact typically exhibits a kind of double adaptation – a two-way fit, both to the user and to the task. On the one hand, the shape of the scissors is remarkably well fitted to the form and the manipulative capacities of the human hand. On the other hand (so to speak), the artifact, when it is in use, confers on the agent

[60] Many different versions of this idea can be found. Clark provides a different example:

> some characteristic powers or capacities which humans do not naturally possess: the ability to make neat straight cuts in certain papers and fabrics, the ability to open bubble packs, and so forth. (Clark, 1998, p. 193)

For this reason alone, the conception of the interface as a relation between a "user" examined separately vis-à-vis a computer defined on its own is misleading at best.

Clark appears to be widely read and cited (Google Scholar puts him beyond 22,000 citations). The direct impact of the extended mind hypothesis on interface design seems, however, to be limited. Perhaps this is because it is unclear how the hypothesis impacts the design of interfaces. The question is: what is done differently in terms of interfaces when there is no clear demarcation between user and computer? The direct outlet for both the insights of embodied-embedded cognition and the extended mind is a direction such as "tangible computing" (Dourish, 2001; Ishii & Ullmer, 1997). Ishii and Ullmer (1997, p. 2) present their vision as a shift from the desktop environment ("boxes sitting on desktops") onto our bodies and the physical environment we inhabit. This is given a very concrete translation where digital information is coupled with everyday physical objects and environments (or coupling bits with atoms, as they call it). The task they set for themselves is equivalent to attaching meaning to physical symbols (discussed in "the computer is a medium" section above). At the end point of their vision lies the ambition of changing "the world itself into an interface" (p. 2). Reading through the article, it becomes clear that many ideas of a traditional desktop environment are challenged, but the basic idea of a human vis-à-vis a computer is retained. For instance, throughout the paper, small hand-drawn images and photographs portraying use situations illustrate the points made. Almost all of the images contain a user (at minimum, a hand) and an object and a frame around both. The use or interaction situation thus perfectly preserves the idea of interaction across a border or between two entities (the world taking the place of the computer). The user's interaction with the world remains compatible with other ideas (computer as an artifact, machine, tool, medium). The same point can be made for the embodied/embedded perspective and the extended mind hypothesis.

Distributed

An important step in challenging the FoT as it presents itself in the figure of "Human" vis-à-vis "Computer" is to dissolve the notion that there is "a user" (singular) (Grudin, 1993). The distributed view (Hutchins, 1995a)[61] takes the idea of scaffolding or off-loading the burden of calculation into the environment (Brooks, 1990; O'Regan, 1992; Zhang & Norman, 1994; Zhang & Patel, 2006) in the extended mind hypothesis and widens the unit of analysis to encompass an entire work practice consisting of individuals, artifacts, and environment. Distributed cognition thus transcends the boundaries of the individual actor (Rogers, 1997). Hutchins (1995a) famously uses the example of a navigation crew aboard an aircraft carrier that has to coordinate its practices and rely on different positions and tasks in an overall process where no single individual has a global overview, and actions are not coordinated

[61] For introductions to distributed cognition, see Rogers (1997, 2006) and Harris (2004). Historically, distributed cognition was developed by Hutchins (2000) who himself traces his sources of inspiration to such thinkers as Minsky (1986) and Vygotsky (1978).

by central intelligence. In this approach, it is possible to speak of "mind" or cognition distributed over many people, over physical artifacts, and even as part of the organization of the environment. It is a way of looking for and understanding cognitive systems across barriers that traditionally enclose the mind (the skin or the skull). "Distributed cognition looks for cognitive processes, wherever they may occur, on the basis of the functional relationships of elements that participate together in the process (Hollan et al., 2000, p. 175). The theory has been employed in many different work environments. Examples include airline cockpits (Hutchins, 1995b; Hutchins & Klausen, 1996), collaborative work (Rogers & Ellis, 1994), team work (Artman & Garbis, 1998), air traffic control towers (Fields, Amaldi, & Tassi, 2005), and call centers (Ackerman & Halverson, 1998). Relative to HCI, the article quoted above by Hollan et al., (2000) proposes distributed cognition as a new foundation for HCI research:

> [HCI] has focused almost exclusively on single individuals interacting with applications derived from decompositions of work activities into individual tasks.... For human-computer interaction to advance in the new millennium we need to better understand the emerging dynamic of interaction in which the focus task is no longer confined to the desktop but reaches into a complex networked world of information and computer-mediated interactions. (p. 192)

The distributed approach does not have to explicitly address the idea of an interface between a human and a computer in order to take issue with it. Like the embedded-embodied and extended approaches, it inherently challenges the idea of locating meaning inside heads because the structures and processes of cognitive systems are "distributed between internal and external representations, across a group of individuals, and across space and time (Zhang & Patel, 2006, p. 333). To paraphrase Putnam:[62] meaning is just not (entirely) in the head. Instead, it attempts to find answers to "how the elements and components in a distributed system – people, tools, forms, equipment, maps and less obvious resources – can be coordinated well enough to allow the system to accomplish its tasks" (Kirsh, 2006, p. 258). This also means that the demarcation of the system becomes, at best, fuzzy if we attempt to look for concrete boundaries. Instead, we have to adopt a type of systemic thinking that:

> begins with a particular phenomenon to be explained or purpose to be achieved. It then requires a degree of conceptualisation, rather than mere perception, to characterise an appropriate system in terms of components, relations and boundary. The boundary may in part have a material embodiment but generally it will simply represent a *distinction* or demarcation between that which has been selected as part of the system and that which is not. (Mingers, 2006 p. 69, emphasis added).

The boundary of the system is not a border, a physical edge, enclosure, or demarcation. It is the *distinction* that either makes something part of the system or not. The interface (or rather

[62] Putnam's semantic externalism or "meaning just ain't in the head" (1975/1985).

the interaction) is therefore not anywhere in particular, but it is everywhere interaction takes place. Ubiquitous computing (Weiser, 1991), context-aware computing (Dey, Abowd, & Salber, 2001), and pervasive computing (Ark & Selker, 1999) are to be taken literally. The dream is that when we interface the world, we interface a completely connected system. A coffee cup [12] or even a plant [12] becomes an input device while all surfaces become available as screens [57, 58]. The dream is captivating though also obviously impractical. How does one design for an interface that is everywhere at all times? "A problem with the distributed cognition approach is that it is not a methodology that one can readily pick off the shelf and apply to a design problem" (Rogers, 1997, p. 5). As an example, one can ask: how does the system pick up what is relevant whenever it is accessed? There is an assumption in distributed cognition that the system at work is known and relevant for all involved in its use. It therefore becomes interesting to investigate what a situation or context is and how much of what goes on in a given situation is context-dependent.

Situated

The last consideration brings the distributed view within inches of a situated take on cognition (Clancey, 1997; Goodwin, 2000; Haraway, 1988; Suchman, 2007; for an overview of situated cognition, see Robbins & Aydede, 2010; for a rundown of historic antecedents, see Clancey, 2008). The situated view is also intermingled with all of the above views on cognition. It therefore repeats and reinforces many of the already-mentioned claims. The particular focus that gives the situated view its name is the emphasis on the situation or context. The position is that all knowledge is activity "[T]hinking is a physical skill like riding a bike" (Clancey, 1997, p. 2), "knowing and doing" are inseparable (Brown, Collins, & Duguid, 1989), and all knowing is situated in a particular context. One cannot separate knowledge from the context in which it is generated (as abstract theoretical thought or collected in a book). This means that part of what goes on in knowledgeable behavior is triggered or emerges in the situation; part of the thought process is distributed across different people's behavior, artifacts, rules, and material layout; and overall that the situation unfolds, not as realizations of prior plans or intentions, but as practitioners' "reflective conversation" with their material, to use a phrase from Schön (1983, p. 78).

Situated cognition has found a prominent place in educational research (Brown et al., 1989; Chaiklin & Lave, 1996; Lave & Wenger, 1991). Perhaps its most direct impact within the HCI community is bringing ethnographic and ethnomethodological research methods into play (see Dourish, 1999). Relative to interfaces, the approach suffers from the same problem as the distributed view, that it is difficult to determine specific consequences of knowledge being situated for a particular design or the community as a whole (Nardi, 1995b; the perhaps most famous situated cognition text by Suchman, 2007, investigates the interface of a Xerox copy machine). A major problem has already been mentioned above, namely, that of defining context (Dey, 2001; Dey & Abowd, 2000; Schmidt, 2000). The concept is ill-defined in the literature (Dey et al., 2001; Dourish, 2004, and it competes with other terms such as work setting (Engeström & Middleton, 1996), use context (Winograd, 2001), and ecology (Ingold, 2000; Nardi & O'Day, 1999; Raptis et al., 2014). Confusion arises because the claim appears to be that meaning is created *ad hoc*, improvised *in situ* – not determined

by a set of identifiable contextual conditions – yet contingent upon it. Therefore, context is all important but not determinable. Furthermore, action exhibits regularity, but no determining factors can be found. As Agre (1997, p. 7) asks, "how can activity be both improvised and routine?"

Overview

Such questions are to be expected coming from a field that retains the work ethic, quoted above, wherein "things have to work" (Agre, 1997, p. 13). The matter-of-fact outlook of engineers and designers needs to answer the question "what is different because of this?" However, it would be a misunderstanding to simply yield to a pragmatic insistence immediately.[63] The above approaches help us, in different ways, to widen our understanding of what a thing is. They counter "the cultural perception that information and materiality are conceptually distinct and that information is in some sense more essential, more important, and more fundamental than materiality" (Hayles, 1999, p. 18). Thus, the mechanical and the meaningful are reintegrated. The meaning that is created *is* the thing that we see. Further, while our focus may be on the thing, there are constraints at work (our body, our technology, our communication, material, social, epistemic, contextual constraints, etc.) that both enable and limit what thing (i.e., meaning) is created. The point that the different perspectives labor to generate is that for *any* of the things we might focus on, there is more at stake than can be captured in locally determining what *thing* we are talking about and its relation to neighboring things. A thing cannot be simply described exhaustively within its boundaries and then added up with other fully described things to give a "complete" picture. In fact, what a thing "is" seems to have very little to do with its surface boundaries. Notwithstanding, this realization is not enough. As Drucker (2011b) points out, "recognizing embodiment only gives us a place from which to begin thinking about cognitive processing, it does not supply a basis for a theory of interface" (p. 8). To understand the creation of meaning (and hence the flow of information in a system, e.g., a collaborative work setting), we have to alter our *unit* of investigation.

The price for this altered view is ambiguity. The above theories posit that meaning is created, not found. Because meaning is created (or emerges) within a system, the world as it appears becomes the expression of the workings (enactment) of the system. The interface simultaneously becomes the edge of inception where meaning emerges. As Ishii and Ullmer (1997, p. 2) state, "the world itself is changed into an interface." It is in this way that things are to be considered endpoints of our cognition. If everything is the interface, and the interface is involved in anything "meaningful" that is created, then what handle should we grasp to determine how to design this interface? It seems that we fall back to a default position of using our everyday conceptions, which are mostly about things. Therefore, the

[63] Of course, by focusing on "business as usual," the perspective perpetuates the FoT. When ramifications for the existing design setup are requested, then the assumptions constraining the current design are uncritically adopted. Consequently, a perspective is (re-)instated wherein meaning is encapsulated in the form of a thing and each and every thing in any given situation is attempted determined. In this perspective, creating meaning is more akin to *re*-creating meaning, either so that the things we encounter are realizations of prior plans, intentions, or ideas or so that whatever meaning we arrive at is already known to us; it only needs to be formed or described (e.g., "we form an opinion of something").

contra-positioning of us (our bodies and our perspective) against different "things" we interact with is maintained – bound by the surface of things. What is needed is a position that is able to reimagine the "cut" that is made by a given interface and the meaningful world that is consequently generated (cf. article 2), preferably in a way that allows for concrete design instructions and avoids relapsing into separating form and matter (or the mechanical and the meaningful).

For this reason, it was necessary to go from the literature on cognition to understanding the precise act of creation. This moved the discussion unequivocally into philosophical territory as there are no hadron colliders for the mind, which brings us to the next set of sources. First, a few omissions have to be addressed.

There is a third wave in HCI (Bødker, 2006) that covers the "A" in the acronym 4EA. It stands for affective (Boehner, DePaula, Dourish, & Sengers, 2005; Picard, 1997). It broadens the scope of the second wave even further to include mixed use contexts and takes culture, emotion, and experience into consideration. The aim of design shifts to also incorporate attractiveness, pleasure, and value. Bødker (2006, p. 1) writes that the focus of the third wave to some extent "seems to be defined in terms of what the second wave is not: non-work, non-purposeful, non-rational, etc." There is plenty of reason to count this wave as an important development. When it is not considered here, it is because it seems that movement from the second wave to the third was neither motivated by any consensus in the field on the topics of the second wave, nor does it seem that it has brought about a host of novel interface designs. As such, either the discussions were unresolved, found infertile, left dead in their tracks or, what seems more likely, halted by the fact that cognitive science *and* philosophy have not progressed beyond the subject-object dichotomy either.

A graver omission in the literature is activity theory (Wertsch, 1989; Vygotsky, 1978, 1986). There are many highly prominent HCI scholars who identify as activity theoreticians (Bertelsen & Bødker, 2003; Bødker, 1991; Kaptelinin, 1995; Kaptelinin & Nardi, 2006, 2012; Nardi, 1995a; Nardi & O'Day, 1999). The focus on action or activity runs parallel with the inspiration drawn from pragmatism (for a comparison of activity theory, situated action models, and distributed cognition, see Nardi, 1995b). Many activity theory-inspired articles have been consulted. The choice not to include them was based on the strong conceptual position that "object" and "subject" hold in the theory. Although these concepts are not used in a conventional way, the added task of disentangling different uses was deemed an unnecessary complication, which was not balanced by gains toward the points the thesis are trying to make.

2. Making a difference (operations of distinction)

This section introduces the relevant literature in determining how meaning is systemically created. It requires a bit of explaining. Parts of this section thus contain material that would normally be part of a discussion section. As the major part of this discussion is taken in the thesis' articles, and the argument for the choice of literature depends on such an explanation,

it has been written into the state of the problem. The following section therefore explains the coherence of the choice of literature with the overall thesis problem.

When "things" are seen as expressions of a system at work, then what the above theories draw attention to can be understood as *active forces* in the creation (genesis) of things – not as direct mechanical forces that push and pull things, or as underlying causes creating phenomena (this would be a causal explanation that posits unseen or underlying things, i.e., the *ex nihilo nihil* principle), but as intensive forces that provoke flows and push systems across thresholds (DeLanda, 2002). Protevi (2007) gives an example of differences in temperature that provoke material flows: "The Gulf Stream brings equatorial heat north, warming Northwestern Europe, and sinking off Greenland as temperature drops, density and salination increase, and the stream plummets to the ocean floor to join the sub-surface ocean currents" (para. 6). A more mundane example is the draft created by the temperature difference between a heated house and cold outside air. These intensive flows push systems towards limits and across thresholds. An example of a crossed threshold would be the phase change from liquid to solid, for example, from water to ice.[64] The things we see as a result – the cuts we make in the world – are our perceptual thresholds being crossed. It is not that whatever thing we hold in our focus is unimportant; but to understand it, it makes no sense to separate it from its surroundings. If a crystal forms in supercooled pure water, we would tend to focus on the formed crystal as a thing. However, what we should focus on is its *occurrence*. Ice crystals form as a result of the phase change triggered by the presence of a nucleus (e.g., a seed crystal or an impurity). When we focus on a singular ice crystal as "the thing," we overlook the homogenous body of supercooled pure water and the crystal growth as part of the phenomenon.[65]

Understanding "things" in this in way requires a mindset that sees things as systemically enacted. The qualifier "systemically" means that it is not enough to show that meaning is enacted. The enactments have to be shown to fit into a system of creating meaning. As an example of this, we can take Jakob von Uexküll's (1957) description of the world of a tick.[66] From the time a tick is fully matured and until it dies, it reacts to only three types of stimuli or signals. First, it is directed by a general photosensitivity in the skin to climb up a bush or something similar. Second, once it is clinging to a branch, it only releases its grip when triggered by sensing butyric acid from a mammal walking underneath. Third, a sense of

[64] Bateson provides a different illustration. He describes that "it is possible to make systems out of digital neurons that will have the *appearance* of being analogic systems. This is done by the simple device of multiplying the pathways so that a given cluster of pathways might consist of hundreds of neurons, of which a certain percentage would be firing and a certain other percentage would be quiet, thus giving an apparently graded response. In addition, the individual neuron is modified by hormonal and other environmental conditions around it that may alter its threshold in a truly qualitative manner." (1979, p. 124)Intensive differences can thus give rise to discrete and "countable" events or things like a switch that is flipped when a certain threshold is reached.

[65] Bateson deftly conjures the wonder that ought to strike us when we consider a thing in isolation: "There is a profound and unanswerable question about the nature of those 'at least two' things that between them generate the difference which becomes information by making a difference. Clearly each alone is – for the mind and perception – a non-entity, a non-being. Not different from being, and not different from non-being. An unknowable, a Ding-an-sich, a sound of one hand clapping" (Bateson, 1979, p.78).

[66] See also Bateson (1979, p. 56).

temperature reveals whether it has fallen on a warm-blooded creature and triggers a sequence of actions where it burrows and pumps itself full of blood (p. 6). All three "signals" exemplify the animal *performing* its world. What makes it a system is the fact that the signals are mutually exclusive.[67] What makes it enactive is the fact that perceiving the signals are indistinguishable from performing the actions. There is not a perception first, which is then followed by an action. The tick's action *is* its perception. Things come into the world for a tick and become "meaningful" in a performative or operational sense whereby differences in perception are differences in action. If it perceives differently, it behaves differently and vice versa. In system terms, we can say that it changes state and that the perceptual change is identical to the change of action or system state. Only insofar as it has *changed* state can we say that it has perceived or sensed. The tick's perception *is* its release. Perception = action. The two coincide or, even better, should not be considered two. From a tick's "perspective," no such "thing" as an animal exists (a discrete entity). We (from our perspective) can see that there is an object that triggers release. The object, or the fact that it triggers a release, is not a concept or an idea (it is not "made up" in a separate world of the intellect), neither is it an isolated perception (a signal); it (the thing) is exactly the release of the trigger. In other words, perception is not passive; it is always active. It also means that this active perception means *doing* something different *within* a system. It is in this performative sense that systems are seen to bring forth a world (mentioned in the introduction).

Maturana and Varela's (Maturana, 1987, 1988, 2002; Maturana & Varela, 1980, 1992) theory of autopoiesis is a description in formal terms of bringing forth a world performatively. The definition runs as follows:

> An autopoietic machine is a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components which: (i) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network. (Maturana & Varela, 1980, p. 78)

An autopoietic system is a system that continuously creates and recreates itself. The processes it produces both constitute the system and produce new processes, thereby producing the result (the sustainment of the system). The theory has been well received in, for instance, sociology, inspiring Luhmann's (1995a) social systems theory. In interface terms, an autopoietic system is host to a special type of communicative exchange where the interface is "a border zone where systems of representation come into contact. It is a membrane, regulating the exchange of vital messages from one side to the other" (Kerne, 2002, p. 143). Mingers (2006, p. 68) differentiates a membrane from an enclosure (or

[67] As Bateson (1972) puts it: "Information in the technical sense, is that which excludes certain alternatives" (p. 381).

border), such that a membrane is "active rather than passive." Winograd and Flores (1986) make a notable attempt at bringing the theory into HCI. It is, as mentioned above, motivated by the question of life. Maturana and Varela (1980, p. xii) ask the dual questions: "what is the organization of the living?" and "what takes place in the phenomenon of perception?" The two questions mirror the split between the mechanical and the meaningful. As in the case of cognitive theories, it is the conflation of the two questions that is of importance. In a conventional epistemological setup, we would set the system and its environment in opposition. The so-called correspondence of what goes on in the system with what goes on in the environment poses insurmountable epistemological problems. This is solved in an autopoietic system of creating meaning.

On the "system side," an autopoietic system is treated as operationally closed. Signals in the system only refer to other signals in the system. The three thesis articles treat this under the heading of "redundancy." It is what gives the system its informational strength. All signals are performative differences or changes of state (as in the case of the tick). Within the system, "the world that is brought forth" is the interplay of differences generated by the system itself. The system is thus closed to the outside without reference to an outside and, therefore, no correspondence problem. On the environment side, "the world that is brought forth" is strictly speaking "simply" a multitude of signals or triggers. "[T]he external world [only has] a triggering role in the release of the internally determined activity of the nervous system" (Maturana & Varela, 1980, p. xv). However, as in the case of the tick, "perception" means changing the state of the system. The world (as it appears) is (still) found to be meaningful insofar as the system changes. Therefore, "the world that is brought forth" also means the usual meaningful world we encounter when we open our eyes (we do not see triggers; we are triggered). In this line of thought, the world can be said to be created or brought forth because we are not triggered in the same way as the tick, the lion, or the parakeet.

This is only possible because the *differences* that constitute the organism double as the differences by which we experience the world (like the tick). Unfortunately, the theory also threatens to ensconce us (humans) in a species-specific world.[68] Von Uexküll's (1957) theory, which can be considered a precursor to the theory of autopoiesis (Brier, 2003; Farina, 2010), designates a specific Umwelt or perceptual world for each animal; he uses the image of each animal inside its own soap bubble:

> When we ourselves then step into one of these bubbles, the familiar meadow is transformed. Many of its colorful features disappear; others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble, we see the world of the burrowing worm, of the butterfly or the field mouse; the world as it appears to the animals themselves, not as it appears to us. This we may call the phenomenal world or the self-world of the animal. (von Uexküll, 1957, p. 5)

[68] Hayles (1999, p. 10) describes the autopoietic stance thus: "We do not see a world 'out there' that exists apart from us. Rather, we see only what our systemic organization allows us to see. The environment merely *triggers* changes determined by the system's own structural properties."

Maturana and Varela (1992) seemingly accept this with little regret. Maturana (1988, p. 31) speaks of "domains of reality" that are all equally legitimate:

> Although all domains of reality are different in terms of the operational coherences that constitute them, and, therefore, are not equal in the experience of the observer, they are all equally legitimate as domains of existence because they arise in the same manner as they are brought forth through the application of operations of distinction by the observer in his or her praxis of living.

Therefore, the performative alignment between the mechanical and the meaningful is only superficial.[69] The system and the world are still set in opposition in this mindset. We should take note of the observer's role in this matter. Mingers' (2006) observations ii and iii quoted above show how the theory of autopoiesis preserves the distinction between the mechanical and the meaningful. He uses the terms "mechanistic" for the former and "explanation or description" for the latter. Within system boundaries, things are not "meaningful"; they simply *are*. It takes an outside observer to see something meaningful (i.e., an explanation or description). To reiterate:

> Observers can perceive both an entity and its environment and see how the two relate to each other. Components within an entity, however, cannot do this but act purely in response to other components. (Mingers, 2006, p. 34)

The trouble with this as well as the approaches reviewed above (4EA, distributed, situated) is that for all their efforts to overcome the subject-object dichotomy, it is ultimately still preserved in some form. It should for instance be clear that what Maturana and Varela (1980), as well as von Uexküll (1957), have done is to pit the world against different *versions* of the world, dispensing with the issue of a "true" version (relativism).[70] Crudely put, there is an overly strong urge to position the *processes* relative to the *result* of the processes (treated in article 1). Terms such an entanglement (Hodder, 2012), co-determination (Mingers, 2001), fruitful circulation (Stewart, 2010), socio-material (Orlikowski, 2007), mutual specification and co-determination (Varela, 1992), extension (Clark, 1998), and embodiment (Chemero, 2009) are just a handful of examples that indicate that there are at least two "somethings" involved in the authors' thinking. The question that is *not* posed is why it is so necessary to juxtapose the system and the environment. Unless it is to uphold the observer position that Mingers (2006) is referring to, then there seems to be no reason other than tradition that we should position a system and its environment side by side for comparison. If I wanted to learn about driving in ideal curves, would I seek "correspondences" between the mechanical workings of the car on one side and the road on the other? The example of the tick can be used to clarify this point. If we "place ourselves" in the perspective of the tick, then according to the perception = action thesis, we are not

[69] This, of course, does not mean that a non-superficial alignment would be one of realism. It means that it would be one where there was no need for an alignment.
[70] Like a Kantian "ding-fur-uns" versus a "ding-an-sich."

able to tell the difference between a thing "out there" and our actions of perception "in here" – because there is none. We would not identify something out there as a "trigger" – we would be triggered (change). Similarly, we would not identify an operation of distinction "in here" – we would distinguish (change). As Mingers' second observation states: components within an entity cannot observe the difference. A more convoluted but more accurate way of stating this is that a system has no way (none whatsoever) of deciding what is "inside" a system and what is "outside." This likely strikes most people as counter-intuitive. However, the issue has nothing to do with whether what we are trying to decide *is* inside or outside. The issue is that the inside/outside distinction is situational. In mathematical terms, the distinction is arbitrary or one of definition.[71] We can conjure the problem via Luhmann's (1995b) definition of what constitutes observation:

> Observing means making a distinction and indicating one side (and not the other side) of the distinction. (p. 85)

In Luhmann's system theory, distinction and indication are not separate. However, if we intentionally misread this quote, we might ask "which side is indicated by the distinction?" If a distinction divides something into sides, how do we know if the distinction indicates this side rather than the other? Imagine that we make a distinction – a blue mark on a white background. Our first impulse would be to say that this distinction indicates what is now marked in blue. However, if we change the blue mark into a sticker and stick it on a white canvas (like a price tag on a moving box), we might just as well state that the mark indicates the white. Since any action undertaken in a system is a change, a changing system would have no reason to assign the change (not the cause, but the change itself) to an outside or an inside. The tick does not determine whether there is butyric acid "out there" or whether there is a cognitive process of release "inside it" – it releases. The idea that we determine whether things are "out there" or "perceptions/cognitions" are "in here" (and that it matters) is put into question, not for the usual epistemological reasons (to distinguish reality or to determine its construction), but because the problem has been stripped of its obviousness. The problem setting does not include an account of whether the problem can arise at all (surely, we can question whether something is real, but the question is whether we are able to differentiate a given phenomenon as belonging inside or outside – what would that look like?).

There is considerable analysis on how signals or triggers become systemic, which I have relegated to Appendix 4. For present purposes, it suffices to state what the discussion has lead to. What I have called systemic enactment is a way of connecting the idea that a system is situated or contextual (and hence everywhere) with a systemic genesis. By "genesis," I

[71] There is a joke going around in mathematician circles: an engineer, a physicist, and a mathematician are challenged to calculate the shortest stretch of fence capable of containing a herd of sheep. The engineer jumps at the challenge and makes a square fence, which narrowly contain the sheep since a square has a smaller circumference in relation to total area than a rectangle. The physicist scoffs and makes a circle shaped fence, which narrowly contains the sheep since a circle has the smallest circumference in relation to total area. The mathematician smirks and makes a circle shaped fence, which narrowly contains himself, and then he defines himself as being outside.

mean a creative act of differentiation. By "systemic," I mean that this act also serves as an explanation of how meaning is created in a systemic way, that is, the way an act demarcates what belongs (and what does not belong) to the system. The things we (humans) see in any given perspective each exemplify the particular genesis of things (the FoT). By the time we see them, the act of differentiation that brought them about has already occurred. Considering *things* as "acts of differentiation" does not situate them "inside" our cognitive apparatus (or the things "out there"). Instead, this lays the conviction bare that "things" primarily concern phenomena. This conviction only reveals the half of it. The discussion here and the treatment in the thesis articles show that "thing" is a format that informs us of what to do and how to do it. Things are *instructions*, if you like (see article 2). When we encounter things, we have followed said instructions. The format of things serves as a demarcational principle. We know that something belongs to the system if we can make a thing of it. We recognize a thing as part of the system *because* it is a thing – regardless of which thing it is. Thus, the foundation of any system is its unit (the difference it makes). *The unit is a system's interface*. Since it follows a principle according to which it includes and excludes, the system may encompass "the whole," but it does not include everything. We are thus rescued from a view that threatens to include everything as relevant or overtax an unspecified "context" with an explanatory burden. What is and is not included are decisions relating to "what should the system respond to?" and "how should it respond?" This is not a purely mechanical matter, as Mingers' (2006) observation ii indicates, because it is not a matter for an observer to "add" a layer of meaningfulness (observation iii). Meaningfulness is a consequence of the responses being systemic (each pattern of behavior has to be different from every other because if it was not, shifting to another pattern would not be a change.)

The literature relating to difference

A system and its interface thus boil down to *making a difference*.[72] When we know the difference a system is capable of, we can recognize its interface, and we are able to analyze how it brings forth a world. It was because of this foundational aspect of "the smallest difference a system can make" (its building blocks) that it was necessary for the thesis to find an answer to how systems were fundamentally constructed and what the interface had to do with it. The matter of the genesis of things had to be considered in three ways: an original cosmogonic sense of creating worlds; an ontogenetic sense of how the assemblage of differences that we find in the form of the world has systematically evolved (without a blueprint); and a concrete sense of how each and every concrete thing, occurrence, and event can be seen as an expression of the system that made it. I pieced together answers found in Spencer-Brown's (1972; Keys, 1972) logic of distinctions, Bateson's (1972, 1979) second-order cybernetics, Deleuze's (2001) treatment of difference, and anything that could tell me what a thing is (Brown, 2009; Garcia, 2014; Heidegger, 1971). Many precursors, parallel efforts, and developments were also identified in the process: general systems

[72] It is tempting to write "basic difference" or "unit of difference," but that would lend difference an air of ontological certainty – any difference will create a system as long as every difference preceding the first one is formatted in the same way.

theory (von Bertalanffy, 1969), cybernetics (Heylighen, 1990; Weiner, 1948), and dynamic systems theory (Thelen & Smith, 1993).

One would be hard-pressed to give fair accounts of the influence that the above pantheon of thinkers have had. An excuse for the following is that it is only a particular aspect of their thinking that is at stake here: all of them can be considered world builders, each in her own way. They bear witness to the fact that the concept of "bringing forth of a world" has not been used metaphorically here. The task, as it developed, was to read across these different thinkers to find clues to how "making differences" brings forth a world.

I begin with Spencer-Brown (1972), since both Luhmann (1995a) and Maturana and Varela (1980, 1992) build upon Spencer-Brown's logic of distinction and are in dialogue about its foundational aspects (Luhmann, 1995b, 1998, 1999, 2002; Varela, 1979). Spencer-Brown's grandiose statement at the starting point of his logic holds not even the slightest hint of irony:

> [A] universe comes into being when a space is severed or taken apart. (Spencer-Brown, 1972, p. v)

The statement shows the foundational role that "making a difference" plays in a system. The concept of difference answers – in every respect – the "ancient" question of how *something comes from nothing*.[73] The question that divides the answers is whether difference arises from identity or identity from difference, or rather, the real division is whether difference is considered a question to be answered or one to be posed. Spencer-Brown (1972) clearly answers the question. His entire system can be built from a single primordial or originary (first) creative act. Every*thing* that comes after this act echoes and repeats the first act. This means that the first creative act is a difference, one that springs from identity or sameness. Spencer-Brown calls the creative act – or severing – a "form," a "mark," or a "cross." In *Laws of Form* (1972), he develops two laws that, together with the form, constitute a system by which it becomes possible to reconstruct "the basic forms underlying linguistic, mathematical, physical, and biological science and… begin to see how the familiar laws of our own experience follow inexorably from the original act of severance" (p. v). In other words, it is a theory of everything, literally, in a single form. Spencer-Brown's influence stands in stark contrast to his relative obscurity outside the circle of mathematicians, logicians, and semioticians. Part of the explanation is that his theory is presented in complex mathematical terms; another is that his attempt at a "popular" introduction (Keys, 1972) is

[73] Leibniz' (1697, pp. 527) famous statement asks "why there is something rather than nothing?" – but all mythological cosmogonies implicitly ask a similar question. How can something come from nothing? Spencer-Brown, writing under the pseudonym James Keys, uses the term "void" rather than nothing:
"In the deepest order of eternity there is no space. It is devoid of any quality whatever. This is the reality of which the Buddha speaks. Buddhists call it Nirvana. Its order of being is zero. Its mode is completeness .... Having no quality at all, not even (except in the most degenerate sense) the quality of being, it can have none of these suggested properties [being, priority, temporality], although it is what gives rise to them all. It is what the Chinese call the unnamable Tao, the Mother of all existence. It is also called the Void" (Keys, 1972, p. 123).

highly esoteric (for an introduction to Spencer-Brown, see Robertson, 1999). Spencer-Brown's form can easily be related to the format of things. His answer to the problem of "how something comes from nothing" is a cross or a distinction. The Wikipedia article on *Laws of Form* (quoted here because Spencer-Brown's points are given in everyday terms, not mathematical) determines a cross to signify three things simultaneously:

- The act of drawing a boundary around something, thus separating it from everything else.
- That which becomes distinct from everything by drawing the boundary.
- Crossing from one side of the boundary to the other.[74]

The three relate to three of the angles on interfaces discussed above: the ideas of the interface as a boundary, as an artifact, and finally as enacted. Any "thing" – considered as an expression of a format – accomplishes all three *at once*. It has a boundary. It becomes foregrounded from everything else (in a figure/ground dyad). Finally, it has to pass from non-existence to existence (becoming or *creatio ex nihilo*). It is of secondary importance whether we think of this as enactment or creation or both. A thing can therefore be said to carry all of the signatures of a distinction. Therefore, it can be designated as an "act of making a difference" that brings forth a world or, as developed here, an interface.

The trouble is that Spencer-Brown (1972) does not tell us *where* the distinction comes from. Just as in the case of a system deciding what is inside and outside, the ultimate question that Leibniz (1697) asks (why is there something rather than nothing?) is a question of meaning. He has given us a tool to build *any* world, but he has neglected to give us a reason to make one world over another. We are thus stuck in Mingers' (2006) separation of the mechanical and the meaningful. The purely mechanical is, in a sense, blind even when it comes to seeing. Consider von Uexküll's (1957) thoughts on different external stimuli on an optic nerve:

> Since the time of Johannes Müller we know that a muscle responds to all external agents in one and the same way – by contraction. It transforms all external interference into the same effective stimulus, and responds to it with the same impulse, resulting in contraction. Johannes Müller showed also that all external influences affecting the optic nerve, whether ether waves, pressure, or electric currents, elicit a sensation of light. Our visual sensory cells produce the same perception whatever the source of stimulation. (p. 9)

We could choose to conclude that an eye that sees the *same*, regardless of the stimuli, is blind. Similarly, Lettvin, Maturana, McCulloch, and Pitts (1968) provide an example of frogs that have been shown to ignore food right next to them but vigorously "hunt" moving dark spots created by the experimenters. "The frog does not seem to see or, at any rate, is not concerned with the detail of stationary parts of the world around him. He will starve to

[74] https://en.wikipedia.org/wiki/Laws_of_Form

death surrounded by food if it is not moving" (p. 235). In the same way, Hoffman (2009) gives the example of male jewel beetles living in Western Australia that attempt to mate with empty beer bottles. They do so because the bottles are "shiny, dimpled, and just the right shade of brown to trigger, in the poor beetle, a category error" (p. 1). When we conclude that the frog and the beetle commit errors, we likely do so with the idea that what "goes on" in the frog/beetle does not correspond with what they aim for (so we assume a type of meaningfulness although it is instinctual or even mechanical). If, however, we grant them the same type of performative world as the tick, their perceptions cannot be "erroneous."[75] They either switch or refrain from switching into patterns of behavior, which means that their perception is a crossing or a distinction (into a different type of action); it is not separate from their behavior. We can still conclude that for the survival of their species, it would be beneficial for them to distinguish between flies and dark spots or female beetles and beer bottles, but they are not committing any errors. This is a way of stating that information – or that which we have called the "mechanical" here – cannot be considered "meaningless." The entire separation of the meaning*less* mechanical and the meaning*ful* hinges on information being separable in a logical, symbolic, mathematical, cognitive, representational way that makes use of signals, functions, processes, and mechanisms that "in themselves" are devoid of meaning.

The problem is, of course, that there is no information "in itself." Articles 1 and 2 discuss the implications of this insight. The gist of their findings is that information is best understood as changes. Lewontin (2000) uses an example of travelling to illustrate how DNA only becomes "information" about the organism "in the actual process of cell function" (p. xiii): "If I drive eighty miles west and twenty-five miles north, it is impossible for you to know that I will arrive in Brattleboro, Vermont, unless you know that I started in Boston" (p. viii). Like Lewontin's travel directions, information consists of changes. When changes are put on hold, they become instructions waiting to be resolved. Changes that are inert are not information (this would be changes that do not change). This also means that we have to produce the distinctions before we can cross them. We have to produce the instructions in order to follow them. What is before you *hic et nunc* (the text) are rows after rows of distinctions – that by the time you reach the next period – have all been crossed.[76] The "information" that we see and identify as material symbols are not the changes they supposedly represent. They are the differences by which we elicit changes similar to the changes elicited by the environment (discussed in article 2). That is another way of saying that logic, mathematics, text, and cognition are not phenomena in a different realm separated from the "real world." They are part of the real world. We try to capture changes, but we

[75] Dretske (1998, p. 69) argues this point: "If the function of the neural detectors on which the frog depends to find food is merely that of informing the frog of the whereabouts of small moving dark spots, then the frog is not misrepresenting its surroundings when, in the laboratory, it starves to death while flicking at shadows. For the internal representation triggering this response is perfectly accurate. It indicates what it is supposed to indicate: the presence and whereabouts of small, moving dark spots. The shadows are small moving dark spots, so nothing is being misrepresented."

[76] Only now that we have been made aware of them, they settle into a different register of changes whereby we see them as differentiated from the background (i.e., symbols or marks).

have to do so in mechanics that elicit these changes. We therefore mistake the mechanics for the changes, or in Korzybski's (1933) terms, oft-quoted by Gregory Bateson, we mistake the map for the territory. Bateson (1979) sees, with uncommon acuity, that patterns or distinctions are not "ideal entities" captured in a Platonic form world; they are part of the world and can be found in infinite variety. The question is not "where does meaning come from?" The question is rather "what is the pattern that connects one type of meaningfulness with another?" or in Bateson's elegant prose:

> What pattern connects the crab to the lobster and the orchid to the primrose and all the four of them to me? And me to you? And all the six of us to the amoeba in one direction and to the backward schizophrenic in another?" (1979, p. 16)

The relationship between the text and the world is not one of representation but one wherein the patterns enunciated with the text are cognate with the patterns enunciated with the world:

> The shapes of animals and plants are transforms of messages. Language is itself a form of communication. The structure of the input must somehow be reflected as structure in the output. Anatomy *must* contain an analogue of grammar because all anatomy is a transform of message material, which must be contextually shaped." (Bateson, 1979, p. 27)

Hence, the living world of patterns that Bateson sees is an ecology full of distinctions. There is no need to search for the creation of distinctions or bestow the label of "meaningful" on a particular set of distinctions. They are all meaningful. Bateson is probably the original inspiration to the thinking presented in this thesis. Part V of his main work *Steps to an Ecology of Mind* (1972) explains such concepts as redundancy, mapping, and difference, which play a major role in the thinking conveyed in the thesis. Despite attempts, his writing defies categorization (e.g., as an ecological thinker; for an introduction, see Charlton, 2008, although his texts easily stand on their own). His theoretical works could therefore be deemed to lack a uniform direction, but this would be a misunderstanding. While there is no ambition of grand theory building in the tradition of Hegel or Kant, his thinking is clearly rooted in the idea of looking for the "pattern that connects" everything (Bateson, 1979, p. 16). Bateson's many acute insights reveal themselves and are best seen as patterns of thought. These patterns always simultaneously reveal something about the world as well as something about us as worldmakers. Remarkably, they often do so in a manner where the pattern itself instantiates the revelation. Just as a system is revealed in the difference it makes (and which makes up the system), Bateson provides patterns or examples that are self-contained. A prime example is his most famous concept: the definition of a unit of information as "a difference that makes a difference" (1972, pp. 315, 459; 1979, p. 110). It is an important formulation of 2.order cybernetics or the inclusion of the observer in the observed. Bateson's easy prose belies the elegant complexity of his thoughts. The phrase marries the mechanical and the meaningful such that the first "difference" can be read as mechanical and the second "difference" can be read as meaningful. Ingeniously, the phrase

could of course be read in reverse, but the phrase really ought to be "difference"[2] (difference squared) because Bateson's overall point is that there are no *two* differences, only a difference that makes a difference is a difference proper (it is nonsensical to have a difference that made no difference). So the difference Bateson speaks of is the enacted difference par excellence. He approaches it in an extremely judicious manner:

> Difference, being of the nature of relationships, is not located in time or in space. We say that the white spot is 'there,' 'in the middle of the blackboard,' but the difference between the spot and the blackboard is not 'there.' It is not in the spot; it is not in the blackboard; it is not in the space between the board and the chalk. (1979, p. 109)

The quote would be perplexing if we did not recognize it as a resistance to the format of things. Giving in to the temptation of capturing the difference as a thing would conceal its enactive nature – the thing has to occur. Bateson's patterns lay the ground for the basic intuition in extended, distributed, and situated cognition that a system (e.g., a cognitive system) is not demarcated by physical boundaries, regardless of how intuitive they may appear:

> The total self-corrective unit which processes information, or, as I say 'thinks' and 'acts' and 'decides,' is *a system* whose boundaries do not at all coincide with the boundaries either of the body or of what is popularly called the 'self' or 'consciousness.' (Bateson, 1972, p. 319)
>
> The network is not bounded by the skin but includes all external pathways along which information can travel. (p. 319)

What is important are the distinctions drawn by the systems and that they do not respect the boundaries of physical entities. An already discussed example is the distributed cognitive work done by the crew of a ship (Hutchins, 1995a).[77] The distinctions that a system draws are always provisional and opportunistic.[78] As Latour (2005) notes, social aggregates are the object of performative definitions, and "the object of a performative definition vanishes when it is no longer performed – or if it stays, then it means that *other* actors have taken over the relay. This relay, by definition, cannot be "the social world" since this is the very world in dire need of a fresh relay" (p. 37, emphasis in original).[79] Like Latour, Bateson (1979) ultimately differentiates between that which is mind and that which is nature (his last work bears the title Mind and Nature – A Necessary Unity, 1979). Even if the two are not

[77] A different example would be an actor-network, as discussed in actor-network theory (Latour, 2005; Law, 2007; Callon, 1986), had it not been for the explicit emphasis on entities and the mixing of the material and the semiotic.

[78] E.g., the Danish politician Erhard Jacobsen was famously accused of willfully missing a vote in parliament in 1973, triggering a general election. His excuse was that he was stuck on the freeway as his car had run out of gas. The lack of gasoline thus **became** as aspect of the performance of Danish democracy

[79] I do not mean to say, in relation to the example given, that Danish democracy ceased to function; on the contrary, it carried on functioning, incorporating the absence of the politician and the lack of gasoline into its enunciation.

relegated to separate realms, and the social is seen as ripples in the water, there is still something that comes into existence and disappears again.

> We draw distinction; that is, we pull them out. Those distinctions that remain undrawn are not. They are lost forever with the sound of the falling tree which Bishop Berkeley did not hear. (Bateson, 1979, p. 107)

We are thus responsible for differences in the world. We draw the lines. We make the cuts. Bateson adopts Carl Jung's distinction between pleroma (the undifferentiated world) and creatura (the differentiated world) in order to speak of the world as we know it as opposed to the world as it would be entirely undifferentiated (1972, p. 462). These terms largely correspond to Spencer-Brown's (1972) distinction between what he calls the Void and the mark/cross. In the Void, or pleroma, there are no distinctions. "The pleroma knows nothing of difference and distinction" (Bateson, 1972, p. 462). Through the crossing, a world comes into being – and so do the distinctions. Bateson comes very close to expressing the same relation as Deleuze between intensive forces and extensive results, which was exemplified above (the Gulf Stream):

> We have been trained to think of patterns, with the exception of those of music, as fixed affairs. It is easier and lazier that way but, of course, all nonsense. In truth, the right way to begin to think about the pattern which connects is to think of it as primarily (whatever that means) a dance of interacting parts and only secondarily pegged down by various sorts of physical limits and by those limits which organisms characteristically impose. (1972, p. 22)

In other words, we focus on the fixed affairs (things or extensities) and overlook the intensities with which they are created. Furthermore, we believe that the extensities, by the act of creation, are or become something new and different (emerging) from their intensive origin – as if water changing from solid to liquid suddenly brought something new into existence. The distinctions between Void and mark and pleroma and creatura are cosmogonical, which accounts for the creation of what was before there was something. Deleuze and Guattari (2002) provide a similar cosmogony with a mythological air with the concepts of the "plane of consistency" (see Bonta & Protevi, 2004, p. 124), the "plane of immanence" (1994), and the "body without organs: (2002, 2004). Colebrook (2002, p. 76) gives this account:

> First, there is chaos or the flows of differences that are life, prior to any organized matter or system of relations. Deleuze and Guattari refer to this as the 'chaosmos.' It is not yet a 'world'; nor is it life perceived as a whole (cosmos) formed out of chaos; it is radically outside. Second, from this flow of differences or these singular forces and intensities certain organisms are differentiated.

Unlike the two former distinctions, these concepts are not created to give testimony to an originary creative Big Bang. The organisms that are differentiated, which Colebrook (2002)

speaks of, are not created as "more" than they were before; they are not realizations of prior forms, or testimonies to an original creative act, or the arrival of the "real" as opposed to the only-potential. Instead, that which is created are ways of dealing with chaos in which "all intensive differences are contained – "complicated" but not "explicated." It is a chaos that "envelops and distributes, without identifying, the heterogeneities that make up the world. In other words, Deleuzian Chaos is formless, but not undifferentiated" (Parr, 2005, p. 43). In much simpler terms: the creation from chaos that Deleuze and Guattari (2002) speak of does not emanate from nothing to something (*creatio ex nihilo*). It is from something to something else or rather from some~~thing~~ to some~~thing~~ else. The strikethrough signifies that the statement is not meant to adhere to the *ex nihil nihilo fit* condition. It is not a thing from which another thing comes. Rather, it is to speak of change, transformation, and creation without reference to a prior seed or "blueprint" – that it is possible to actualize something that brings possibilities into existence that were not possible before without having *added* anything. Once created, the things that are created are ordered by principles of identity by "imposing structures, creating hierarchies, conceiving of things as 'the same' from one moment to the next, using definitions to limit meanings, and ignoring new and potentially creative inquiries" (Parr, 2005, p. 204). The world we know has been organized by what Deleuze and Guattari (2002) call strata. "Life does not produce closed forms, but 'strata' – relatively stable points that slow the flow of difference down by creating a distinction between inside and outside" (Colebrook, 2002, p. 76). These strata are actualized systems that work by continually capturing "matter from milieus" and organizing it to produce "stable structures" (Bonta & Protevi, 2004, p. 150). This organization does not hold *more* than there was before,[80] so there is no addition of distinctions as in autopoietic systems. These are already contained "complicated" (that is folded into being, from Fr. plier – fold), but not "explicated" (that is, unfolded). Creation is *immanent* and ongoing rather than transcendent. What is there and what is created were always there, only different.

The creation that is at stake is one whereby we catch a glimpse of the intensive origin of things – when a thing breaks down and is replaced by another; when a new idea springs into life; when a pattern is broken and altered. This is not a "return" to chaos but the plane of consistency that assures "the production and sustenance of all intensities" (Zukauskaite, 2014, p. 80). On this plane,

> there are no longer any forms or developments of forms, nor are there subjects or the formation of subjects. There is no structure, any more than there is genesis. There are only relations of movement and rest, speed and slowness between unformed elements,

[80] This does not mean that the world is to be counted as a known set of possibilities only waiting to be actualized. That would rob us of the possibility of innovation. Deleuze (2001, p. 212) borrows the term "Divergent actualizations" from Bergson (1998). For Bergson, the idea was to shed light on the problem of innovation; if the future is simply the realization of possibilities already dormant in the past, there is no true innovation. For the future to remain open, it has to be able to produce possibilities that were never before possible. Deleuze uses the distinction virtual-actual (Deleuze & Parnet, 2007; Deleuze, 2001, p. 212) instead of "possible-real" to express the idea that something can arise out of a beginning that has no blueprint to guide the final result. DeLanda (1998, p. 30) argues, as mentioned earlier, that Deleuze conceives of the relation between actual and virtual as a kind of problem-solving, i.e., instantiated in even the simplest of systems.

> or at least between elements that are relatively unformed, molecules and particles of all kinds. (Deleuze & Guattari, 2002, p. 266)

The attempt to see these intensive forces is the same as the attempt to reveal the genesis. Deleuze (2001, p. 223) puts it this way:

> It turns out that, in experience, intension (intention) is inseparable from an extensio (extension), which relates it to the extensum (extensity). In these conditions, intensity itself is subordinated to the qualities which fill extensity (primary physical qualities or qualitas, and secondary perceptible qualities or quale). In short we know intensity only as already developed within an extensity, and as covered over by qualities.

In the language of "things" that has been employed here, we can say that we are so used to things that when we attempt to express what came before, it has to be in the language (format) of things. We imagine a prior thing (or in the case of being as such – a non-thing, that is, chaos, nothingness, the void, etc.). The alternative "before," according to Deleuze (2001), is one teeming with intensities. When things alter, they – for a brief moment – let go of their organization, and the opportunity for them to become something else arises. This is the body without organs. It is like Bateson's (1972) remark that difference is not located anywhere, although it is tempting to think of it as "between."

> The [Body without Organs] causes intensities to pass; it produces and distributes them in a *spatium* that is itself intensive, lacking extension. It is not space, nor is it in space, it is matter that occupies space to a given degree. (Deleuze & Guattari, 2002, p. 153)

The plane of consistency is a field of "experimentation" (Bonta & Protevi, 2004, p. 124). In information theory, this would only be recognized as "noise" or something to be eliminated. However, as Bateson (1972) remarks, this is where innovation comes from:

> All that is not information, not redundancy, not form and not restraints—is noise, the only possible source of *new* patterns. (Bateson, 1972, p. 416).

Deleuze (2001), the most complicated of writers to influence this thesis, cannot, like most great philosophers, be summarized without running the risk of grave omissions, simplifications, and distortions (for introductions, see Bonta & Protevi, 2004; Colebrook, 2002; Parr, 2005). He writes with equal ease on philosophical matters, movies, art, literature, and politics. His prose (especially in his later works) strikes the uninitiated as impenetrable bordering on mystical. As mentioned earlier, together with his collaborator Felix Guattari, he appropriates vocabulary, images, tools, and concepts from a range of disciplines and wrestles from them in new ideas. Deleuze and Guattari, in their work *What is Philosophy?* (1994) conceive of philosophy as the creation of concepts (Smith & Protevi, 2015). The conceptual apparatus presented above, in itself, gives rise to novel ideas. In the same way, it suggests that matter or the world is in no short supply of distinctions (or even observations to pick out distinctions). We do not have to assume responsibility for the

differences in the world and, ultimately, for the creation of meaning in the world. The world is already meaningful. Deleuze's philosophy attempts to:

> replace essentialist views of the genesis of form (which imply a conception of matter as an inert receptacle for forms that come from the outside) with one in which matter is already pregnant with morphogenetic capabilities, therefore capable of generating form on its own. (DeLanda, 1998, p. 30)

Therefore, differences, distinctions, and meaning are not *imposed* on the world; they are immanent to it; they arise from it. Deleuze (2001) is a differential thinker whose thought provides much needed resistance to what Ingold (2000, p. 340) calls the idea that "culture is conceived to hover over the material world but not to permeate it." Alongside Derrida (2002), he thinks difference anew so that it is no longer subjugated to identity. He attempts to think about the difference "between" the chalk and the blackboard that Bateson (1979) speaks about. The treatment here allows us to see that thinking about difference or distinction is not simply about the difference between "this and that" or a discussion about a discrete definition of difference. It connects the very smallest with the very largest. If we provide all of being with a different cosmogony, then it affects the tiniest of differences. Thinking about differences and intensities was necessary for a theory that inquired into the nature of interfaces because, as shown earlier, interfaces are responsible for the creation of differences. It is only by reaching this point that are we able to take on the task of thinking things without things.

It was not possible to examine the format of things without a firm grasp of its enunciation (its genesis), which brings it to life. Without such an awareness, every concept created, every thought offered, potentially only perpetuates the format of things. Any conceptual treatment would be minted in the format.[81] Every case in point, metaphor, or example would have to awkwardly point to itself while maintaining its enunciation. The reflexive problems created by a methodological approach would spiral into a *mise en abyme*. It had to be made apparent that the interface that allows us to see phenomena will present itself the same way. In particular, the format of things had to be made apparent in relation to interfaces. When Grosz (2009) states that the thing is an "outlined imposition" on the world, she carries the conviction that distinctions belong to us and that, without us, matter would be entirely undifferentiated (and thus meaningless):

> The thing is what we make of the world rather than simply what we find in the world, the way we are able to manage and regulate it according to our needs and purposes (even if not, as James suggests above, at will or consciously. We cannot but perceive the world in terms of objects. We do not do so as a matter of will). The thing is an outlined imposition we make on specific regions of the world so that these regions become comprehensible and facilitate our purposes and projects, even while limiting

[81] As mentioned earlier, Garcia (2014) makes a valiant attempt to think the thing without dealing with an abstract concept of thing or being swallowed by the facticity of a particular thing.

> and localizing them. Things are our way of dealing with a world in which we are enmeshed rather than over which we have dominion. The thing is the compromise between the world as it is in its teeming and interminable multiplicity […] and the world as we need it to be or would like it to be… (p. 126)

The purpose was never to state that things are unreal. That is not the case. They are real. The purpose was to make the format observable in order to remain open to alternatives. Even though things are real, a world without them is possible. We can enact a different real world. The format of the thing had to be made apparent not only in itself but also in its consequences. Grosz describes how the thing freezes (it becomes static) at the same moment when the space it occupies is inscribed:

> The thing and the space it inscribes and produces are inaugurated at the same moment, the moment that movement is arrested, frozen, or dissected to reveal its momentary aspects, the moment that the thing and the space that surrounds it are differentiated conceptually or perceptually. (2009, p. 126)

The resistance to the juxtaposing of the system and environment (subject and object) was not only an empty repetition of a critique that is seemingly endlessly reproduced across different fields (Ingold, 2012). It was a refusal to accept the critical (discursive) position that believed itself to have accurately framed the problem as an annulment or transcendence of a boundary between a subject vis-à-vis an object. When encountering a new text, one only has to read on until the announcement of this (or a similar) dichotomy. Regardless of whether the text purports to examine, enforce, or overcome the dichotomy, it is evident that beyond that point, the format of things is recognized. It was necessary to make that apparent in order to create a particular awareness, one that recognized a second-order isomorphism between the dichotomies found in disparate phenomena with the observer position that pointed them out. The position (from the corridor) from which the dichotomies were pointed out *reproduced a subject-object dichotomy*. The insight that dissolves such a position is that the particular making of a difference, and thus the interface (or format) that produces it, is signaled by the relative position that a difference takes in an ecology and nothing more.

3. What you see is what you do

Once the hegemony of the format of things was broken, other possibilities could be made available. Thus, reaching this mountaintop provided a clear view of the next one: how to make a different interface available. We "just" have to create a different difference. This third part presents literature on the future task of creating novel differences. It also contains a review of interface concepts and novel input/output systems that are currently available in mainstream media. Creating a new "difference" is not as simple as discarding the concept of things and starting afresh. Developing a new language while extricating ourselves from an old is no easy task. The imaginary horizon from whence ideas supposedly come is still formatted in the language of things. "Design problems are constrained both by explicitly

formulated requirements and constraints, and by implicit assumptions about the form of the solution" (Stacey & Eckert, 2010, p. 249).[82] As Drucker (2011b, p. 9) puts it:

> If we have an elaborate, extensive, language for describing thing, or entities, in any number of useful ways, we have an impoverished vocabulary for describing relations among them, especially when those relations are not static, but dynamic, and constituted as events, rather than fixed in hierarchies (like kinship, value systems, or databases, to cite a few examples).

The proposition lodged within the thesis of the Format of Things is that there are constraints at work that radically shape our mind and world. It is found in titles such as *How Things Shape the Mind* (Malafouris, 2013), *How the Body Shapes the Mind* (Gallagher, 2005), and *Philosophy in the Flesh* (Lakoff & Johnson, 1999). This thought is not new. In media theory, McLuhan (1964) famously proclaimed the medium the message; in linguistics, there is the popularized notion that language affects thought known as the Sapir-Whorf hypothesis; and Ong (2002) famously wrote about the effects of writing and orality, respectively, on the mind:

> Persons who have interiorized writing not only write but also speak literately, which is to say that they organize, to varying degrees, even their oral expression in thought patterns and verbal patterns that they would not know of unless they could write. (2002, p. 55)

Fleck (1979) speaks of thought styles that determine "the formulation of every concept" (p. 9). Thought styles are social constraints on thought that are socially reinforced and "constrains the individual by determining what can be thought in no other way" (p. 99), somewhat like the duality of structure in Giddens' (1979) theory of structuration. Hoffman's (2009) theory of "perception as interface," quoted earlier, posits a "*species-specific user interface* that guides behavior in a niche. Just as the icons of a PC's interface hide the complexity of the computer, so our perceptions usefully hide the complexity of the world, and guide adaptive behavior" (p. 1, emphasis in original). The charge of determinism is ever-present against these theories. This is a much more complex discussion, which, unfortunately, space does not allow here. I do not consider what is said here as deterministic; it is probabilistic along the lines of Drucker's (2011b) statement that "Interface is not a thing, but a zone of affordances organized to support and provoke activities and behaviors probabilistically, rather than mechanically" (p. 7). Aside from determinisim, the theories are also subject to the reflexive problem that this thesis has taken such care to consider and that I believe should lie at the forefront for anyone seriously considering them. Wittgenstein's (2005, para. 5.6) declaration: "The limits of my language mean the limits of my world," points to the reflexive (or transcendental) problem that if there truly are fundamental conditions to our thought, we seem to have transcended them in

[82] Nadai and Maeder (2008, p. 10) express the same thought in relation to social forces: "Constraints in the sense of internalized social forces (norms, values) impose boundaries on decisions and actions by shaping expectations of possible outcomes."

being able to determine them. What has been said here goes in the other direction. There is no transcending of conditions. There is no outermost corridor or an innermost truth. There is only the circumvention of a particular set of conditions. If we change what things are themselves, the world changes with us.

Gibson (1986) provides the most lucid example of an approach that aims to alter how we perceive things (literally and figuratively). In *The Ecological Approach to Visual Perception*, he proposes the idea of direct perception. It is the idea that the qualities of the world – or what he calls "affordances" – are directly perceived. There are quite a number of different takes on the concept (Chemero, 2003; Stoffregen, 2000; Turvey, 1992; for an overview, see Bærentsen & Trettvik, 2002; Jenkins, 2008; McGrenere & Ho, 2000).[83] The concept is easily misconstrued as claiming a particular privileged access to the world or mistaken for naïve realism, that is, the claim that the world is simply given to us because the world simply *is* as it seems to us (Noë, 2002). However, the proposition is to be understood along the lines of distributed or extended cognition. Cognition does not take place "in the head," but rather, the world as it appears to us *is* cognition taking place. The challenge is to not simply see things in the world "out there" but to understand that the act of cognition – and, in this case, perception – is taking place "out there" as well. His ideas on affordances are known to many within the field of HCI as the concept has been popularized in the community by Norman (1988). There are considerable differences between Norman's concept of affordance and Gibson's. In Norman's parlance, an object indicates or signals certain action-possibilities. A well-designed doorknob signals whether it is to be turned, pushed, or pulled. Norman makes affordances relational so that an actor's context and the qualities of an object can be said to play a role in the perception an actor has of it (he distinguishes between real and perceived affordances). Gibson's (1986) original concept is of much greater consequence in the reimagining of the interface. Gibson himself did not make peace with the existing conceptual apparatus available to him. Like for other cognitive theories, Gibson would ideally dispense with the subjective-objective dichotomy altogether, but he settled with the rather unsatisfactory answer "both, yet, neither, nor":

> An affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer. (Gibson, 1986, p. 129)

Consequently, part of the problem is built into the attempt to overcome the dichotomy itself. Relative to the focus here, what Gibson intends in the proposition of direct perception is clear. The cognitive processes involved in perceiving are not simply processes of seeing but

[83] It is also possible to point to a number of precursors to the concept such as Lewin (1917, 1936; see May & Achiam, 2014). Almost a century before Gibson's seminal work, Bergson (1991) pondered the same idea: "The objects which surround my body reflect its possible action upon them" (p. 6), without coining a term for it.

relate to other parts of our cognitive apparatus, for instance, our motor skills and our proprioception (internal sense of body). This means that there are skills, such as navigating or manipulating objects in the world, tied to seeing (November, Camacho-Hübner, & Latour, 2010). An object not only appears in our visual field to be seen but is also to be walked around, picked up, or sat upon. Its properties are therefore in the clumsy language of "system and environment," on the one hand, its own (a fact of the environment) and, on the other, related to what we do or can do with it (a fact of behavior). Therefore, what the concept of affordance brings us is an awareness that in the "what" of the thing, we can also see the "how" of it. When we see a thing, we are able to recognize that we see a cognitive act taking place (like Fontana's cut). However, we are also able to see that "that which sees" is not the disinterested eye of a neutral observer; it is tied into an assemblage (that not only counts the being or animal) that has a vested interest in what is seen.

> The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or for ill. (Gibson, 1986, p. 127)

An object affords picking up or sitting upon because we have arms and buttocks. We can see *directly* whether an object is walk-around-able or sit-upon-able because it belongs to an environment we navigate with a body that is partly responsible for the environment. Gibson's theory is written as a theory of perception, but its points transfer well to cognitive matters. The "body" and environment we have to take into account are "epistemic constraints," if you like, that predispose us toward certain patterns and figures of thought. The throat, vocal cords, and tongue that allow us to speak; the granularity of our vision, the surface and inscription tools that allow us to read and write; the Gestalt psychological principles, the social conventions, and the habits of thought – all constrain our thought and make some patterns (not determined, but) more likely than others. The pattern pointed out here is that which is most easily overlooked, that our thoughts are given in the format of things. If we want to change these patterns, we should change the format.

Direct manipulation?

The one concept within HCI with the potential of sparking such a change is the idea of direct manipulation interfaces (DMIs), as envisioned, for instance, by Douglas Engelbart in the 1960s. Direct manipulation is the continuous representation of objects and actions of interest, physical interaction rather than complex codes, and rapid, incremental, and reversible operations coupled with immediate feedback cycles (Schneiderman, 1997). The idea was and is to give the "qualitative feeling that one is directly engaged with control of the objects – not with the programs, not with the computer, but with the semantic objects of our goals and intentions" (Hutchins et al., 1985, p. 318). The mouse controller is often held out as the first attempt at realizing this vision. However, the vision was never realized. The mouse controller is itself a paradoxical example. Perhaps because the interaction with a mouse is more analogue or tactile than "interaction" via a keyboard, the authors ignore the

fact that if we "touch" the object *via* the mouse, then the manipulation, by definition, stops being direct.[84] The mouse was seemingly already "transparent" at its inception.

> The systems that best exemplify direct manipulation all give the qualitative feeling that one is directly engaged with control of the objects – not with the programs, not with the computer, but with the objects that concern us. Are we analyzing data? Then we should be manipulating the data themselves; or if we are designing an analysis of data, we should be manipulating the analytic structures themselves. Are we playing a game? Then we should be manipulating directly the game world, touching and controlling the objects in that world, with the output of the system responding directly to our actions, and in a form compatible with them. (Hutchins et al., 1985, p. 318)

What should be glaringly obvious in this quote is that, aside from the game world, the objects that we are supposed to touch directly do not inherently "look like anything." Data does not look like folders or file icons. An analysis does not "look like" a bar chart or a pie diagram. The authors reveal that the information they have in mind is paper-based when they reference Sutherland's work on the *Sketchpad* and his discussion on the "power of graphical interfaces, the conception of a display as "sheets of paper," the use of pointing devices, the virtues of constraint representations, and the importance of depicting abstractions graphically" (p. 316). The quote provides clues to the reason that DMIs have not yet been realized. When it comes to designing the interface, too much emphasis has been placed on what it should look like (metaphor, usability) and too little on how it is done (created). Conversely, when it comes to designing the means of control, too much effort has been invested in making particular processes possible, and not enough effort has been spent considering whether the results these processes aim at are the right ones. The research and design suggestions presented below show that projects focused on output (displays, HUDs, holographic images, etc.) have been *results*-oriented while those focused on input (wiimotes, the body as an input device, etc.) are *process*-oriented. Both ought to be oriented toward the creation of meaning. I discuss this in article 3. The future of interfaces is conditioned upon figuring out how to make "digital matter" behave in a way that makes it possible for us to weave and manipulate information into intelligible patterns. The computer is a medium whereby so many constraints of speech and writing are no longer necessary, but we have not replaced them with new constraints and so we starve our minds. These points are made by the embodied and extended view:

> [W]ork materials are more than mere stimuli for a disembodied cognitive system. Work materials from time to time become elements of the cognitive system itself. Just as a blind person's cane or a cell biologist's microscope is a central part of the way they perceive the world, so well-designed work materials become integrated into the way people think, see, and control activities, part of the distributed system of cognitive control. (Hollan et al., 2000, p. 178)

[84] Of course, using a strict definition of "direct," the only true direct manipulation are brain-machine interfaces.

A vocabulary and perspective that understand the immanent nature of meaning are therefore needed. Few thinkers embrace such an understanding better than Ingold (2000, 2010, 2011a, 2011b, 2012, 2013). His ecological perspective does not draw up a world centered on a subject gazing disinterestedly upon pre-existing objects and manipulating them with pre-defined actions. Rather, the world of materials is contingent and in constant flux whereby gatherings (Things with a capital T) constitute processes, things, and the skills that produce them. The material is not inert matter upon which we impress forms; it is an active part of the relationship that forges the world. We have to listen to the material (Löwgren & Stolterman, 2004) and, like a designer, be in a reflective conversation with the materials of the situation (Schön, 1983). Worldmaking is a skillset and one that is grown anew in every generation (Ingold, 2010, p. 5, 186). An enskilled world is much more complex than a world in which forms are found fully-formed or discovered in the recesses of the mind. In it, hunting caribou (2000), weaving string bags (2000, 2001), or sawing a plank (2011a) cannot only be seen as bringing forth a world; they also explain its emergence, its refinement, and its possibilities for innovation as a continuously changing generative process. "Knowledge of the environment undergoes continuous formation in the very course of their moving about in it" (2000, p. 230), and therefore, such knowledge is accounted for "in terms of the generative potentials of a complex process rather than the replication of a complex structure" (p. 230).

The question of creation is turned on its head and inside out. It is not a question of creating something from something else (in an ontological or material sense as well as in an intentional sense – no blueprints or intentions are realized); neither is it a question of explaining how something new can come from "what is." It is a matter of showing how "what is there" occasionally aligns to create patterns. When things are made and seemingly emerge from nothing, it is simply a special case of general patterns – just as a circle is a special case of an ellipse or, in Bateson's (1972) terminology, why things are more likely to be "in a muddle" than to be "in order." An example that perhaps draws in all of the elements of a creative process without adding something new is the mundane phenomenon of applause. The intensity of harmonic waves in constructive interference is proportional to the square of the amplitude. This means that two people clapping in synchrony sound four times as loud. An ecstatic audience applauding creates something that was not there before, in a traditional sense, which ceases to exist once the applause subsides. However, nothing has been added.[85] Meaning and creation are immanent. This realization is so delicately present in all of the literature reviewed here that it could have been drawn out as a main theme. However, doing so would have made a theme out of it and made "immanence" a concept under discussion. What is needed is a shift from a thinking permeated by the format of things to one that sees skill – a shift that avoids triggering knee-jerk reactions that demand

[85] We might say that something has been subtracted. The roar of an undisciplined crowd can be very loud, but a smaller one disciplined into unison will easily compete. This takes skill. Aligning your clapping with another requires synchronization or entrainment, like the ones oscillators display spontaneously when placed near each other. It requires that the clapper is able to distinguish and eliminate beats (discussed in article 2).

knowledge of *where* meaning is situated or created. It would have to be an imperceptible shift like the quasi-scientific fable of the frog that:

> sits quietly in a saucepan of cold water, and if you raise the temperature of the water very slowly and smoothly so that there is no moment marked to be the moment at which the frog should jump he will never jump. He will get boiled (Bateson, 1979, p. 109).

Ingold (2000) recognizes what I have called the format of things in the introduction to his seminal work, *The Perception of the Environment*:

> I now realise that the obstacle that had prevented me from seeing [that a person is an organism and not something added on top] was a certain conception of the organism, one that is built into mainstream theory in both evolutionary and environmental biology. According to this conception, every organism is a discrete, bounded, entity, a 'living thing,' one of a population of such things, and relating to other organisms in its environment along lines of external contact that leave its basic, internally specified nature unaffected. (p. 3)

Ingold is, like the other authors from whom I draw inspiration, a polymath writing in anthropology, architecture, technology studies, and human-animal relations. He points out that the thing, or the *fait accompli*, is exactly the idea that things *are* their (final) forms. Once our eyes have been opened to a leaky world full of makeshift solutions improvised into existence by bricoleurs and cast-aways (p. 371; see also Pye, 1964, p. 10), then the forms fade. It is not that they are not "there," it is simply that they are not very important for "being." Zen-Buddhists and mathematicians may obsess about drawing a perfect circle, but the world does not depend on forms for being. Paper mock-ups and brand-new-in-box artifacts do not differ except for the elimination of noise. What the working prototype does not have, relative to the shiny product in the store, is veneer. A product that is "finished" has its unintended differences glossed over. All differences are aligned, punctuated, and point toward the same "idea." We are so used to seeing accents, a mumbling teenager, sloppy handwriting, dated texts, etc., as errors, aberrations, and something to be fixed, that we overlook that the vast majority of things are messy, unfinished or already in decay, or on their way to becoming other things (Ingold, 2010, p. 5). Ingold provides an account of skill that avoids using the format of things altogether. There is no separate intentionality or functionality to be found in the head or the tool. There is no separate body or system to be considered in isolation from its environment. Skills are not passed on as formulae, and workmanship is not reducible to the execution of pre-existing designs (Ingold, 2000, p. 291). Skills, according to Ingold with reference to Pye (1964), are not the mere application of force but involve care, judgment, and dexterity. The forms that come out of the exercise of skill are "the outcomes of dynamic, morphogenetic processes," and "their stability can be understood in terms of the generative principles embedded in the material conditions of their production" (Ingold, 2000, p. 346). Forms are, again, like Fontana's cut. We can say, with some anthropomorphization, that "the brain" is less interested in the form and more

interested in seeing the act that made it. This is what the skilled eye sees (Grasseni, 2007). Things look different to a skilled person. We might think of this as a type of professional affordance. The basic idea in direct manipulation was right. The problem was the idea that the information that the designers sought to provide was the manipulation of virtual physical objects emulating real ones:

> Whatever changes are caused in the objects by the set of operations must be depicted in the representation of the objects. This use of the same object as both an input and output entity is essential to providing objects that behave as if they are the *real thing*. It is because an input expression can contain a previous output expression that the user feels the output expression is the thing itself and that the operation is applied directly to the thing itself. (Hutchins et al., 1985, p. 333, emphasis added)

In information terms, the "real thing" is not important – not even in the real world. What is important is the interface that allows *the system complex* to change states. What is immanent in Ingold's thinking is that information *is* change. It is not about change, not the process or the result of change, but change. Like Bateson's (1979) difference, which is nowhere, change itself cannot be captured. Change can be found by many differences, and it can never be found without a difference, but we err when we equate it with one. Bateson (1972) and Gibson (1986) provide quite complementary ideas that tell us what information is. Bateson (1972) writes:

> When I strike the head of a nail with a hammer, an impulse is transmitted to its point. But it is a semantic error, a misleading metaphor, to say that what travels in an axon is an 'impulse.' It could correctly be called 'news of a difference.' (p. 460)

In comparison, Gibson (1986) writes:

> Once again, let us remind ourselves that events in the world should not be confused with the information in light corresponding to them. Just as there are no material objects in an array but only the invariants to specify objects, so there are no material events in an array but only the information to specify events. No object in the world is literally replicated in ambient light by a copy or simulacrum. (p. 102)

Information is change. What the three articles together demonstrate, as well as each individually regarding its own topic, is that we too often confuse differences that elicit change for change. When we try to conjure change "itself," we are once again fooled by the differences produced that are necessary to prompt change. Every letter written, every sound uttered, every thought constructed is mistaken for its enunciation. This mistake gives rise to all manner of philosophical problems – chief of all is the idea that we are currently conceptually equipped to imagine the interface of tomorrow. This is very evident in the available range of more or less futuristic suggestions for novel interfaces found in movies, YouTube videos, and similar sources with which I round off the state of the problem.

Not considered

Before we launch into a presentation of the various ideas found, it should be noted that there are several areas that have not been included in the search. The huge field and area of information visualization (Card, Mackinlay, & Schneiderman, 1999; Tufte, 1983) is not included, first because it has too many constraints in common with writing for procuring information. There are many areas of research that are tangential with the study of interface or interaction design that in a more comprehensive review would have been considered (Wearables, Internet of things). The following selection has been restricted to vision and touch. Olfactory (taste, tongue) and sound/auditory (speech, voice user, voice response) are not included (Kortum, 2008). A single example that relates directly to visuo-tactile interfaces and locomotion (proprioception) has been included in the list (the Cyberith Virtualizer [15]). As the videos show, strict demarcations between what can be included as input and output technologies cannot be upheld (I recommend seeing through at least a handful of the videos to get a general idea of the list).

Gestures (process) or "input"

> It is not through the transmission of formulae that skills are passed from generation to generation, but through practical, "hands-on" experience. (Ingold, 2000, p. 291)

The fierce resistance to ideas of cognitive representation and the communicative idea of the transmission of cognitive content of all of the above mentioned theories should be evident. Equally evident should be that the HCI community embraces these ideas with clear implications for the resulting designs and the horizon under which they are imagined. Denying representation its powerful place in the midst of scientific endeavor applies equally to descriptions of process and result. Ingold (2000) argues against the reductionist idea of describing skills and processes as "programs," "rules," or "mappings" that either control actions or describe the core of the actions being executed. This is, of course, inherently an argument against the fundamental mission of robotics and AI. One cannot put skills into formulae, neither in descriptions nor in diagrams, and expect them to cover the gradual attunement of movement and perception that goes into learning a skillset (p. 357; see Kilbourn & Isaksson, 2007, for a vivid description of skills and affordances). This is of course the idea in the area of "gesture recognition:"

> The essential aim of building hand gesture recognition system is to create a natural interaction between human and computer where the recognized gestures can be used for controlling a robot or conveying meaningful information. How to form the resulted hand gestures to be understood and well interpreted by the computer considered as the problem of gesture interaction. (Khan & Ibraheem, 2012, p. 161)

The human and the computer are seen as communicative participants. The gestures are the means of communication. "Gesture interfaces use hand and face movements as input controls for a computer" (Kortum, 2008, p. 5). They are externalized by the human and then

perceived and interpreted by the computer. Thus, the problem of "how gestures become "meaningful" is already framed for researchers working to create a new "interaction language." This area overlaps and is variously referred to as haptic-, tactile-, or tangible computing, gesture recognition, or natural UI (Dourish, 2001; Karam & Schraefel, 2005; Khan & Ibraheem, 2012; Kortum, 2008; LaViola Jr., 2013; Ullmer & Ishii, 2001). The most well-known examples of systems incorporating gesture recognition are tools that have now been in commercial use for some time: Microsoft Kinect [28], Nintendo Wii [70], and Sony PlayStation Move [47]. The framing achieves two things: it makes gestures physical "things." Although gestures can be described as "events," "physical manipulations," or even "dynamic," they can basically be demarcated (e.g., they have a beginning and an end). It also shifts the problem of meaning unto a further act of interpretation – meaning has to be added. The problem is the same when the focus is on devices instead of gestures (Dernoncourt, 2012; Hahn, 2010).

Gestures are considered to be a hark back to a more natural or rudimentary form of physically embodied communication, despite the overwhelming evidence that they are social conventions (Dalsgaard & Hansen, 2015; Norman, 2010). Moreover, the "language" that is built follows the lead of Saussure's (1986) difference between signifier and signified. Gestures are treated as providing the physical basis for the language. The "manipulative" part of gesturing is thus strictly tied together with the manipulation of the "physical" icons, files, folders, panels, menus, buttons, that is, the entire range of well-known interface elements. The "naturalness" comes with the expectations developed that when we move an icon, we move it "physically," that is, it behaves in a recognizably physical way (e.g., Bumptop [5]). This constitutes the syntax, if you like. What we choose to do with the icon is then supposedly the "meaning-part" or semantics. The approach allows researchers the freedom to experiment with different input media such as:

Sound – SoundWave uses the Doppler effect to sense gestures [59]; Skinput uses sound travelling through our bodies while the skin's surface is also used as an output surface [58] (Harrison, Tan, & Morris, 2010).

Touch – Touché (Disney research) uses Swept Frequency Capacitive Sensing to provide touch/gesture recognition known from mouse pads that provide gesture differentiation. The selling point is that the system can be applied to all kinds of everyday objects (screens, liquids, doorknobs) [64], other objects attempted/made into input devices are plants (Botanicus Interacticus (Disney research) – Interactive Plant Technology [6]) and coffee cups [12].

Electromagnetic noise – Humantenna uses electromagnetism to create whole-body gestures [23].

Temperature – Metaio picks up the thermal heat signature left by humans touching objects to create gesture recognition [62].

Radar – Google's Project Soli uses radar technology to create what appears to be the most fine-grained input discrimination created yet [49].

Video – Leap Motion uses traditional video input to capture gestures. The technology is included because Leap Motion was among the first to capture gestures in 3D [30]. Under the heading of video, we can also count "traditional" eyetracking such as Tobii (eyetracking) [63].

Some researchers are interested in dispensing with as much physicality as possible. The muscle-computer interface [67] (Saponas et al., 2009) and MYO gesture control armband [42] both use the electrical signals in the muscles as input signals. Brain-computer interface research (also called BMI/BCI or neurowear) attempts to create the ultimate in "direct interfacing" (Graimann, Allison, & Pfurtscheller, 2010) Brainloop [8], the Honda brain machine [22], and the mind control machine [40]. Other researchers want the "real" world and the "virtual" to blend as much as possible. They are interested in making hybrid forms of interaction (Reactable [50]; Patten on tactile interfaces [45]; inFORM (dynamic shape display) [24]; Maeve [33] uses cards on a large touch display). Some of the research projects are more interested in providing feedback information to the user, also known as haptic feedback: "Haptic interfaces use the sensation of touch to provide information to the user" (Kortum, 2008, p. 4). There is also Revel that uses reverse electrovibration as a form of dynamic tactile feedback [51]; AIREAL [3], Intel Air Interface [26], and Displair [16] all use air (or mist) as a form of feedback.

As fascinating as these research projects are, it is obvious when looking through them that the variable is the medium. There is no doubt that incredible innovations await in technology-driven developments of different media (e.g., PaperTab [44]). However, the approach also creates a form of myopia. Preoccupied with getting the sensing technology right, the input gestures are dealt with in a formulaic fashion: to examine the medium's capabilities, isolate a set of input gestures, and to attach commands to each of these gestures. Rock & Rails, for instance, extends the well-known multi-touch interactions on a mousepad or touchscreen with different types of shaped gestures [52]. For this reason, the mock-up interfaces displayed in the videos mostly present well-known 2D surfaces to be tapped, swiped, or pinched. When novel commands are introduced, they are mostly provided with a 1:1 correspondence between gesture and command (e.g., MYO provides a hand pointed like a gun [42] for first-person shooters). Some gestures appear to be analogue (gradable), for instance, MYO shows an extended hand palm down to manipulate a flying drone [42], with the angle of the hand controlling pitch, yaw, and roll; sensor synesthesia shows different variations of touch and motion [55]. Saffer (2009) gives an insight into the myopia created by the belief that gestures have to first be identified before meaning is attached:

> In one sense, everything we do with digital devices require some sort of physical action to create a digital response… What is different, though, between gestural interfaces and traditional interfaces is simply this: gestural interfaces have a much wider range of action with which to manipulate a system. (p. 6)

According to Saffer, the primary effect of including the (whole) body in the input arsenal is that the range of options is expanded. This, of course, ignores any systematic thoughts on how meaning is created. It overlooks the possibility of a combinatorial system for creating meaning, and it leaves the visual vocabulary in the hands of well-known 2D conventions springing mostly from writing. I am not denying that there are more "physical actions" available; I am flatly denying that their availability has anything to do with the versatility of the system. If gestural commands are pairings of one gesture with one command, then the developers will end up with a system of Chinese characters. Gestures have to be systemic, that is, they have to be combinable with legible and consistent consequences (i.e., they have to exhibit behavior), and as discussed in all three articles, they have to create redundancy.

Vision (Result) or "Output"

> [S]killed workmanship serves not to execute a pre-existing design, but actually to generate the forms of artefacts. (Ingold, 2000, p. 291)

Creating a system instead of gestural commands would make an interface a question of skill, both in terms of learning it and mastering it. Standard commands with standard executions may serve the casual user well, but in terms of providing a cognitive tool for creating knowledge work, it can only fail. What is lacking in the approach to gestures is, in fact, something that is taught in every basic class on interaction design: clear feedback on the relation between input and output – or, rather, that the feedback is there, but it pertains to the wrong thing. This is clear in a desktop interface when you have pressed a button or moved an icon. What is not clear is "why" you have done so and what consequences it has. The icon remains ever unperturbed by being moved and clicked. This problem of framing persists on the output side. Here, there are, of course, as many possible variations in medium as with input. Most of the attention, though, is concentrated on visual output. Being so heavily immersed in a visual culture and visual conventions, we are only temporarily impressed by, for example, projection technologies that aim to make visual output mobile such as Skinput [58]; SixthSense [57]; and LightGuide and ShadowGuides [31]. The holy grail seems to be in creating a 3D interface, which is achieved either with the use of a transparent screen or a personal display (HUD or glasses). An example of the first technology is the Samsung see-through screen [65, 66]. Sensors detect movement, thus creating the possibility for interacting with objects on the display [25]. An application is found in HoloDesk [20] – later renamed SpaceTop [60] (Lee, Olwal, Ishii, & Boulanger, 2013). "True" holograms (not dependent on screens) are still in very early development. Vermeer is a 360 holographic display that creates a 3D volumetric/light field display [68]. A more mature technology that is on the verge of breaking into mainstream media consumption is the other type of personal screen used for augmented reality or virtual reality (Sherman & Craig, 2003) using Heads-Up Displays (HUDs) or glasses: Hololens (Microsoft) [21], Magic Leap [35], Vuzix [69], Google Glass [18, 48], Metapro SpaceGlasses [37], Oculus Rift [43], Lumus [32], and Atheer labs [5]. The list is far from complete. Their intended uses span from being purely consumer-oriented (e.g., gaming [43])

to industrial [69]. They also differ as to whether what is displayed creates virtual objects or overlays/augments reality (or a combination). These projects seem to have taken the same "physically" oriented path as researchers on gesture. First, they make it possible to see (and possibly interact) with this technology, *then* figure out how to make the interaction meaningful. The videos show comparatively fewer examples of actual interaction and more "proof" of achieving a 3D view. When interaction is shown, it is – as in the case of gesture technology – in the form of familiar activities. The Metapro SpaceGlasses video [67], for instance, shows seven different gestures that, aside from interactions with engineering blueprints, strangely choose to display interaction with representations of a smartphone and a laptop computer. There are five variations of interface "content" in the videos that stand out. The first is simulated interaction with physical objects (e.g., a virtual vase, a chess board [37]). The second is gaming environments (shooters seem to be preferred). The third is technical drawings (blueprints, models of DNA). The fourth is overlayed information (giving information on sites, people, buildings, directions, etc.). The fifth is interaction with well-known surfaces (simulations of screens). All of these deal either with information as we know it or physical interaction as we know it. This point is perhaps even clearer if we turn toward imaginings of future interfaces.

There are scholarly attempts at looking ahead (Rogers, 2009; Winograd, 1997), but these rarely touch upon specifics of interfaces. When it comes to concrete "predictions," science fiction movies (Grouchnikov, 2012; Shedroff & Noessel, 2012) and concept videos are better sources. First among these is, of course, the now iconic interface in the movie *Minority Report* [41] that was envisioned and later realized as "G-speak" by John Underkoffler. An almost equally iconic status has been bestowed on the interfaces found in the Iron Man franchise [27]. A less well-known example is the control room found in the *Matrix* trilogy [36]. These science fiction examples step slightly beyond the attachment of the user to a screen (G-speak to a lesser degree). On the anecdotal side, Robert Downey Jr. apparently ad libbed most of the movements in the scenes, making the task of creating the interface and aftereffects a creative challenge (Grouchnikov, 2012). Notwithstanding, the examples available from large corporations imagining the future are all conspicuously screen-bound: Aurora [4], Microsoft [38, 39], Corning Glass [13, 14], Samsung Future lifestyle [53], Siemens Smart buildings [56], CIID/Toyota – Window to the world [10]. Upon viewing these videos, what should draw attention is not whether the interaction is free-form, whether there are occlusion problems, or sufficient screen real estate. It is that *none* of the videos show any content (visual objects, types of information) *being created*. Aside from typing on a keyboard and drawing figures (familiar activities that obviously produce new information), tapping, swiping, pinching, etc. (mostly well-known gestures), are used to browse, move, transfer, open, close, alter, or copy information; alternatively, it is to set an automated display of information into motion. However, the future apparently does not include the average consumer producing content. It resembles a "browser-reality" where information, as found on the internet, is accessed. The information we create are "likes," "bookmarks," or "buy" – commands. More complex creation seems impossible without a keyboard. This is not surprising given that, in this approach, "to create" would entail making a "create" gesture – and why would you want to create, say, a blank icon? Moreover, folders

are already automatically created on smartphones by hovering one icon over another. The second glaring take-away from perusing these videos is that the information that is mostly looked upon and talked about – often embedded in full 3D capabilities – is presented as information (text and images) on a (2D) surface. The obvious question is "why would you go to the trouble of creating 3D if you use it to present 2D information?" An even more embarrassing question is "why would you interact with 3D as if it was 2D" – that is, point, tap, etc.? When 3D dynamic images are shown, they are mostly decorative. The solutions presented are what Bret Victor (2011) calls "Pictures under glass." In response to the many images of people tapping their way through future interfaces, he asks the very poignant question: "do you seriously think that the future of interaction should be a *single finger?*"

Attempts at interfaces and GUIs

Both of these points (the lack of content production and the pictures under glass) speak to the thread running through this thesis – that there are constraints at work, even in our imagination, that shorten our horizon and limit our focus to a point where we are not directing our efforts toward the right matters. The things we see, the thoughts we have, and the things we create all anticipate the material conditions of a problem expressible in print. The ideas that are produced with the available tools observe and reproduce the material conditions of their (possible) production (even if they never see an iota of paper) as text or images passively received.[86] When we try to imagine new types of information, we do so heavily mired in assumptions about what information looks and feels like and how it behaves. What is overlooked are the epistemic constraints that go into the conceptual work (our imagination). We copy what we know from the sources we have. Starting with the physical and adding meaning conform to our take on language (Saussure's combination of a physical symbol connected with a social or conventional meaning).[87] When we enter 3D territory, we follow that recipe. An almost comical example is a literal 3D interface that takes the file/folder structure from the desktop metaphor and literally makes it three-dimensional as if travelling through a gigantic hangar of files [1]. A slightly more serious contender was Bumptop [7] (Agarawala & Balakrishnan, 2006), which was purchased by Google in 2010 and never heard of again. What is out there in terms of attempts at novel interfaces is often very inventive, but it is also unmistakably incremental upon a textual universe. For instance, Mag+ is a rethinking of the traditional magazine [34]; Breyn is a type of multiuser-multitouch touchscreen for group brainstorming [9]; and GLOBALedit App is a system for Microsoft Surface tables that specifically target professionals with the need for curating large photosets [17]. When the imagination turns toward the interface, we find examples such as 10/GUI [2] and Stripes [61] that, despite their novel ideas, revolve around a regular desktop; Pierce [46] seeks out a new visual approach but ends up creating symbols; Code Bubbles [11] and Grape interface [19] present inklings of visual objects that exhibit behavior but stay within the limits of known entities (text, images, folders). Laevo

[86] This is also what is implied in the origami "proof certificate" in article 2 ("something can come of this, given the right circumstances of folding").

[87] There is nothing intrinsically wrong with the approach. A video such as [54] shows what designers can do with a known creative area, e.g., drawing. This works because the meaningful activity (drawing) is identical to the physical activity. It is of course its uncritical use as a blanket approach to interfaces that is the problem.

[29] (Jeuris, Houben, & Bardram, 2014) is perhaps the most innovative of the videos. It shows an integration of a calendar and different workspaces. Still, however, it is based on the desktop interface.

This last part of the "State of the Problem" has shown that the problem of the format of things is immanent to the thinking done in the design community whenever it is engaged in designing and conceiving interfaces. The examples presented do not in any way make up a comprehensive list. The term "immanence" is employed literally. As discussed, the theoretical or philosophical underpinnings of this or that approach to interfaces are not among the topics of discussions among designers. The format is embedded in the designs. However, it is also embedded in the imaginative reservoir of the ideas floating about. These videos and the examples drawn from the HCI literature on different conceptions of the computer and interface follow the same common thread found in the theoretical sources used to shed light on interfaces (the sources from cognition theory as well as those on differences, affordances, and ecology). All of these theories that implicitly or explicitly take a stand (or have been used to take a stand) on the matter of "what an interface is" *do not take the interface that produces the ideas into account*. What has been shown here is that *this* interface (the one you are currently facing) is formatted according to the FoT (i.e., it is constrained to produce ideas in print) and produces ideas accordingly. The only escape has been to broadcast this fact as loudly as possible and, through all the examples, make visible what they do *not* say by making it glaringly clear what they *do* say: Here is a thing. The state of the problem is that it is *not* a problem – which is the problem. Things as they are conceived of today belong to a textual universe. For the computer to move on from its Gutenberg inheritance, it has to embrace an interface "conceived as a dynamic space of relations, rather than as a thing" (Drucker, 2011b, pp. 3, 8). This requires the abandonment of the FoT in favor of a world where interfacing is creation, and to see objects is to create them as "acts of conceptual creation" (Henare et al., 2007, p. 15).

Conclusion

Interfaces are important because they are the tools of our imagination. The world we create and the future worlds we imagine are delimited by interfaces that give rise to ideas, cut the world up into manageable pieces and provides the appearance of order we call reality. Occasionally, interfaces let us glimpse something unexpected, but ordinarily our imagination is not as boundless as we would like to think. Interfaces harbor ontological biases that tells us what the world is like and epistemological assumptions that structure how we seek to understand it. To imagine something truly novel we have to create new interfaces and so the question that has been raised in this thesis is how to imagine new interfaces from within the boundaries of old ones?

My contention has been that our commonsense interface or view of the world is dominated by what I have called "the Format of Things." The direct target was the idea, found in the domain of HCI, of an interface as an interaction between human and computer. But it was crucial to establish computer interfaces as cognates of much older interfaces that are usually treated on philosophical terms, such as perception, the spoken word and writing. Without such a connection it would have been impossible to coax out the intimate and profound relation between the inquisitive frame of mind that stages the question and the resolute mindset that confidently provides answers. My original contribution to the pool of knowledge that eventually will help the computer come into its own as a medium has been to determine a way to investigate the workings of interfaces through the worlds they create rather than attempt to capture them reflexively or methodologically (indirectly) in descriptions as "some*things*."

In order to break the hegemony of the Format of Things and shift the boundaries of our imagination, it was first necessary to "solve" the problem of reflexivity, that is, how to clarify the conditions of interfacing, while subject to those very conditions? An investigation into dichotomies was the conceptual vehicle that made it possible to state that 'things are how we see, not what we see.' The first article analyzes and explains how dichotomies can arise from the FoT. It further attempts to show how the FoT, working as a linguistic modality, is part and parcel of our everyday perspective and is responsible for the preservation of such dichotomies as the theory/praxis divide. The article made it apparent that what (and how) we think is circumscribed by a particular genesis and that all things are able to speak of their creation and ontogeny in and of themselves.

Next, the FoT had to be made visible in a manner where all things considered would evince their kinship. The second article provided a lengthy build of a model out of metaphors, investigating how interfaces are created. It concluded, yet again, that things are *how* we see, not *what* we see; when we obsess over the relationship between the map and the territory, we are confusing change with difference. The article also presented a definition of what an interface is, which applies recursively to itself: An interface actualizes a generative systems mapping of phenomena within a particular set of constraints. However, the definition was not the main take-away. Rather, the article provided the ability to see what Bateson calls the

“pattern that connects” across multiple phenomena (in this case metaphors). To be able to draw together disparate phenomena, without aligning them as expressions of the same form and disregarding their particular traits, constitutes what Bateson would call higher-order learning. By making the FoT visible, the symmetry of all things (metaphors, concepts, objects, thoughts and drafts) created came to the fore. Once words and things were seen as transforms of one another rather than correspondents, their common origin, their genesis, could be recognized

Finally, establishing the common ancestry of all things coupled with the insight that meaning is created, constructed, and performed, made room for different geneses. The third article presented a proposal of the first step in changing the world we are creating, as well as the ideas we have, in a more dynamic direction. The possibility of reimagining the computer by creating a new interface was transformed into the task of making a different world available through a different way of enacting it. To *see* differently we have to *do* differently. The non-linguistic examples of meaning making pointed toward analogue interfaces as sources of inspiration to answer the question of what digital materiality is. Analogue computer interfaces will be an entirely different form of knowledge creation that makes use of our spatial awareness, our proprioceptive faculties, and our unique ability to connect visual output with embodied manipulations. Once the computer has been constrained as a medium that behaves in a systematic, predictable, and open-ended way, the computer can unfold properly as a new medium and a new way of creating knowledge.

The results of the investigation are as complexly related as the investigation itself. On the surface, an important result is the abandonment of classical philosophical problems of representation and correspondence. Long-standing dichotomies at work in our theoretical luggage can be safely discarded. But their abandonment is incidental to a different form of shedding. In this dissertation, I have essentially asked: What can we say about the assumptions at work of what perception is, what information is, and what communication is, when faced with the world as it appears to us? The line of reasoning has been:

> What you see (the world or whatever phenomenon you are preoccupied with) has to be the product of a process that has already taken place (if there is such a process, then it must be at work, since you are experiencing things).
>
> This means that (although you can attempt to capture it) the process (and whatever presuppositions it involves) is only investigable through its consequences (it is hidden in plain sight *qua* the world as it appears).
>
> We are nonetheless capable of recognizing what we do (the process) in what has been done/created (as in Fontana’s cut or Gibsonian affordances).
>
> If one accepts these claims at face value, we have to investigate (not the process, but) what-has-to-be-the-case in order for the world to appear this or that way (again *qua* the phenomena we are faced with).

Investigating what we do becomes a matter of inference rather than one of reflexively determining what we do. So the importance lies not in any particular problem that may or may not have been solved. The import lies in a change of modality. What has been questioned is the certainty with which we so readily engage in both theoretical and practical problem-solving when presented with a problem. The untoward confidence we have in our ability to pose and understand any *question* is testament to a form of unintentional transparency of the interface through which the questions are posed. The confident mode in which we attempt to provide answers to problems is often already so heavily mired in the assumptions of the question that "questioning the questioning" takes on the appearance of esoteric and philosophical navel-gazing. This caveat is self-evident to critical scholars, however the rigor of it is rarely extended to our basic ability to pose questions or the formats in which the questions are posed. When we ask 'have we got the problem right?' we are part of the way there, but only when we ask 'are we capable of asking the question?' have we switched into an inquisitive frame of mind that has the potential to transform the world.

Such claims could be dismissed backhandedly as theoretical with no practical value. It is true that the dominant interface, through which we most often see the world, identified as "the Format of Things" applies to our engagement in the world generally, but the concrete instantiation of the format that prompted the entire thesis was the FoT as I found it in the thinking surrounding user interface design. As article one shows, the desktop metaphor (or WIMP paradigm) is not an innocent communicative device; it is an exponent of the FoT. It enunciates and installs expectations of phenomena articulable in writing, like a Trojan horse. The format instills an ontological certainty of the permanence of objects (things) and an epistemological certainty of the clarity of ideas. With these certainties, the format controls our ideas of the world, our perceptions, and even our mind's eye by replicating everywhere and in everything. To break the hegemony of the format, it was necessary to break the sway that the format holds over the things produced as well as the methodological discourse theoreticians employ in their self-understanding and in their methodological considerations about their production.

For the same reason it was necessary to extend the application of the insights to the thesis itself. It was necessary to show that the thesis, considered as a Thing, was itself in the balance, so to speak. To engage in this entire undertaking without recognizing that the thesis itself was (and is) an event, would be to fall into the self-same trap I have so carefully pointed out for others. What I concluded about interfaces in general had to apply to the thesis as an interface in particular. When I ask: "What is it about words and things that makes them comparable?" and "Why is it that, although the answer may seem almost infinitely complex, the question is seemingly uncontroversial?" I am engaging with philosophical problems, but I am also committing to answers that have to apply *hic et nunc*.

So, great care has been taken to ensure that the problem of assuming methodological certainty was not simply pointed out and then promptly ignored. The thesis has been, as proclaimed, methodological and theoretical. The different options available have been

discussed so as not to simply launch an investigation of “what a thing is” or “the format of things” without further thought. The import of well-known philosophical reflexive problems, dichotomies, and a critical-discursive self-understanding among theorists (the corridor) was made clear. Although the “voice of reason” has been employed throughout this text, I have also strived to show the direct implications of the findings on what is said in the most concrete way possible – that is, to make the present text conspicuous as the production of things and as an interface, to make its enunciations stand out. If I succeeded in so doing, then - while producing ideas formatted according to the FoT - there was simultaneously an enunciation of more: each thing speaking of its genesis. This reflexive point was, indeed, not just methodological. This effectively made the thesis itself an interface, one that, on one hand, replicated and made use of the FoT and, on the other hand, opened up gateways to a different world. The importance of this point cannot be underestimated. If the interface of the FoT has become less transparent, the aims of the thesis have only been reached halfway.

The other half was the positive ambition of outlining a credible alternative to the FoT. The use of such concepts as “zero distance,” “dual consciousness,” and “enunciation” may have been slightly esoteric, but some level of eccentricity was felt necessary to ward off the habitual dealings with the world in the format of things. The concepts were part of an attempt to show an unfolding genesis (A Thing or interface) that exhibited meaningful creation without recourse to a world of objects and subjects. If the FoT could be shown to be a special case in a wider range of possible interfaces, then things could be shown to be one of many ways to enact the world. The path that was settled upon was to overload the format and force it to become as clear as possible in its consequences; to ask what things are and what they have to do with the HCI complex. The surprising answer found was that things are not inherent to the world. Things are the world’s way of enunciating words. Conversely, words are our way of enunciating what the world does with things. Things are not what we see but how we see. It was also shown that the contrasting of words and things (human and computer; subject and object) is the consequence of a pattern that attempts to map (determine) everything in the world as things first and relations between things second. The ability to see the process in the result (e.g., Fontana’s cut) was key to realizing a different way of looking at things.

Ultimately, the goal of the thesis was to rouse the design community to a renewed sense of urgency in creating future interfaces independent of pen-and-paper thinking. Thinking with your hands may, in the future, become more than a figure of speech. The image of ‘impossible Lego bricks’ is not about flashy displays of graphics, but is an encouragement to rediscover the entire bandwidth of available human cognition. The proposal is to work with constraints and invent analogue computer interfaces with which we are capable of doing knowledge work of at least the same complexity, granularity and speed with which these words are typed. I am under no illusion that this thesis will have a readership of more than a handful of people, but insofar as what I have said has some merit, I will have indicated a fruitful path of development and, one can hope, inspired new steps in the same way as I have been inspired by all of the authors quoted.

As announced, the thesis has remained in the realm of philosophy to deal with problems of relevance for the work of imagining interfaces. I consider many parts of this process to have found a satisfactory (albeit temporary) answer. Although entirely theoretical, the undertaking has, because it has been methodological, also presented itself as an empirical matter. Anything said here can be scrutinized as phenomena created in a certain interface. It was thus a happy, almost serendipitous, coincidence that these philosophical and reflexive problems haunted my initial research on interfaces. Without them, the effort to clarify the assumptions at work in my own thinking (and interface) would have spiraled into a *mise en abyme* without any hope of rescue. What has been said is still, however, only an indication of a line of flight for the novel conceptual development of interfaces. It inscribes itself in the pattern with which I opened the introduction. There is a shift towards understanding that there are alternative geneses available – a shift that will never reach fruition as long as the current format is perpetuated.

Caveats and limitations

William James (1949, p. 198) outlined the classic stages of a theory's career. A new theory is first "attacked as absurd; then it is admitted to be true, but obvious and insignificant; finally it is seen to be so important that its adversaries claim that they themselves discovered it." I am no William James. This is not a masterpiece. Nonetheless, the thesis has to ward off charges of incoherence, irrelevance, and running in open doors. The quote touches upon what has probably been the greatest challenge to opening up this line of inquiry. It would be one thing to overcome skepticism and stark resistance. It is a completely different thing to overcome indifference and misconstruction. The FoT is so deeply entrenched in the make up of our concepts, percepts, and precepts, that it, until now, did not even warrant a name. The format is beyond confidence and being taken for granted. Moving a subject from the periphery of attention into the unforgiving focus of scholarly scrutiny requires a long and arduous balancing act. Challenging such a position means chipping away at assumptions without setting off any knee-jerk reactions. At the same time, it means gradually building confidence in an opposing idea – that it is possible to see and think otherwise – without being dismissed as simply reiterating *insert choice of existing theory* (e.g., pragmatism, philosophy of difference, becoming or process, activity theory, socio-material assemblages, etc.).

Are you not running in open doors and simply stating the obvious?

The most salient reason I have found for maintaining my stride is that dichotomies continue to be propagated by proponents and adversaries alike that take them for granted as starting points of their inquiry – either as part of the conceptual backdrop or as the end-all challenge to be overcome. I find this to be true in theoretical endeavors in general and in the HCI community specifically, not in the form of explicit convictions. Very few are interested in the subject-object problem or problems of representation in the HCI community.[88] Rather, the proof is in the pudding. There is no hesitation in the community when speaking of "the

[88] Although an analysis of, e.g., the task-analysis cycle (https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/human-computer-interaction-brief-intro) will reveal that it is a variant of the separation of process and result or the input-output model of perception.

user," files, folders, browsers, clicks, and buttons. Equally effortless are discussions of affordances or the usability of this or that part of the user interface (understood as an interactive surface in front of the user). For the many man hours poured into interface design, unkindly speaking, we are still being presented with what Bret Victor (2011) calls "pictures under glass." This reason is also an answer to the above charges. The thesis is therefore *de facto* relevant if one agrees with this claim. One could counter that overcoming the desktop metaphor is old news. The community has long since moved on from the design of data objects as icons, so I am challenging a paradigm that is no longer in vogue or hegemonic. This is a valid argument if one equates the FoT with the desktop metaphor and accepts that the community has in fact moved on to other challenges. As attempted in the literature review section, I do not believe this to be the case. The desktop metaphor is an expression of the FoT. Moving away from a focus on icons and folders does not constitute a move away from the FoT. Great emphasis is now put on tablet devices and smartphones, and interaction "moves" such as the swipe maneuver have taken center stage in tablets and smartphones, but we are (except in games) basically still dealing with pages of information. The task of exploring what to do with objects – if you are not meant to move them around (icons), push them (buttons), resize them (pictures), or browse them (pages) – has simply been laid dormant. A different way of stating this is: we still see and engage with flat print-based surfaces in our everyday life, and even when mock futuristic visions are created, they retain the language of tap, swipe, and write (see the literature review).

Why treat the matter in such convoluted ways?

The second, more defining, reason to stay the course has been the lingering question concerning the wanting progress in truly leveraging the computer to alleviate the cognitive workload of knowledge workers. I say this despite the clear impact the computer and internet have had on our world. My suspicion has continually been that the lack of progress has less to do with the ingenuity of the designers and thinkers and more to do with the constitution of ideas (that is, the format of things). As explained above, any examination of the problem has been effectively walled in. It was never possible to step back and reflect on the concept of things, processes, difference, or becoming without creating the impression that this was an abstract, theoretical, and conceptual matter with little impact on actual interfaces. Moreover, it was not possible to move forward into discussing the consequences of these thoughts for particular designs without having the subject matter mistaken for the problem to be discussed. Conveying the idea that a browser perpetuates a print-based conception of knowledge and engenders a subject-object dichotomy is hardly compatible with the standard requirement of articles in the field to give specific design advice ("so if you don't want buttons, are you suggesting swipe interfaces?"). Last, it was not possible to step sideways into methodological considerations without triggering curious reflexive problems or assuming tautological transparency. Nonetheless, I have been adamant that it is possible to become aware of what you do while you are doing it. Schön (1983) unwittingly frames the issue nicely when he characterizes how we engage in the world and solve problems:

> When we set the problem, we select what we will treat as the 'things' of the situation, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed. Problem setting is a process in which, interactively, we name the things to which we will attend and frame the context in which we will attend to them. (p. 40)

Obviously, what I have brought to the fore in this investigation is a question not posed by Schön. Why "things?" What are the consequences of accepting things as decisive, as the boundaries, and that to which we attend?

Is this not simply abstract musings without practical consequences for the HCI community? Once it is recognized that many conceptual problems lie nascent in the format employed (the incisions or cuts made into the world), it becomes possible to see what we do when we see. Like Fontana's cut, we see the movement that created the cut in the cut. Take for instance this quote: "A word referring to an object is also an organization of perception" (Smith, 2005, p. 84). I concur with the basic tenet of Smith's observation, but anyone with philosophical training can immediately see the can of worms she opens in this small quote. By setting up a referential relation between two objects (word and object), a classic dichotomy is enacted that potentially eclipses what the quote is aimed at (that a word is not simply a naming but performs what I have referred to above as the labor of division). A different quote closer to the HCI community would be "We contend that managing one's own electronic world can be a frustrating task for most computer users…What is needed is a metaphor and system for organizing the electronic 'bits of paper' we all so easily collect" (Fertig, Freeman, & Gelernter, 1996, p. 410). The authors of the article propose a new way of managing one's "electronic world." What does the world consist of? Electronic bits of paper! This is particularly interesting relative to the title of the paper: Lifestreams: An *Alternative* to the Desktop Metaphor (my emphasis). By "alternative," the authors are not thinking of a fundamentally different interface. They simply have a different way of organizing files, emails, pictures, etc., in mind. This is what I aim at when I contend that the problem of the FoT is hidden in plain sight. The authors want to solve a problem, but they retain their units of analysis – the "things" remain the same. Regardless of the authors' theoretical allegiances, all too often, theoretical assumptions go unnoticed while nested in descriptions, ledgers, vocabularies, and units of analysis. These assumptions shorten our horizons. The quote is not held up as a particularly pregnant example. On the contrary, my contention is that this problem is ubiquitous and thus not practical to claim or prove in a thesis. A more current example would be two quotes from the book *HCI Beyond the GUI: Design for Haptic, Speech, Olfactory, and Other Non-traditional Interfaces*: "Haptic interfaces use the sensation of touch to provide information to the user" (Kortum, 2008, p. 4), and "Gesture interfaces use hand and face movements as input controls for a computer" (p. 5). Are these harmless descriptions of alternatives to the GUI? Certainly; however, they are also heavily theory-laden assumptions of importance for what "things" we choose to attend to. Compare with these cursory rewritings: haptic interfaces generate tactile patterns of information. Gesture interfaces establish a conventional vocabulary of quasi-symbols for generating information based on recognition software. Not particularly elegant, but there is

no mention of a user. Obviously, a constraints approach (article 2 and 3) would take note of the different cognitive and bodily constraints at work, but there is no need to set up a communicational, perceptual, or informational relationship between two entities (user and computer/interface).

Is there an original contribution to this eclectic collection of insights?

The thesis' approach is that we are able to recognize all things as enunciations *as we enunciate*. A case in point are what would normally be called the self-referential properties of the text in front of you. In an understanding in which text does not refer, there is no text in front of you being interpreted, there are only changes being resolved. With this realization (demonstrated in article 2), descriptions are relieved of two characteristics. On one hand, descriptions are not "neutral." They are not "simply" detached recordings or observations of the world, themselves devoid of consequence and only mirroring "reality." On the other hand, they provide no privileged access to the truth (showing the world as it is). They are recognized as expressions of a type of knowledge – one that is and has been important – but alongside and equal to other types of knowledge. If there ever was going to be a thesis that explicated what it means for visuo-tactile interfaces to be able to generate meaningful patterns, it would be one that was able to do so without simply being antithetical to words but *showcased it itself*. The most important insights of the thesis are that things are *how* we see, not *what* we see; that words are not things to be interpreted, but *changes* (article 2); and that to reimagine the computer we have to change what we see and thereby change what we see. The primary obstacle is mistaking difference for change. When Bateson (1979) says that difference is not located in time and space (quoted earlier), he is talking about change ("news of difference" as he calls it). The world presents differences (things) by which changes are accomplished. We (another part of the world) can create other differences (words) by which comparable changes are accomplished. When we try to compare the two types of differences, we confuse change with difference. We look for change and find difference. The differences are "there" insofar as we discriminate (make the cuts), but we would not be able to discriminate if they were not there.[89] This insight is what allows us to see linguistic knowledge (text) *on par* with other types of knowledge (perceptual, mechanical, social, instead of subsuming all forms of knowledge as either tacit or (which amounts to the same) in need of translation.[90] The thesis thus makes an approach to interfaces available that allows you to investigate its genesis *qua* the incisions it makes into the world. The cuts or incisions no longer have an origin (natural or social) and do not necessarily take place anywhere specifically. Instead, cuts are where needs, abilities, strategies, and constraints gather or assemble. All phenomena become, in a sense, empirical

[89] Note that the urge to place the phenomenon in the social or the world hovers incessantly in the background. Part of the format of things is to locate the thing somewhere. We can also see clearly that once a thing is placed, there is an assumption that prior to its placement (coming into existence), it had to be somewhere else. If that was not the case, then the social vs. the world would not be an issue. This is also the reason that I do not write "we change" but "changes are accomplished."

[90] There are many situations in which conscious, knowledgeable, non-verbal behavior is generated, learned, and built upon, but their status changes as soon as they are attempted and verbalized. For instance, the practical knowledge of a dancer is not a tacit form of knowledge that is performed and is only really captured as knowledge when it is explicitly stated. The insight is discussed in article 1 and brought to bear in articles 2 and 3 where metaphors and analogue interfaces are treated as enunciative on equal terms with text.

data in this approach. There is not an utterance, a piece of text, action, or thing that does not speak of its own becoming (enunciation). From this insight, "zero distance" to one's enunciations is possible as well as the dual consciousness exemplified by Fontana's cut. The unravelling of the format of things, reflexive problems, and dichotomies and the escape to another format all follow from this change of gaze.

Are you not engaging in a self-contradiction?
How can I avoid reproducing the FoT when the thesis is made up of words? Ong (2002) points out that Plato's derision of writing is precisely spelled out in writing:

> One weakness in Plato's position was that, to make his objections effective, he put them into writing...Writing and print and the computer are all ways of technologizing the word. Once the word is technologized, there is no effective way to criticize what technology has done with it without the aid of the highest technology available. (2002, p. 79)

The position is reversed here. The present technology of writing is problematized as coming up short from within a written position. The thesis makes no pretense that it is capable of avoiding the FoT. The strategy is exactly to overstrain the format, make the things themselves speak, and showcase their patterns in the process.

If you're so smart, why ain't you rich?
It is evident that concrete examples of visuo-tactile interfaces are not part of the thesis. As mentioned in the preface, this was a conscious choice. The technology for delivering three-dimensional visuo-tactile interfaces is only now emerging and is still some way from becoming available to the average consumer (e.g., Microsoft's Hololens, Oculus Rift, Sony Morpheus, etc.). A development project would exhaust my resources and demand skills that I do not possess (coding, drawing). In the end, such a project would still require a theoretical basis, which from the outset faced the same challenge with which this thesis has grappled – the unseen format of things. Of course, these problems apply to any development project, but Seeing is Believing. I have distinctly felt trapped in a Moëbius strip. If I could devise ways of seeing what I was talking about, then I could convince people to join in a development project. For people to join in creating a demo, they would need to know what I was talking about. People who I have engaged in conversation about the topic had no clue what I was talking about and asked for visual examples and so on.

Future Work

So what to do? If what has been said here has any merit, very little work has been done so far that will put us on the right track. This is exhilarating for dreamers and exasperating for doers. I believe both are needed. Bret Victor (2013), quoted in article 3, is of the rare breed (I also count Alan Kay among them) that both dreams and does. He says:

> Media matters because media are thinking tools. The representations we use of the systems is how we think about it. Our representations are how we understand the

> system and what we understand about it. If we want powerful new ways of understanding systems, we need powerful new representations and we need a powerful new medium, so we can create and work with these representations. So much of the way we work with representations today is derived from pencil and paper medium. Even when we're working with the computer we're still thinking in pencil and paper. There's an incredible opportunity to rethink how we think about systems. (2013)

I quote this again to point out that Victor, first of all, thinks of fundamental change as one in our habits of thought. We have to think differently about work, media, and representations. However, more importantly, designers will have to change what they see – literally – and what they imagine before they put stylus to trackpad. To do so, they have to imagine the future constraints of a medium that is not yet settled, constraints that will influence our thought processes with the same force that pen and paper has. How do you do that? – in particular, when it has been made a condition that you do not think with your "pen-and-paper mind?"

The first suggestion is to take our cue from Ingold's (2001) approach to skill. Care, judgment, and dexterity are descriptions of enskilled behavior, far removed from the mechanical lingo we have been accustomed to when describing practical knowledge. When a Telefol woman teaches her daughter how to loop stringbags, encourages her to get the "proper feel for looping" (p. 24), and tells her that her hands will, in time, "move like running water," the gradual sensitizing and heightened discernment are part of a learning curve wherein the world gradually unfolds in greater complexity and detail. This does not happen concomitant to the development of skill. Greater discernment *is* skill. As article 1 shows, the description of skill from an outside perspective and the description of the "object" of skill seen from the enactor's viewpoint are merely two different ways of describing the same process or pattern. Ingold insists, and rightly so, that *description* inadequately captures what is at stake in the exercise of skill. "[E]ven the simplest and most routine of everyday tasks are refractory to codification in propositional form...the skilled practitioner consults the world, rather than representation" (p. 164). A process in an interface moves from mechanical execution to one of skill when an interface is capable of systemic differentiation in the same way one can speak of games that are easy to learn but hard to master.

The second suggestion is to rediscover aspects of our dynamic engagement with the world. Rhythm has been part and parcel of our communicative world since before writing and numbers, e.g., oral tradition (Ong, 2002) and the oral-formulaic composition theory (Lord, 1960). The example of timing discussed in article 1 shows that a description of flows is not dependent on subjects and objects but speaks of "windows," balance, and cues. The existence of a type of "sequential thinking," which the anthropologist Anthony Wallace (1978, p. 238) refers to as "a long yet elegantly simple moving image in three-dimensional space," is testament that there are thought processes that defy "codification in propositional form." For instance, pointing out that an experienced mechanic can identify engine trouble

from specks of dust (Crawford, 2009) is another way of saying that there are forms of knowing that are capable of holding open and integrating many dimensions of a problem space at the same time – not only spatial dimensions, but alternative paths of action, temporal dimensions of an event unfolding, different anticipated reactions from other actors, etc. None of these dimensions is adequately captured in propositional descriptions. However, as the game Miegakure in article 3 shows, we are capable of navigating many spatial dimensions simultaneously (what the developer calls thinking in 4D). It is our representational formats that are lacking.

The third is to concretely investigate the type of "impossible objects" that we are capable of designing and forming accurate expectations of them. Something akin to the principles found in Gestalt theory should be examined and tested relative to our ability to manipulate and understand dynamic figures that are virtually, not physically, possible. As sketched out in article 3, the computer as a new medium is capable of realizing impossible constraints. This points to objects that can be divided into as many parts as we would like, take on as many shapes as we can imagine, and be related to as many other objects as a community needs. The difficult part is to make this possible in a way that is systematic so that even if we have never seen the object or constellation of objects before, it will be "decipherable" and yield information much as an unfinished house shows the carpenter what has already been done, its current state, and the remaining tasks. We return to nature's way of telling stories:

> Thus nature is alive to our eyes partly because its shapes are fossils of the events that gave rise to them. The past history is not merely inferred intellectually from clues, but directly experienced as forces and tensions present and active in visible shape. (Arnheim, 1974, p. 417)

A new interface will not be a uniform or globally understood sign or symbol system. It will be a system of meaningful creation; a gradually acquired world of complex entities and movements. The entities will become familiar and be recognized through use, and the behavior of unfamiliar "objects" will be examined by trial and error. Structures and objects will be recognized as results of the application of skill. These will become punctualized and commonplace in a way that will make the action sequences in the movie *Minority Report* seem comical. The creative possibilities of these "impossible Lego bricks" will be unmistakable. A new medium will endow users with creative agency, which will allow abstract knowledge work and coherence in personal information space on par with the creative capabilities of speech and writing. Getting a grasp of the differences of a system which make or break the onset or diffusion of events taking place is a small step toward understanding social events and forces at work. It is like having a music key[91] and knowing that no force binds the hands of the players, only that, given the restraints, a measure of predictability is not only possible but inevitable.

[91] Much in the way Goffman (1974) envisions in frame analysis.

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Video Resources:

[1] 3D Interface: https://www.youtube.com/watch?v=Lh1m15-2HNo
[2] 10/GUI: https://www.youtube.com/watch?v=zWz1KbknIZk
[3] Aireal (Disney): https://www.youtube.com/watch?v=xaFBjUJj00M
[4] Aurora (Adaptive Path/Mozilla): https://www.youtube.com/watch?v=FZ-zvx1QCcA
[5] Atheer Labs: https://www.youtube.com/watch?v=jXNOQsO-flc
[6] Botanicus Interacticus: https://www.youtube.com/watch?v=EcRSKEIucjk
[7] Bumptop: https://www.youtube.com/watch?v=M0ODskdEPnQ
[8] Brainloop: https://www.youtube.com/watch?v=KwNUpOVZu2E

[9] Breyn: https://www.youtube.com/watch?v=6HyrcIV-yW0
[10] CIID/Toyota: https://vimeo.com/25547151
[11] Code Bubbles: https://www.youtube.com/watch?v=PsPX0nElJ0k
[12] Coffee Cup: https://vimeo.com/57437189
[13] Corning (A day made of glass): https://www.youtube.com/watch?v=wk146eGRUtI and https://www.youtube.com/watch?v=Sc8lzavmXOk
[14] Corning a day in 2020: https://www.youtube.com/watch?v=OptqxagZDfM
[15] Cyberith Virtualizer: https://www.youtube.com/watch?v=k7n5kRRHDpw
[16] Displair : https://www.youtube.com/watch?v=TNcTssBV1fI
[17] Globaledit App: https://www.youtube.com/watch?v=cZLmbpdcvZw
[18] Google Glasses: https://www.youtube.com/watch?v=v1uyQZNg2vE
[19] Grape Interface: https://www.youtube.com/watch?v=UMcMiewdoZA
[20] Holodesk: https://www.youtube.com/watch?v=JHL5tJ9ja_w
[21] Hololens (Microsoft): https://www.youtube.com/watch?v=A_NeDEPKvcA
[22] Honda Brain-Machine: https://www.youtube.com/watch?v=q-fE9QBy0FI
[23] Humantenna: https://www.youtube.com/watch?v=7lRnm2oFGdc
[24] inform: https://vimeo.com/79179138
[25] Interactive Displays (Microsoft research): https://www.youtube.com/watch?v=oGa1Q7NvsI0
[26] Intel Air interface: https://www.youtube.com/watch?v=Ggpg26fOU1Q and https://www.youtube.com/watch?v=xSWf9lxDA0M
[27] Iron Man 2: https://www.youtube.com/watch?v=VB3w5NhCicU
[28] Kinect (Microsoft): https://www.youtube.com/watch?v=pzfpXAbQ61U
[29] Laevo: https://www.youtube.com/watch?v=BAc7sBvViFg see also http://www.stevenhouben.be/portfolio/laevo/
[30] Leap Motion: https://www.youtube.com/watch?v=_d6KuiuteIA see also https://www.leapmotion.com/
[31] Lightguide: https://www.youtube.com/watch?v=vNaw9GpuVLQ
ShadowGuides: https://www.youtube.com/watch?v=0faNHo5q38s
[32] Lumus: https://www.youtube.com/watch?v=p2dmE_Ltv3I
[33] Maeve Table Demo: https://www.youtube.com/watch?v=f1X5ffRrde8
[34] Mag+ (boonier R): https://www.youtube.com/watch?v=iAZCr6canvw
[35] Magic Leap: https://www.youtube.com/watch?v=kw0-JRa9n94
[36] Matrix: https://www.youtube.com/watch?v=Jt5z3OEjDzU
[37] Metapro Space Glasses: https://www.youtube.com/watch?v=LuMv29nKo2k see also https://www.getameta.com/
[38] Microsoft future vision 2020: https://www.youtube.com/watch?v=ozLaklIFWUI
[39] Microsoft future vision: https://www.youtube.com/watch?v=1VuQeR-N8nE
[40] Mind Control Machine: https://www.youtube.com/watch?v=pL0FzHHrQv8
[41] Minority Report: https://www.youtube.com/watch?v=7SFeCgoep1c see also https://www.ted.com/talks/john_underkoffler_drive_3d_data_with_a_gesture
[42] Myo: https://www.youtube.com/watch?v=te1RBQQlHz4 and https://vimeo.com/99226065
[43] Oculus Rift: https://www.youtube.com/watch?v=314KSffGm3I

[44] Papertab: https://www.youtube.com/watch?v=81iiGWdsJgg
[45] Patten, J. – Tactile Interfaces: https://www.youtube.com/watch?v=5WI6ZqCUNk0
[46] Pierce – Final Visual Thesis: https://vimeo.com/28406819
[47] Playstation Move (Sony): https://www.youtube.com/watch?v=s9ybHddDMgM
[48] Project Glass (Google): https://www.youtube.com/watch?v=9c6W4CCU9M4
[49] Project Soli (Google): https://www.youtube.com/watch?v=0QNiZfSsPc0
[50] Reactable: https://www.youtube.com/watch?v=CUlp30uTw6U
[51] Revel (Disney Research): https://www.youtube.com/watch?v=L7DGq8SddEQ
[52] Rock & Rails: https://www.youtube.com/watch?v=buzXWfeYKNI
[53] Samsung: https://www.youtube.com/watch?v=1nKFW-lDNK8 and https://www.youtube.com/watch?v=ZSn0lnjgFag
[54] Sensing Techniques for Tablet+Styles Interaction: https://www.youtube.com/watch?v=9dgHgHQSuuY
[55] Sensor Synesthesia: https://www.youtube.com/watch?v=Zuu7ZnyWrJA
[56] Siemens Smart Buildings: https://www.youtube.com/watch?v=EUkgYiQD3Yw
[57] SixthSense: https://www.youtube.com/watch?v=Tq22KBGwMxc
[58] Skinput: https://www.youtube.com/watch?v=g3XPUdW9Ryg
[59] SoundWave: https://www.youtube.com/watch?v=rFM59B3tYI4
[60] SpaceTop: https://www.youtube.com/watch?v=FQnongiycns
[61] Stripes: https://www.youtube.com/watch?v=hXVDGc45nho
[62] Thermal touch: https://www.youtube.com/watch?v=K2XL0qnu4Z4
[63] Tobii: https://www.youtube.com/watch?v=4fvdBhPdhIU
[64] Touché: https://www.youtube.com/watch?v=E4tYpXVTjxA
[65] Transparent Screen Samsung: https://www.youtube.com/watch?v=rwCi-WqMIFA
[66] Transparent Display (Microsoft Research): https://www.youtube.com/watch?v=GAWCzUyzpLE
[67] UIST – Muscle Computer Interface: https://www.youtube.com/watch?v=6_7BzUED39A
[68] Vermeer (Microsoft research): https://www.youtube.com/watch?v=lW7k-6FUxoo
[69] Vuzix: https://www.youtube.com/watch?v=B8BfayZFX28
[70] Wii (Nintendo): https://www.youtube.com/watch?v=8qfhikLalek

Appendix 1 – Article 1

The Format of Things

Abstract

How are dichotomies possible, and why are they so pervasive and resilient despite many efforts to overcome them?

Well-known philosophical dichotomies such as representation versus reality and subject versus object are still often tacitly accepted across many disciplines as fundamental starting points of inquiry and principal problems to be solved or overcome. Only very few attempt to explicitly overcome these age-old dyads. This article poses the more modest theoretical meta-question of their genesis and provides an answer. If we do not accept dichotomies as fundamental or basic, is there a way to account for their positioning vis-à-vis each other? The article assumes the position that there are different cognitive modalities available for human problem generation and solving, e.g., linguistic, mathematical, visual, and mechanical modes with strongly differing landscapes of attention. Through an analysis of a particular "format of things" that belongs to a linguistic modality, the argument is made that dichotomies are an effect of the recursive application of said format. The analysis of the format allows us to revise the everyday conception of what a thing is. The article sums up the new idea with the assertion that "things are not what we see but how we see." The attendant discussion provides an economical explanation of how dichotomies are set up and why they persist. It shows that the requirement for establishing dichotomies is the acceptance of the format that creates the problem. Once the format is instated, any attempt to overcome it inevitably reproduces the dichotomy. The final part of the article is dedicated to opening up a line of theoretical inquiry that is sensitive to other modalities and formats through an application of the analysis on the dichotomy between theory and praxis.

Keywords: Format of Things; Cognitive Modalities; Dichotomies; Theory-Praxis Divide; Redundancy

Introduction

> As cognitive scientists we continue to live, it seems, in an impressively stable age of representation. (Wheeler, 2010, p. 320)

There are formidable problems in cognitive sciences that carry on well-known philosophical debates such as representation versus reality and subject versus object. These dichotomies are accepted as fundamental starting points of inquiry and principal problems to be solved or overcome. Only the very brave attempt to tackle them head on. This article asks and provides an answer to the more modest theoretical meta-question: *How are these dichotomies possible, and why are they so pervasive and resilient, even in the face of many efforts to overcome them*? If we do not accept them simpliciter as fundamental or basic, can we account for their positioning vis-à-vis each other? The article takes the position that there are different cognitive modalities available for human problem generation and solving, e.g., linguistic, mathematical, visual, and mechanical modes with strongly differing landscapes of attention. It argues that dichotomies are effects and expressions of a format particular to linguistic modes of determining phenomena and problems. By focusing on the requirements of the format, it becomes possible to collate otherwise disparate phenomena. The article offers a general answer to the question posed, exemplified with an analysis of the construction of the dichotomy between theory and praxis.

One may object that such monumental debates, let alone the many issues they entail, cannot simply be lumped together. To that end, I strongly emphasize that this article is not engaged in solving problems in any of the debates and does not attempt to conflate one debate into another. The purpose is solely to look for what Edelman (1998) refers to as second-order isomorphisms or *similarities among shapes*. Representation and reality, subject and object, theory and praxis, and map and territory, etc., all of which are similarly placed pairs in opposition. Drawing cross-disciplinarily from studies of cognition, perception, and practice, there is no claim that the terms on one or the other side, such as the brain, perceptions, maps, or theory, bear more than family resemblances to each other. Their connection lies in the way they are delineated and brought in opposition. There *is* a claim that the acceptance of a dichotomy as a starting point is consequential, regardless of whether the dichotomy is affirmed or denied.

The task is not simple. The distinctions under scrutiny are naturalized in their use and part of our everyday commonsensical ideas of the order of things. They are burrowed in concepts, such as “theory” and “praxis” or presupposed in words like “description” or concepts like “modelling.” Other less controversial distinctions, such as between “internal” and “external,” are routinely used interchangeably or as auxiliary terms, thus complicating their relations. Furthermore, every discipline and science has made a methodological effort to seek out and explain the relation between the scientist, the technology in use, and her chosen field, thereby installing such distinctions at the heart of scientific endeavor.

The article is divided into three parts. The first part introduces the theoretical backdrop where the dichotomies are unfolded, including definitions of what is meant by cognitive

modalities, dichotomies, and format, and a review of the existing positions on dichotomies. The second part proposes an explanation of how dichotomies are created while the third part uses the explanation to analyze the dichotomy of theory and praxis and offers a sketch of how to switch formats.

Part I: Theoretical Backdrop

Modalities

The anthropologist Anthony Wallace drew up a fascinating image of the merger between the mechanician and the scientist into a scientific engineer during the industrial revolution. Wallace (1978) contrasts the type of thinking that the mechanician does with intellectual traditions that depend on language, which he interprets broadly as linguistic or mathematical:

> The work of the mechanician was, in large part, intellectual work. This was true in spite of the fact that he dealt with tangible objects and physical processes, not with symbols, and that some of what he did was done with dirty hands. The thinking of the mechanician in designing, building, and repairing tools and machinery had to be primarily visual and tactile, however, and this set it apart from those intellectual traditions that depended upon language, whether spoken or written. The product of the mechanician's thinking was a physical object, which virtually had to be seen to be understood; descriptions of machines, even in technical language, are notoriously ambiguous and extremely difficult to write, even with the aid of drawings and models. (p. 237)

Interestingly, he does so to underscore that the two modes are equally complex and demanding even though they rely on fundamentally different "grammars." The disadvantage of the non-linguistic style of thought is that its main output is not easily communicated whereas theologians, humanists, and scientist can converse freely because "the thinking is done with the same system of symbols as those used in communication" (p. 238). In the merger, a well-known labor of division between theory and praxis is born whereby the "mere 'mechanics,' artisans and craftsmen [are] fundamentally alienated from the engineer and the architect, who design machines but leave it to the mechanics to build and maintain them" (p. 239; see also Ingold, 2001). Wallace's account is remarkable because he inverts the usual order in which the story is told. Under the hegemony of a theoretical gaze, any practical undertaking is usually provided with a function in reference to theory (demonstration of, application of, execution of) or claimed to hold its own significance according to its own rationale (tacit knowledge, know-how). In Wallace's account, two equal modes of thought conjoin, but only one emerges as the prototype of knowledge.

In the following, activities such as speaking, playing, writing, calculating, trading, working, designing, etc., are considered different *modalities*. Characteristic of each mode is a particular *format* of what is accepted or interpreted as an event, e.g., a speech act, a move, an utterance, a deal, or a sketch. A format is not a definition or categorization that

circumscribes a particular set of phenomena; rather, it is a plastic and dynamic requirement for an event to be recognized and taken into consideration in the given mode. Usually, when defining or categorizing, we look for similarities and systematic differences between entities or different classes. Borges' (1999) oft-quoted Chinese list of animals divided into categories is an example of a list that explicitly attempts to defy the requirements of categorization. For instance, the list puts "those that belong to the emperor" side by side with "stray dogs," "those that have just broken the flower vase," the self-referencing category of "those that are included in this classification," and the perplexing category "Et cetera." In terms of definition and taxonomy, the list fails; however, each entry on the list preserves the format of "an entry into the list of categories" signified by a bullet or the space given to each entry. It is exactly this format that allows us the paradoxical comparisons. A format enables the recognition of false or ill-formatted moves, e.g., differentiating equations is inconsequential in the game of tennis.[92] In a more fundamental way, a format limits what is possible, e.g., in order to be part of an article, an observation has to be put into writing. This rather crude definition is taken to be sufficient as the topic is not the investigation of these modalities as such. A more sophisticated analysis would take into consideration the kinship of modalities with, for instance, Goffman's (1974) frame analysis or the concept of activity in activity theory (Nardi, 1996).

The modalities are not comparable systemically as first-order isomorphisms; that is, they cannot be subsumed under a single code or format, e.g., what constitutes events in playing music and doing math cannot be reduced to the same basic structure or organization. Rather, modalities should be considered related systemically as second-order isomorphisms (Edelman, 1998) that resolve into family resemblances. For example, different aspects of playing music relate internally to other aspects in ways that resemble how different aspects of mathematics relate internally (for instance, both encode and decode actions into symbolic formats). However, this resemblance has nothing to do with how the dynamic interplay of a music ensemble in performance relates internally in ways that resemble the rapture of a team playing soccer and ignore all the relations of playing music that have no counterpart in doing math. This perspective allows the consideration of elements as holding a similar structural position to other parts without necessarily sharing any function or trait. For instance, Wallace (1978) notes that there is a difference in the thinking involved in designing machines as opposed to that of linguistic and mathematical thinking. According to him, the former emphasizes sequence whereas the latter looks to classify phenomena:

> To the mechanical thinker, the grammar of the machine or mechanical system is the successive transformations of power – in quantity, kind and direction – as it is transmitted from the powersource (such as falling water or expanding steam), through the revolutions of the wheel, along shafts, through gears and belts, into the intricate little moving parts, the rollers and spindles and whirling threads of the machine itself.

[92] Of course, just as "one cannot not communicate" (Watzlavick, Beavin, & Jackson, 1967), a format can be stretched and tweaked to include almost anything.

> The shapes and movements of all these hundred parts, sequentially understood, are a long yet elegantly simple moving image in three-dimensional space. (p. 238)

In this modality, "language is auxiliary – often so lagging an auxiliary that the parts and positions of a machine have no specific name" (p. 238). What is of interest is the "working out" of the system. Although naming and describing phenomena may be of great use in patent applications or communicating precise technical drawings, *understanding* the system comes from engaging in its workings in a way that would be impossible based on description alone. In contrast, we would have a hard time imagining a theoretician who would be allowed to discuss a phenomenon that was not given a name or definition. Notwithstanding, entirely theoretical treatments of phenomena are commonplace. In other words, both modalities have included a relation between a description and a phenomenon. However, where the description is the main focus in a linguistic mode and the phenomenon is considered a mere instantiation or example, in the mechanic mode, the focus is the "moving image," and a description is an extraneous and even inferior attempt at understanding what is going on.

It is from this perspective of different possible modalities that dichotomies are examined. The table below exhibits four examples of well-known dichotomies. Although readers well versed in philosophy, anthropology, or cognitive studies will be able to identify close relationships between the terms in the left and right column, respectively, there is, as stated earlier, nothing more than family resemblances between them. The claim is that the pairs exhibit a second-order isomorphism in the way each part relates to the other, e.g., representation relates to reality in a way that is comparable with the way subject relates to object.

Representation	Reality
Subject	Object
Theory	Praxis
Map	Territory

Table 1. A table of dichotomies

Dichotomies

Before turning to a review of the existing uses of dichotomies, I would like to introduce a different problematization of dichotomies. Consider Figure 1 below. Albrecht Dürer's famous woodcut may well serve as a visual exemplification of a dichotomy. The image can be read with each of the pairs in mind without great distortion, for instance, on the left side, we may interpret the draftsman as a subject or as signifying representation (as he is drawing the nude) while the nude may be seen as the object or the reality being portrayed. As such, the image would illustrate, for instance, the epistemic relationship between the perceiver and the perceived.

Figure 7(1 in article). Albrecht Dürer's draftsman drawing a reclining nude with perspective device (inverted)

First, we can note that there are all manners of possible variations in how to engage with the portrait. The entire image can be seen as a representation of a historic or imaginary (in any case, absent) reality. It can be seen reflexively as the part of reality that your brain is currently in the process of representing. One could assert that the nude is also a subject and that the scene should be interpreted as communicative, with the perspective device sitting fittingly in the middle, or we could state that the draftsman could be interpreted as an object just as well as the nude, etc. However, for the image to work as a dichotomy, the two sides have to be interpreted as opposed. Second, we can note that it is possible to "switch" sides on the dichotomies, although it is much harder. We might accept that the nude is a subject, but why is the draftsman in this case an object?[93] Similarly, if we accept the nude as representation, why should the draftsman be reality? Third, the two sides of the image correspond to our everyday conceptions of a first person perspective (perceiving the nude) and a third person perspective (seeing the perception of the nude) from an observer's point of view (our position perpendicular to the image). This aligns with our ability to, in our mind's eye or as depicted in Figure 2, assume the draftsman's perspective and see the nude through the perspective device.

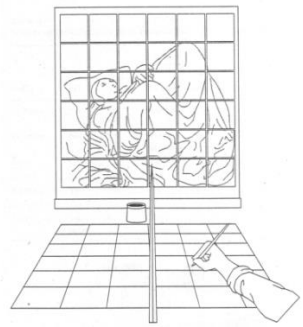

Figure 8 (2 in article). The draftsman's perspective of the nude (Source: Zimmer, 2006)

All of the above considerations focus on how to interpret the relationship between the two sides, as seen through the lens of a particular dichotomy. What ought to attract our attention is the fact that, strictly speaking, we have *no* particular reason to connect the draftsman with the nude. For all intents and purposes, all that is depicted are two persons. This is a very different problem than figuring out their assumed relationship. In order to not simply be an

[93] We could easily imagine the scenario from the nude's perspective, but this would break the image's affinity with dichotomies (unless the draftsman was interpreted as the object). Furthermore, if we substitute the nude with an object proper, say, a vase, taking the vase's perspective would require some anthropomorphizing on our part.

object (like the nude), the draftsman has to indicate something that is not present in the image. The draftsman indicates a *process or activity*. Without this assumption, he simply becomes another person in the room. Furthermore, it is not enough that there is a process. It also has to be undertaken *with respect to* the nude as an object (as in a goal or purpose). The dictionary definition of a dichotomy is a "division into two mutually exclusive, opposed, or contradictory groups" (Dictionary.com, n.d.). In order for two phenomena to be linked dichotomously in the sense discussed here, it is not enough to identify two opposed phenomena. The manner of their opposition has to be some form of equivalence or congruence in the sense that one should be derivable from the other by the application of rules. To use a Batesonian term, the dichotomy should contain redundancy:

> Any aggregate of events or objects (e.g., a sequence of phonemes, a painting, a frog, or a culture) shall be said to contain 'redundancy' or 'pattern' if the aggregate can be divided in any way by a 'slash mark', such that an observer perceiving only what is on one side of the slash mark can guess, with better than random success what is on the other side of the slash mark. (Bateson, 1972, p. 131)

Redundancy is usually understood as "superfluous." What Bateson is pointing to can rather be termed "2.order information." It is not information about the phenomena, as such, but information about the information. The two triangles in Figure 3 are congruent in that one can be transformed into the other; that is, they coincide when repositioned and reflected. The 2.order information that the two triangles *are* congruent gives me the ability to reconstruct triangle DEF with, say, the information of triangle ABC and the position and angle of D.

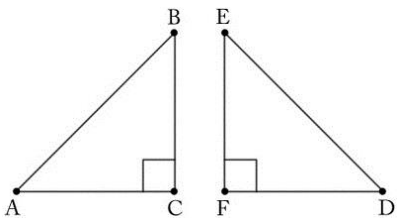

Figure 9 (3 in article). Congruent triangles

However, the obvious equivalence of the triangles in this example is misleading. Consider the following quote from an article on evolutionary biology: "The study of patterns deals with the detection of order in nature while the study of processes deals with the mechanisms generating and maintaining this order. Patterns result from processes" (Chapleau, Johansen, & Williamson, 1988, p. 136). In this quote, patterns and processes are congruent, or they can be said to contain redundancy. This illustrates a situation where there are no obvious similarities between the two phenomena in question – just as in the case of the subject and the object. In Figure 4, we have an algorithm for creating a knitting pattern (left side of Figure 4) and the resulting pattern (right side of Figure 4) side by side:

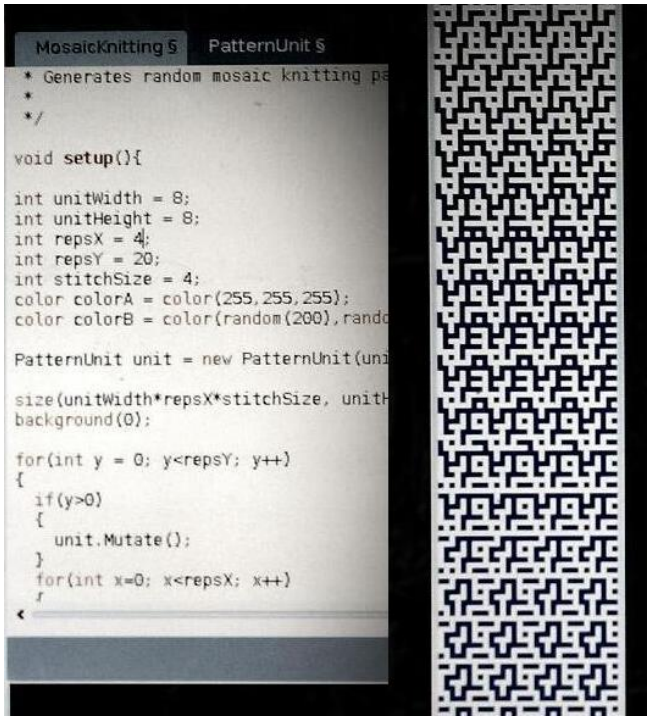

Figure 10 (4 in article). Knitting pattern in the form of an algorithm and resulting pattern

The puzzle about the relation between the draftsman and the nude is reiterated and perhaps clearer in this case. It is not at all obvious that the phenomenon on the left has anything to do with the one on the right. If one were given the information that the two were "opposed" or "mutually exclusive," one would struggle to find points of comparison. The two "opposing" sides look nothing like each other. They are not "similar" in any conventional way we can think of. Without skills in coding, one would not recognize the symbols on the left as an algorithm and would have no reason to suspect that the pattern on the right was produced by it. However, given such knowledge, it is easy to see how the two can be considered transforms of each other. It is not surprising that given the algorithm, we can produce the pattern. This is how the pattern is redundant relative to the algorithm. On the obverse side, and perhaps more surprisingly, given the pattern, we could reconstruct the algorithm. Thus, the algorithm is redundant relative to the pattern.[94]

This problematization of dichotomies shows that the opposed terms in dichotomies does refer to different phenomena; however, they are not related by correspondence, similarity, or in simple opposition. Rather, they are interchangeable, not closely intertwined, not in mutual presupposition, not two sides of the same coin, but commutable – one can be turned into the other and vice versa. Like a left-hand glove can be turned inside-out to become a right-hand glove and vice versa – only the process and pattern look nothing like each other. You will find no first-order isomorphisms. This commutability is perfectly illustrated by the example

[94] Obviously, any pattern would be "overdetermined" in that many possible algorithms would reproduce the pattern. Less obvious, the same algorithm can be used to create many different patterns. In his famous paper, The Chemical Basis of Morphogenesis, Turing (1952) presents his hypothesis of pattern formation. The paper uses mathematics to discuss a mechanism by which "the genes of a zygote [an embryo] may determine the anatomical structure of the resulting organism." (p. 37) Such a mechanism would explain how differences in animals DNA give rise to their different shapes. More specifically, the same algorithm may, for instance, give rise to many different patterns of markings in cowskin.

given in Figure 2 where we were able to "enter" the draftsman's perspective from the observation of the draftsman and, in the process, produce a view of the nude. The entire maneuver would not be possible without the draftsman being made metonymically "equivalent" to a process of perception. Less obvious, but perfectly intelligible, is the reverse thought experiment of taking a random picture and reconstructing the position of the viewer from it. A more formal version is that a pattern results from a process, but a process can just as well be derived from a pattern. This process/pattern dichotomy differs from the similar mechanical process/result distinction. In normal processual thinking, "the result" is a *fait accompli* (Ingold, 2010), that is, a thing or an object that either persists in itself or is continually upheld by an attendant process. In the proposed line of thinking, there is neither, for instance, an object *first* and *then* a process of perception (or vice versa), nor is there an object X that persists concomitant with a process Y that continually (re-)produces it. Although X and Y are different identifiable phenomena, their positioning vis-à-vis each other in a dichotomy signifies not a relation between discrete entities but redundancy between different modes of operation. I will return to a closer look of these modes in the analysis section.

The perspective established here differs radically from one that attempts to explain how or how well a representation is able to represent. One cannot examine a dichotomy by investigating features of either side. There is nothing to be gained, information wise, about "the other side" in investigating one side, unless the dichotomy is assumed, that is, the phenomenon is investigated "with respect to" the other side. There is for example no information to be gained about knitting patterns in investigating features of algorithms, unless one has these in mind. If we accept the proposition that a dichotomy is *not* about relating two disparate phenomena and applying them to the table of dichotomies, we can trace a pattern. For instance, in order for a piece of colored paper to be a representation, a map, or a "description of something," we have to associate a process (drawing or writing), the result of which is the representation, map, or description *with respect to* the represented, the territory, or the described. Without the process, the piece of paper is just a different part of reality, not a description of it.[95] The association with a process is the more conspicuous in the case of the draftsman: we have not set the nude in opposition with the drawing that can be seen lying on the table; we have set *the draftsman* in opposition with the nude. This is only possible because we are able to metonymically associate the producer with his product (Krippendorff, 2006; Lakoff & Johnson, 1980). Another indication that a process is presupposed is the aforementioned ability to assume the perspective of the draftsman. The ability to assume this perspective does not simply require taking the point of view; it also clearly involves taking the process upon oneself, that is, assuming the point of view means engaging in a process, the pattern of which is the perception of the nude.

[95] This even applies to the case of images where a likeness is easily discernible. In the case of an artist making a non-figurative portrait of a person, we would not hesitate to speak of a representation. Conversely, in the case of Putnam's (1982, p. 1) ant that accidently traces a likeness of Winston Churchill or the letters "WINSTON CHURCHILL," we would not speak of representation.

Identifying the uses of dichotomies in the representational debate

With the above framing of dichotomies in mind, we are able to cast a different light on their significance in relation to how many problems are conceptualized in cognitive science (for general introductions to the field of cognitive sciences, see for instance, Dix, Finlay, Abowd, & Beale, 1992; Schneiderman, Plaisant, Cohen, & Jacobs, 2014. The classical position – variously called symbolism, computationalism, representationalism, or simply cognitivism – claims that the mind works as a digital computer. This is either considered on a "high-level" – where cognition is thought to be computations of symbolic structures akin to natural languages (Fodor, 1975; Newell & Simon, 1976; Putnam, 1961) – or on a "low-level" – where cognition consists in multiple distributed groups of simple processing units from which higher level cognition emerges (Edelman, 1998; Hinton, McClelland, & Rumelhart, 1986). Although the exact nature of the form of representation is debated, "neither orthodox camp claims to dispute the presence of representational structures nor the power of representational explanation," as Michael Wheeler (2010, p. 320) puts it. Conforming to the above pattern, in this line of thinking, the focus lies entirely on the relation (representation) between two different phenomena. "[I]nside the agent's head – physically inside the agent's skull, that is – there exists systematically organized (ultimately) neural states whose functional role is to *stand in for* (usually external) objects and situations in the agent's behaviour-producing neural mechanisms" (p. 320, emphasis in original). Our attention is here directed to the functional role of *standing in* of neural states for objects and situations. Remarkably, once this dichotomy is established, the task seems to revolve entirely around determining the exact nature of the representation (similarity, correspondence, isomorphism, etc.).[96] The circumstance that originally gave rise to the idea of a relation (i.e., that there was a resemblance between a cat and the image/perception of the cat) has given way to an interpretation that does not require the two phenomena to resemble each other at all. In the words of Clark (1998):

> The status of an inner state as a representation thus depends not so much on its detailed nature (e.g., whether it is like a word in an inner language, or an image, or something else entirely) as on the role it plays within the system. It may be a static structure or a temporally extended process. It may be local or highly distributed. It may be very accurate or woefully inaccurate. What counts is that it is *supposed to* carry a certain type of information and that its role relative to other inner systems and

[96] "Surely it is correct to say that models can represent the world. This situation invites us to ask a question that has become one of the strands in the alleged problem of scientific representation and that we shall call 'the constitution question': What constitutes the representational relation between a model and the world? Various answers have been proposed to the constitution question. For example, Giere (1988) seems to be offering one in saying that there is a relation of 'fit' or 'similarity' to some degree and in some respects between a model and the world, where the respects and degree are picked out by scientists' intentions in designing and using the model. Others instead think the relationship between model and the real world is one of isomorphism, partial isomorphism, inference generation, and more" (Callender & Cohen, 2006, p. 8).

> relative to the production of behavior is precisely to bear such information. (p. 146, emphasis in original)[97]

Both of the quotes provide impetus to the idea that for cognitivists, representation is not about investigating whether there is a relationship between two different phenomena. Rather, the relation is presupposed and inversed.[98] The agreed-upon mystery seems to be how two very different phenomena can be (about) the same. Moreover, the division of labor is clear. The representational side is tasked with producing a result (the process) with respect to a represented side (an object), which performs the role of being the original. The cognitivist is not struck by thoughts on the legitimacy or relevance of juxtaposing the two phenomena in question. Their connection is taken for granted, and it is understood (although not necessarily explicitly) that one phenomenon is proxy for the process that produces it.

Opposed to the classical position, there is a large and significant array of theories bent on overcoming the mind-matter(body) divide. Portions of the theories in question are sometimes labelled the 4EA approach (embodied-embedded-extended-enactive-affective) (Clark, 1998; Noë, 2004; Varela, Thompson, & Rosch, 1991; Ward & Stapleton, 2012). To these can be added terms such as distributed (Hutchins, 1995), situated (Suchman, 2007), and ecological (Ingold, 2012), which are not always sharply delineated. Obviously, a full account of any of these theories is out of the scope of this article. Many of the theories draw on a common stock of influences such as ecological thinking (Bateson, 1972; Gibson, 1986; Ingold, 2000), dynamic systems theory (Thelen & Smith, 1993), and philosophy (Heidegger, 1962; Merleau-Ponty, 1962). Overall, the theories can be seen as united against or at least skeptical toward a cognitivist view that has variously been labelled Platonic or Aristotelian (Ingold, 2000), rationalistic (Winograd & Flores, 1986), Newtonian (Barad, 2007), and Cartesian (Varela et al., 1991). These labels draw historic lines to a philosophical and scientific mindset that accepts "things" as the primary format. The Cartesian divide famously differentiates between two domains of things, res extensa and res cogitans – the extended things of the physical world and the things of the mind. The theories are united on two points, first, in their conviction that cognition does not (solely) take place in an isolated mind or singular subject; second, in their rejection of the notion that there is an external world with "pregiven [neutral] features that is recovered through a process of representation" (Varela et al., 1991, p. 138, my insert).

The theories in the present discussion can be seen as attempting to transgress the dichotomy between different domains or phenomena. They do so from different angles. Embodied cognition (Chemero, 2009) posits that cognition depends on having a body (e.g., sensorimotor capacities) and that the body (these capacities) is embedded in a larger context

[97] E.g., "Clearly, no one these days believes that a representation of a cat in an observer's brain is cat-shaped (or striped, or fluffy); rather, it is construed as a set of measurements that collectively encode the geometry and other visual qualities of a cat" (Edelman, 1998, p. 449).

[98] "Perhaps the least controversial claim that can be made on the topic of representation is that humans can master systems of representation and that these systems play an important role in thought and communication. It is, after all, hard to see how we could have very rich or abstract beliefs, desires, plans, and hopes if we lacked the ability to embody them in symbolic forms" (Schwartz, 1984, p. 1047).

such that consciousness and intelligent behavior emerge in the interaction between brain, body, and world. In terms of process and pattern, this is a way of saying that the body puts restraints on the cognitive processes in a way that is discernible in the resulting patterns of perceptions. An example is Gibson's (1986) idea of affordances whereby the scale of the body, say the length of legs, puts constraints on how high a step one can take and, consequently, the perception of what is "step-up-able" (Warren, 1984). The extended cognition view (Clark, 1998; Noë, 2004) sees the mind not as limited by the skull but extending beyond even the body to the environment. The embodied-embedded position points to cognitive processes that are constrained by intrinsic bodily dynamics. The extended view expands this by looking at external structures that similarly constrain and thereby mold the cognitive processes at play. Clark (1998, p. 46) borrows the term "scaffolding" from the Soviet psychologist Lev Vygotsky and gives the example of a spice rack that acts as an external mnemonic aid and taxonomy. In terms of process and pattern, this is an example of a process (categorization that is derivable from a particular pattern (spice rack organization). The distributed view (Hutchins, 1995) takes the idea of scaffolding or off-loading the burden of calculation into the environment (Brooks, 1990; O'Regan, 1992) found in the extended mind and widens the unit of analysis to encompass an entire work practice consisting of individuals, artifacts, and environment. Hutchins (1995) famously used the example of a navigation crew aboard an aircraft carrier that has to coordinate its practices and rely on different positions and tasks in an overall process where no single individual has a global overview, and actions are not coordinated by central intelligence. In terms of process and pattern, it becomes increasingly difficult to separate the two. Different positions, practices, and tasks are embedded in different instruments and technologies that give rise to different perceptions, observations, and calculations that all induce changes in positions, practices, and tasks, and so on and so forth. The distributed view is a smidgen away from a situated take on cognition (Clancey, 1997; Suchman, 2007). The position is that all knowledge is activity situated in a particular context: "[T]hinking is a physical skill like riding a bike" (Clancey, 1997, p. 2), and "knowing and doing" are inseparable (Brown, Collins, & Duguid, 1989). At this point, there is a separation between process and pattern only in name, thus aligning with the enactive view (Varela et al., 1991) that, as the name suggests, emphasizes action, though in a way that involves the world. The small prefix "en-" allows us to catch the reference to "something" that is acted out. We might say that just as there are no "neutral" pregiven features or objects in the world, there are no neutral processes that simply carry information. "Organisms do not passively receive information from their environments, which they then translate into internal representations. Natural cognitive systems...*enact a world*" (Di Paolo, Rohde, & De Jaegher, 2014, p. 39). Rather, a process can itself be seen to be patterned. There are differences in how you perceive the world when you are bicycling as opposed to walking or flying – in the dual sense of being different processes and seeing different things (e.g., a bump on the road has different affordances relative to your mode of transportation).

As should be evident, the theories cross the traditional borders between a domain of things and one of thoughts by seeing process in pattern. This dovetails with the idea that has already been presented: that process and pattern are commutable. The difference is that the

process and pattern in question do not lie on the same side of the representational dichotomy (i.e., a subjective process creating a representation) but connect the two sides of the dichotomy. Objects in the world (patterns) can be seen as the outcome of an embodied, embedded, extended, enacted, situated, and distributed process that is not limited by a specific boundary (e.g., the subject, the body, or the skull). It is also an indirect answer to the question posed above; we connect the two different phenomena (process and pattern) because we treat them as interchangeable. There are not simply (neutral) things "out there" to be perceived or interacted with, and there are not simply (neutral) processes "in here" that allow us to perceive objects.

In as much as these theories depart from tradition, they are also bound, to some extent, to the dichotomies in which they are rooted for the pregnancy of their insights. This can be seen in several ways. Most of the theories maintain a representational vocabulary, collating terms such as brain, body, and world (Clark, 1998), using the dichotomy of inner/outer, or speaking of different types of representation, maintaining for instance that there are internal and external representations (e.g., Hutchins, 1995; Zhang & Patel, 2006). It can also be seen in a more general way in the choice of label for each theoretical approach. One can ask: what is it that is embodied, embedded, extended, enacted, distributed, and situated? The answer is variously cognition, knowledge, meaning, or something similar (e.g., The Embodied Mind, Varela et al., 1991). In other words, just as in the case of the draftsman, the process is closely associated with the domain of thinking while the pattern or result is associated with a domain of extended things. Curiously, one can find a statement like the following by Varela (1992): "[T]he inevitable conclusion is that knower and known, subject and object, stand in relation to each other as mutual specification: they arise together" (p. 253). The point is not to enter into a discussion on representation. The statement is easily understood in enactive terms. Rather, it is to wonder why many of the theorists quoted above go to great lengths to break down the implications of a dichotomy only to reiterate it in their vocabulary.

Part II Analysis – How Dichotomies are Created

Those theories opposed to cognitivism do not seem to have gotten rid of any of the dichotomies and, instead, put them closer together. Consider Figure 5 below. Imagine the figure lined up with Figure 1 so that the draftsman lines up with "representation" and the nude lines up with "reality." The "representation" column stands for a way of considering the draftsman. The "reality" column stands for a way of considering the nude. An arrow is equivalent to a process. A circle is equivalent to a result. Each row then becomes an "interpretation" of the relationship between draftsman and nude. Row A illustrates the traditional dichotomy between representation and represented. The process (arrow) terminates in a result (left circle). Together, the two correspond (the arc) to what goes on in reality. This is an indirect perception or representational view of phenomena. It is the result of the process (left circle) that is correlated with the circle in reality (right circle). Below, in row B, the process (arrow) is directly connected with the result (right circle). This illustrates direct perception, as advocated by Gibson (1986). We connect with things directly because the process is not "in here" but "out there."

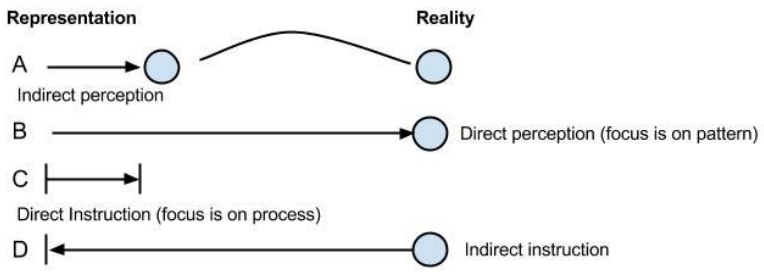

Figure 11 (5 in article). Direct and indirect perception; direct and indirect instruction

As stressed in the example of the draftsman, what is made to "stand in" for reality (a body, a brain, an image in that brain, firing neurons, a map, or a text) is strictly speaking also simply an object in the world. In order for a dichotomy to be in place, a process has to be implied by the object. This was accounted for in the process/pattern dichotomy. What was not examined is that – unlike the very visible arrows in Figure 5 – the process is not present at any time in the case of the draftsman/brain state/text. It is continually implied by the given object. A proper visualization is more closely related to recipes and IKEA instructions that signify a process by step-by-step depictions of a state (see Appendix I). In order to clarify this, we have to differentiate between two forms of instructions – "direct" and "indirect." Carstensen and Nielsen (2001) provide a helpful example of the difference between the two:

> At the end of a berthing maneuver the master may announce over the walkie-talkie that 'we are in position' or he may say 'tie her up.' For all practical purposes both utterances will lead his men to perform the same set of tasks, namely finalizing the mooring procedure. The first statement signifies a state of affairs within the field of work, while the second statement is a direct specification of the task to be performed. (p. 88)

The direct instructions specify tasks, procedures, and methods by depicting each of the states. In the case of the karate kata (a series of movements to be executed by a karate practitioner) (Appendix I), each state depicts either a beginning, end, or resting point of a movement. Movements done in short succession are grouped together. Movements that may be ambiguous from one angle are shown from a different position. The progression through the movements are indicated by a straight fully drawn line while dotted arrows, minor arrows, and fat blocks are used to indicate direction of movement, specific limbs moving, and duration of stances. The entire process is numbered, and a nomenclature is provided. Various other signs signify additional information such as when (and what) to exclaim. The focus of attention is of course the many drawings of a body in different positions. Although the entire diagram does its utmost to make the process intelligible, what it cannot provide is *actual movement*. As Ingold (2000) has convincingly shown, converting (verbal or graphic) instructions into actual bodily movements is immensely difficult. Ingold uses the example of knot making to argue that "practices… cannot be understood as the output of any kind of programme" (p. 358). In Figure 5, the direct instructions are depicted in row C. The horizontal line signifies a process. The vertical lines at each end signify start and end states.

If we take the figure to represent a brain, the line may stand for synapses firing and cognitive processes unfolding, but it has to make do with an object (a static image) (Roepstorff, 2009). The image of a brain can signify a starting or end state, but it can only depict a state, not a process. In representational accounts, the end state or the entire process is interchangeable with the representational result (a perception, a mapping).

The examples of indirect instructions may seem easier (Appendix I). They depict how to put together a Lego set and to tie a tie, respectively. The indirect instructions "signifies a state of affairs within the field of work" – that is, instead of depictions of each state relative to the body, our attention is limited to what is in front of us. As such, the *in*direct instruction corresponds to a first person view (or what you see when you enter – process – a third person perspective as I Figure 2) while the direct instruction is equivalent to a third person perspective. Part of the ease of assembling the Lego set may be ascribed to a certain structuring (or built-in constraints) of how the pieces are able to fit together. However, as in the case of tying knots, the sense of what is going on in the instructions is only obvious once the movements have already been accomplished. These instructions are only clear and concise to the person who has already put together Lego sets or tied a tie. Everyone else will face a task of deciphering the instructions and turning them into actual movement. Examples of elements that are obvious only because we are accustomed to them are the sequential ordering of steps and the assumption that it is the same object at different moments. In Figure 5, the enactive view is signified by row D where the process connects directly with the object in question. Indirect instruction relies on this connection. Seeing observable phenomena *as* cognitive processes requires that a pattern (like the knitting pattern) is recognized as a transform of an algorithm (the process). Gibson's (1986) affordances (direct perception) can be seen as indirect cognitive instructions (e.g., that something is jump-over-able can be seen directly because what is seen (object) is "seen" by a sensorimotor process that does not see the object as much as it sees a transform of a movement).[99] Crucially, however, we can note that indirect instructions *also* rely on objects (static images) to suggest a process.

To be clear, when both direct and indirect instructions are offered, we do not come to the conclusion that we must try to do *two* things. Similarly, when we consider both the process and the result, we ought not to think that we are comparing two phenomena. We are, in fact, considering the same phenomenon in two different ways. These two ways are commutable or are transforms of each other.

For anti-cognitivist theories, the departure from traditional dichotomies (row A) lies in recognizing that perception, for example, is direct, not indirect (row B), and thereby transgresses the divide between a subjective and an objective domain. In the above analysis, this was shown to rely on redundancy between process and pattern, that is, that the two are interchangeable or commutable. What Varela (1992) seems to be getting at when he states

[99] The idea is similar to that of action-oriented representations that simultaneously describe aspects of the world and prescribe possible actions (Clark, 1998, p. 49), only that instead of a map acting as a controller, the world itself acts as a controller, i.e., the world is its own best representation (Brooks, 1990).

that subject and object arise together is the fact that we *can* identify two different phenomena. What is unclear is why we should do so. Interpreting process as instruction shows that the commutability of process and pattern lies in such a way that instructions can be derived from both proxies (the subject and the object). Row C thus provides direct instructions by taking a third person perspective on the process via an object, e.g., a brain, while row D provides indirect instruction by taking a first person perspective on the process via an object, e.g., a knitting pattern. If these instructions happen to be the same, then we can reverse the logical order for a more economical account. The *same* instructions/process can be captured in a phenomenon, that is, an object or static image in two ways. The way in which we capture it depends on whether we have the process or the pattern in mind (e.g., subject and object). This aligns with the use of the term "direct" in Figure 5. In perception, for example, it is clearly "what we perceive" that is of interest. Perception is thus seen as *direct* when the process terminates in and with the object (pattern) while it is seen as *indirect* when it terminates in a representation (process). This is directly mirrored when we are methodologically interested in the process. Instructions are *direct* when signified by the body or the subject (process) while *indirect* when signified by the pattern (object). If this reversal stands, then processes are not derived from phenomena; rather, phenomena express processes.

The vis-à-vis of subject and object is therefore valid when we compare and side-order two commutable versions of instructions (process) but invalid in terms of examining separate and distinct phenomena (patterns) that have nothing intrinsically to do with each other.[100] Examining the phenomenon of a brain will tell us nothing about knitting patterns unless we inspect brain images with respect to such patterns. The "error" committed in the correspondence problem and similar dichotomous problems is that we oppose interchangeable phenomena that stand proxy for the same process with respect to each other, but what we subsequently compare are their indistinguishable cousins, that is, the patterns we find when we examine each separately.

Put in more colloquial terms: *What* you see (the pattern) is a transform of *how* you see (the process). It is possible to speak of an ongoing, situated, provisional accomplishment (Barley, 1986) – but one has to keep in mind that there is not something (thing or object) being upheld by a process. Rather, what is seen is a pattern that takes on its peculiar – varying and differentiating – aspects. A thing is not a *fait accompli* but shifts and changes.[101] There is not a thing first that is *then* subject to a process of perception. A thing *is*

[100] A great part of the error lies in the idea that things and processes have to "take place," that is, we have to situate a phenomenon somewhere. Once a phenomenon is in its place, we proceed to relate it to phenomena that are located in other places. Insofar as there is a process going on (e.g., imaginary, perceptual), *it* has to take place *somewhere* – and that somewhere then becomes the head. The result of the process (e.g., the phenomenon perceived) is located outside the head.

[101] This is not a claim that there exists nothing stable. The point is intended to counter the idea that a process should be *about* a thing or that a thing is a pattern (out there). Rather, the things we see are what we see while in the process of patterning – they are patternings.

patter*ning* (a process) as opposed to seeing a pattern.[102] We may attempt to capture the process in patterning and find an algorithm (process) or establish an object which stands proxy for it, but this process – in the same line of thought – is not a process in a medium that carries content or information about an object; it is (for instance) the very sensorimotor process that creates the pattern. Changes and shifts in processing are equally responsible for shifts in the pattern.

The fundamental error arises as a result of the particular task of capturing a phenomenon (instructions) as an object or static image (a thing). Depending on whether we want to capture the patterning as pattern or process, we lean towards one of the two sides of a dichotomy (two different ways of instructing). We are so accustomed to converting pattern into process and vice versa that we can easily see the body of a man and from that alone assume his perspective and "see what he sees" (Figure 2). The connection between the body or brain of the perceiver with the perceived is therefore obvious and taken together, but it is utterly confusing once we begin to compare them as patterns. Comparing patterns assumes comparability in the very act of juxtapositioning. That is why we struggle when presented with Borges' (1999) Chinese taxonomy. From entry to entry, we are at a loss to find commonalities, and even if we find one between two entries, it is immediately undermined by the next entry. The error can be likened to a faulty recursive operation. A recursion is a mathematical function that can solve complex problems if used properly. It does so by breaking up the problem into smaller sub-problems of the same type as the original, which are then solved and combined for a final result. The tricky thing is that every sub-problem is examined for part of an answer to the problem. If it finds an answer, it stores this part. If it does not find an answer, it repeats the process of breaking up the sub-problem into smaller sub- sub-problems – again, of the same type as the original – and so on and so forth. Finding out whether a problem is answered or should be further broken down depends on an exit condition (or base case). If the answer fits the exit condition, the (sub-)problem is solved. Once all problems are solved, all the answers can be compiled into a complete answer. This type of problem-solving is an everyday occurrence.[103]

The error is generated by using a particular format (thing/object/static image) to capture a dynamic phenomenon (process) – that is, we try to use words or images to capture a particular way of seeing (instructions). In the case of the correspondence problem, we are able to return an answer precisely two times, that is, as an object (direct perception/indirect

[102] This is not identical to the ontological claim that all things are processes (see Seibt, 2013) although it has many overlapping implications. Stabilizing patterning and calling it "a process" does not make it less of an entity. Process philosophy thus remains tied to a particular "thing" format, e.g., dismissing "reality as an assembly of static individuals" but embracing the proposition that "the world is an assembly of physical, organic, social, and cognitive processes" (Seibt, 2013) or distinguishing between "'activity-like,' non-developmental processes or 'goings-on'" and "'accomplishment-like,' developmental processes or 'comings-about'" (Seibt, 2013); each of these can be likened to what has been termed process and pattern in this article.

[103] Herbert Simon has, for instance, described the design process as a decomposition of an overall problem: "The whole design, then, begins to acquire structure by being decomposed into various problems of component design, and by evoking, as the design progresses, all kinds of requirements to be applied in testing the design of its components" (Simon, 1973, p. 190).

instructions) and as a subject (indirect perception/direct instructions).[104] We then proceed to compile them for a complete answer. Both answers are correctly formatted (objects) and are computable (instructions can be carried out), but we will never be able to compile them properly because they are twice-captured commutable instructions. It is this compiling that we attempt when we speak of internal processes in the brain and then ask how they correspond with external objects or vice versa. The earlier-mentioned "redundancy between different modes of operation" is the redundancy between direct and indirect instructions. Compiling two sets of instructions is not quite like asking what the relationship is between Sagarmatha and Chomolungman (both names for Mount Everest). Rather, it is more like securing your seatbelt and then asking where the buckle goes.

This explanation brings us back to the modalities with which I opened the article. It was stated that every mode employs a particular *format* of what is accepted or interpreted as an event. The examples of a speech act, a move, an utterance, a deal, or a sketch were given. The particular modality under examination here is the linguistic mode (writing). The format employed in the linguistic mode is the particular way a phenomenon is captured, that is, the linguistic mode captures phenomena by seeing and naming *things*. We have seen how a *thing* can either signify a process or a pattern, but it is closer to the mark to say that we use the format of a thing to capture a phenomenon as either. The discussion has been focused on discussing how rules (processes) generate structure (pattern) and, conversely, how rules (processes) can be construed from structure (pattern) to sort out how dichotomies arise. The format of a "thing" itself has mostly been referred to in a self-evident or commonsensical manner. However, the format itself carries the key to the question of why dichotomies are so resilient and pervasive:

If what you see is a transform of how you see, then a thing is not something we perceive. A thing is the answer to how we break up the world into "see-able" bits, or to use a computer term, it is how we render the world. Things are *how* we see the world (not *what* we see in the world). "The thing" is therefore a format that simultaneously answers the questions "what is?" and "*how* is it?" The format acts by the law of the instrument, meaning that, because it is the accepted format of when something takes place, then "everything that takes place" takes place in that format – expressed in colloquial terms, "to a hammer, everything looks like a nail" – but taken in reverse: everything that a hammer nails assumes the format of a nail. What has been unveiled is that when a hammer turns upon itself, it will not see a hammer, but a nail (e.g., when we turn to see ourselves, we are satisfied with the answer that we are "subjects," that is, a type of thing). It has also been shown that *from* things (patterns), it is always possible to infer the processes that gave rise to them (we can reverse engineer the processes from the patterns, so to speak). A dichotomy is therefore a setting of the subject (a thing signifying a process) in opposition with an object (a thing signifying the resulting pattern). Both of these can be turned into the other. The process can be computed

[104] The astute reader will note that these are in fact identical; only the "topic" or phenomenon in question differs. This means that one can easily misconstrue direct instructions as working because they directly address "what to do." However, the process at work in direct instructions is not the one depicted in the images or described in the text; it is the process that enables one to see or understand the pattern at which the process is directed. The fact that this understanding can go through a different pattern (indirect) is a matter of translation.

to yield the resulting pattern, and from the pattern, the process can be reconstructed. Insisting that there are two different phenomena in a dichotomous relationship is like insisting that the phenomenon of baking a cake holds a fundamental opposition between the baking and the cake.[105] The opposition thus arises from the attempt to capture the same phenomenon as both process and pattern, which in the format of things requires *two* things.

The format is extremely powerful. We expect the world to reveal itself in the form of things. Even when nothing has been perceived and no event has taken place, the format is still in place as an implicit assumption about the (past, present, or future) form that any phenomenon can take. Any event or thing yet to materialize is already pre-rendered because we know it has to appear in this format. A format thus installs itself, like a Trojan horse, with the expectation of events taking place and phenomena presenting themselves in that format (as things). Whatever problems we subsequently conceive of are shaped and conditioned by this format. The claim here is that in accepting a particular dichotomy as one to overcome, we accept a particular problem (e.g., the correspondence problem) as a starting point. By extension, we accept the format that created the problem. Once assumed, we cannot escape the format (if we abandon the format, it becomes unclear what the problem is), and therefore there are no available solutions that do not recreate the problem.

The answer to the question of how dichotomies are possible is that the format of things allows two ways of capturing a phenomenon that, when brought together recursively in the same explanation, produces a circle that cannot be squared. The answer to why dichotomies are so pervasive and resilient is that things are *how* we (for the most part) see the world, not *what* we see in the world. When we conjure up the dichotomy in an attempt to overcome it, we also (re-)instate, affirm, and propagate the format that allows the problem to become problematic. Thus, even though we may "overcome" the dichotomy, the format still wins the war.

This explanation has three important consequences: 1) we can stop trying to determine what the relationship is between map and territory or any of the other dichotomies; 2) we can allow ourselves to see the dichotomies as generated by the use of the same algorithm recursively; and 3) we can recognize insoluble problems generated by the use of a particular format.[106]

Part III Switching to a Different Format

It is difficult for us to open our eyes and not see objects (as a conscious act), but as Dreyfus (2008) makes clear in Heideggerian fashion, most of the time, we do not see objects.[107]

[105] There is of course the opposition between the recipe and the cake, which suffers from the same defect, but requires a different treatment in order to sort out.

[106] One very potent consequence that requires greater attention than what is possible here is that hyphenated theoretical approaches such as socio-materiality, material-discursive, actor-network theory, and human-computer interaction as well as the anti-representational cognitive theories treated in this article run the risk of setting up precisely those dichotomies in bringing together disparate phenomena without explaining their relation, i.e., the hyphen.

[107] He writes: "[I]n our most basic way of being, – that is, as skillful copers, – we are not minds at all but *one with the world*" (Dreyfus, 2008, p. 14, emphasis in original). This goes against the idea that the thing is a fundamental and inescapable condition of our epistemological make up, a thought that Grosz (2009) puts this

Moreover, there are many formats that do not require the world ordered into things in order to be intelligible. This third part takes the example of the theory-praxis dichotomy as a way of exemplifying problems generated by applying the thing format to phenomena that would be better suited with a different format. It also offers a sketch of how to switch formats.

The above explanation differs only slightly from its performative or enactive origins. The difference is the emphasis that there is no "of," that is, there is not a "performance *of*" or "enactment *of*" something. For instance, Dreyfus uses the terms "skilled activity" and "situation" to illustrate the point that "in our skilled activity we are drawn to move so as to achieve a better and better grip on our situation" (p. 16). The point is well taken, but the wording suggests that "skilled activity," what I have termed process, and "situation," what I have termed pattern are not only separate but connected or coupled in a relation. The trouble is that the situation as it unfolds *is* skilled activity. The same problem is found in the theory of autopoiesis that differentiates between system and environment (Maturana & Varela, 1980). The crucial insight that a system does not act upon information received from the outside environment is termed "operational closure"; it states that our nervous system is in fact a network of active components "in which every change of relations of activity leads to further changes of relations of activity" (p. 164). Thus, the system acts upon impulses from itself and affects further impulses to itself. The question arises from the term itself "closure from what?" The environment reenters in the form of "perturbations" or stimuli or triggers as something "out there."[108]

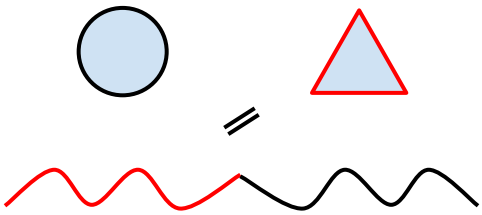

Figure 12 (6 in article). A visual metaphor for the error committed in correspondence problems

Figure 6 is an attempt at visualizing the mismatch that occurs. The top row (triangle and circle) represents the two disparate phenomena (patterns) that one can find when looking at, say, a brain (circle) and a tree (triangle) captured in the particular format of things. The two waves underneath represent the process (instructions) that we may identify the phenomena as (patternings). Speaking of activities and introducing things into the equation are signified

way: "The thing is what we make of the world rather than simply what we find in the world, the way we are able to manage and regulate it according to our needs and purposes (even if not, as James suggests above, at will or consciously. We cannot but perceive the world in terms of objects. We do not do so as a matter of will). The thing is an outlined imposition we make on specific regions of the world so that these regions become comprehensible and facilitate our purposes and projects, even while limiting and localizing them. Things are our way of dealing with a world in which we are enmeshed rather than over which we have dominion. The thing is the compromise between the world as it is in its teeming and interminable multiplicity [...] and the world as we need it to be or would like it to be..." (p. 126).

[108] "The concept of cognitive self-reference describes perception and representation as perception of relations. Stimuli are mere peripheral energetic conditions (i.e., perturbations P) for a semantically closed and self-organizing cognitive system. The structure of the cognitive system determines which structural configurations of its *surrounds* are perturbations of the system, and which are not. The idea is that the cognitive system is in dynamical equilibrium. This means that the perpetually acting components of the system (e.g., neurons) respond solely to the activity of other components" (Peschl & Riegler, 1999, p. 10, my emphasis).

by the left wave and triangle, both marked in red. The "proper" way of bringing in the triangle would be in wave form. This would allow us to see that what we mean to signify by introducing the triangle is a shift in pattern. However, because we now identify the shift with the triangle "out there," we have to identify the former pattern with the circle "in here." What gets lost is that in activity terms, there is no inside or outside. When we speak of activity, there are only changes (processes). There is no particular reason to place it in any specific location. When we speak of things, there are only patterns. Mixing activities and things is a way of crossing the wires and getting the instructions confused. As a further consequence of this mixing, we are prone to associate other dichotomies – e.g., language has a form level (syntax) and a content level (semantics) – so the brain can be identified with processing at a form level and the result is a meaningful environment (lifeworld). Conversely, if meaning is identified with the brain, then matter (the world) becomes the amorphous substrate upon which that meaning is thrust. In other words, concepts that apply equally well to either side are suddenly reserved for one side only.

The example of theory-praxis

The article opened with Wallace's (1978) insightful comments on differences between linguistic and non-linguistic modes of thinking. In a different passage, he points directly to the powerful position that language has in how we communicate and what we regard as knowledge:

> Thinking visually and tactilely has an inherent disadvantage, however, in comparison with thinking in language. Those who think in words— on subjects which are thought about effectively in words— can think a sentence and then utter it for others to hear. If one visualizes a piece of machinery, however, and wishes to communicate that vision to others, there is an immediate problem. Speech (and writing) will provide only a garbled and incomplete translation of the visual image. One must make the thing— or a model, or at the least a drawing— in order to ensure that one's companion has approximately the same visual experience as oneself. (Wallace, 1978, p. 238)

The perceived disadvantage of thinking visually is that it does not translate well into language. Thus, the disadvantage of the image is that it is not text. Why, therefore, is it not an equal disadvantage for a text that it is not an image (after all, the translation into speech was deemed garbled and incomplete)? The philosopher Davis Baird (2004 p. 5) called this a text bias, which Ong (2002, p. 5) refers to as the tendency of scholars to "think of writing as the basic form of language." Baird provides the example of Michael Faraday who invented the first electromagnetic motor. Upon introducing his invention, not only did he publish text and diagrams as per the usual academic format, "[h]e made and shipped 'pocket editions' of his newly created phenomenon to his colleagues" (p. 3). This was a very tangible way of circumventing the problem of trying to express something in a format unsuited to the purpose, however, it did not solve the problem. I suspect that in the eyes of many, Faraday neither "communicated" by sending his pocket editions, nor did he send "knowledge" as much as he sent the result of knowledge or something to that effect.

If we allow the above analysis to be applied to the dichotomy of theory and praxis, then their positioning vis-à-vis each other is an error. Theory, understood as process, is instructions on how to see. This, of course, corresponds with the etymological origin of theory, theoros, which means spectator.[109] Praxis, understood as pattern, does not simply mean an act or an execution of a prior plan or intention[110] but bears with it all the connotations of skill connected to craft and art (see Ingold, 2001). Insofar as the two capture different ways of informing (as in "giving form" or patterning) skilled activity, there is no particular reason to place and identify knowledge with the paper that the theory is written on or the materiality that the praxis traverses. Nonetheless, we differentiate between theory and applied science, abstract knowledge and hands-on knowledge, episteme and techne (see Parry, 2014). We can infer – when we look for signs of knowledge – that the image of knowledge is text. Just as in the case of what was seen to be "direct" perception and instruction in Figure 5, text is seen as closer to knowledge through chains of metonymy: text is seen (theoros); vision is the head; the head is knowledge. Antithetically, the body thus becomes the speechless mirror image or carrier of knowledge. Wallace (1978) is on point when he makes the assumption that an image does not constitute knowledge before it has been translated into words:

> In the Western world, an effect of this special problem in communicating technological information has tended to be the growing isolation of those who think in mental pictures… Indeed, it has become conventional to assume that thought itself is merely a kind of internal speech and to disregard almost completely those kinds of cognitive processes that are conducted without language, as though they were somehow more primitive, and less worthy of intellectual attention. (p. 238)

Once the dichotomy is in place, those who fight to leave room for praxis in how we perceive knowledge are waging a lost battle. Since the format decides what is meaningful and takes place in a given modality, nothing left undescribed can take place. All other modalities are held to the logically impossible standard of having to be or become linguistic in order to qualify as knowledge.[111] The format is given, and therefore, what goes on in praxis was always already given as text (a prior plan or intention) or, at a minimum, has to be reconstructed as text (interpretation) in order to be understood.

Taking away reason – Nothing left undescribed can take place

Schön (1983) provides a lucid example of the manner in which even those who have championed praxis as an important and fundamentally different type of knowledge are caught up in the dichotomy of theory and praxis. In his masterpiece, *The Reflective Practitioner*, he provides us with this version of the dichotomy:

[109] "Theoros" was of course in ancient Greece the term for the official witnesses to a spectacle. For an account of the migration of the term to philosophy and the modern meaning of theory, see Nightingale (2004).

[110] The Wikipedia entry on praxis states that "Praxis is the process by which a theory, lesson, or skill is enacted, embodied, or realized," which provides a clear example of the contrast to theory.

[111] If a non-linguistic modality succeeds in becoming linguistic, it is no longer non-linguistic and thus no longer itself.

> In the varied topography of professional practice, there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing 'messes' incapable of technical solutions. (p. 42)

Elaborating on the difference between the two, Schön's choice of words underscores that the domain of praxis is based on intuition and muddling through while the domain of theory is rigorous and solid:

> There are those who choose the swampy lowlands. They deliberately involve themselves in messy but crucially important problems and, when asked to describe their methods of inquiry, they speak of experience, trial and error, intuition, and muddling through. Other professionals opt for the high ground. Hungry for technical rigor, devoted to an image of solid professional competence, or fearful of entering a world in which they feel they do not know what they are doing, they choose to confine themselves to a narrowly technical practice. (p. 43)

The distinction aligns with those of other giants contemplating the relationship between knowledge and action, e.g., Ryle (2000 on knowing-that, knowing-how) and Polanyi (1966 on explicit, tacit), in that a great divide between conscious and unconscious thought is delimited. Often, the unconscious is given the role of a mute, automated, and enormously powerful entity while consciousness is reserved the role of the tiny helmsman handling this mammoth.[112] These theories have done much for the study of practices and non-linguistic modalities, but as Baird (2004, p. 18) puts it: "'Craft knowledge,' 'fingertip knowledge,' 'tacit knowledge,' and 'know-how' are useful concepts in that they remind us that there is more to knowing than saying. But they tend to render this kind of knowledge ineffable." Practice is thus made mystical on the basis of intuition, feelings, or sensations. Practical problems are seen as messy, wicked, context-dependent, and situated. The much celebrated study of Csikszentmihalyi (1990) presents our conception of work par excellence, that is, the type of activity where you lose yourself (become unconscious) in an activity, all in the concept of flow.

The problem, of course, is not that the "type" of knowledge in question cannot be captured in the format of "things." The problem is, as soon as it is captured, a lopsided inversion takes place. Latour and Woolgar (1986) explain in a famous passage that an otherwise abstract hypothetical scientific statement suddenly comes to be seen as originating from reality. They call this phenomenon an inversion.[113] In this case, the inversion is turned

[112] Lakoff & Johnson (1999) provide an example of this type of thinking: "Conscious thought is the tip of an enormous iceberg. It is the rule of thumb among cognitive scientists that unconscious thought is the 95 percent of all thought – and that may be a serious underestimate. Moreover, the 95 percent below the surface of conscious awareness shapes and structures all conscious thought. If the cognitive unconscious were not there doing this shaping, there could be no conscious thought" (p. 13). The design theorist Christopher Alexander (1964) likewise distinguishes between the unconscious design of primitive people and the enlightened conscious design of the modern day.

[113] They explain the idea this way: "Once the statement begins to stabilise, however, an important change takes place. *The statement becomes a split entity*. On the one hand, it is a set of words which represents a statement about an object. On the other hand, it corresponds to an object in itself which takes on a life of its own.[...]

around. Up until the point where the action is not described, it is not considered knowledge. As soon as it is described, it attains the status of knowledge, but the knowledge no longer originates from the action – the reason being that all descriptions derive from conscious thought. It is thus caught in a vicious double-bind where it is either explicated (and thereby transferred to be part of the language side) or it has to remain unrealized, potential, tacit. Even proponents of practical embodied knowledge tend to unwittingly overvalue the potency of propositional knowledge and cheapen the value of practical knowledge. Crawford (2009) draws up a scenario where a mechanic handles the cleaning of a distributor in a motor in two different ways relative to whether the truck has been out in the rain or off-roading in sand. Without any explicit thought on the matter, he chooses either the lubricant or the compressed air, or as Crawford puts it, he "intuits" which one to use:

> I say 'intuit' rather than 'conclude' because he [the mechanic] may not draw any explicit connections in his mind between muddy boots and remedy A, on the one hand, and sandy hair and remedy B, on the other. Rather, he is familiar with typical *situations*, and their typicality is something of which he has a *tacit* knowledge. This tacit knowledge seems to consist of recognizing patterns. (p. 166)

The word "conclude" is part of a rational vocabulary, and since no explicit (i.e., conscious thought) knowledge is involved in this case, it has to be tacit. Similarly, Baird (2004, p. 19) writes: "There are, however, important differences between work with theory and work with things. Things are not as tidy as ideas. Plato was exactly right on this point. Things are impermanent, impure, and imperfect." This of course ignores the many ways in which language (speech and writing) is ambiguous, indexical, imprecise (Chinese whispers), and based on slurred speech, sloppy handwriting, non-sequiturs, bad reasoning, fallacies, and misunderstandings.

This step-motherly handling of praxis is a way of "taking away reason." Schön (1983) describes how part of his research team at one point analyzed video material and deemed that one boy was not particularly bright. When later it was discovered that his actions were in fact triggered by an error in communication made earlier by someone else, the boy's efforts were suddenly retrospectively transformed from stupid to rather ingenious. The researchers later spoke of "giving someone reason" (p. 67) to indicate giving someone the benefit of the doubt while interpreting their behavior. In the same way, actions and practices are habitually "deprived of reason" with no other excuse than that they do not belong to a linguistic modality. This is not necessarily a sinister plot, however, the scientific effort to continuously map and describe phenomena seems in itself to create a tendency wherein everything that is based on a different modality is slowly engulfed. Ingold (2011, p. 61) determines the project of technology to revolve around capturing the "the skills of craftsmen or artisans, and to reconfigure their practice as the application of rational principles whose

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Before long, more and more reality is attributed to the object and less and less to the statement *about* the object. Consequently, an inversion takes place: the object becomes the reason why the statement was fomulated in the first place.[...] At the same time, the past becomes inverted. [The object] has been there all along, just waiting to be revealed for all to see" (Latour and Woolgar, 1986, p. 176).

specification has no regard for human experience and sensibility"; with reference to Carl Mitcham, he specifies this movement as a "desire to transform the heuristics of technique into algorithms of practice" (p. 61). Similarly, Crawford (2009, p. 37) finds that "[t]he dichotomy of mental versus manual didn't arise spontaneously. Rather, the twentieth century saw concerted *efforts* to separate thinking from doing." In the same vein as Ingold, Schmidt (2015) finds the impetus for this drive towards capture in rationalization:

> As already noted, since about 1400, ordinary work practices have been subjected to systematic studies for the purpose of describing them for others to be able to emulate established practices as well for the purpose of understanding their rationale: why they work the way they do and, when relevant, to rationalize these practices or rather their repertoire of techniques." (p. 106)[114]

Once jobs are at stake, the Luddite sympathies may be given free rein: "[T]he degradation of work is often based on efforts to replace the intuitive judgments of practitioners with rule following, and codify knowledge into abstract systems of symbols that then stand in for situated knowledge" (Crawford, 2009, p. 167).

The trouble is that while the dichotomy is continually challenged, the format quietly wins the war. We either have to bow to a descriptive format in order to convert practice into knowledge or accept the claim that practice is impossible to describe (it is situated, messy, non-rigorous). The only way of dismantling the hegemony of the linguistic format is either to come up with a different medium or to attempt different descriptions that do not capture "things," that is, we have to change format.[115] Practice should be described in a way wherein description does not take center stage and cannot replace the praxis as it unfolds. In order to do so, we have to relinquish tendencies in our descriptions to render praxis antithetical to theory. We also have to abandon the idea that praxis cannot be fully captured in description since the purpose of the description is not to capture the phenomenon. Rather, we have to see that the primary relationship between different modalities is the kindred ways in which they "educate our attention," to use a Gibsonian (1986) term. Such a project obviously requires a treatment in itself. Here, the perspectives can only be suggested with the short example of "timing."

The example of timing

Consider Mike Rose's description of a waitress working at a cafeteria (Appendix II).

[114] Similarly, Crawford arrives at the idea of algorithms: "The crux of the idea of an intellectual technology is the substitution of algorithms (problem-solving rules) for intuitive judgments. These algorithms may be embodied in an automatic machine or a computer program or a set of instructions based on some statistical or mathematical formula" (Crawford, 2009, p. 167).

[115] The anthropologist Tim Ingold is a notable example of a theoretician who attempts such a project.

Praxis is a different type of educating attention – not a lower form of cognition. The main focus of praxis is not knowledge but skill.[116] The type of skill that is sought is different from the mechanized teleological skill found in rational methodological accounts of "how-to-do something." It has to do with what the designer David Pye (1964) calls care, judgment, and dexterity (see also Ingold, 2000). The waitress working an entire shift could be said to be calculating different timetables and adjusting each to the other. However, that would be reducing her to a mechanic executioner of algorithms. The way she moves and shifts in and with the streams of motion is timed in a way that has more to do with a choreographed dance than executing a plan. Because the different streams of time and motion are interdependent and only loosely coupled (what the chef or a particular customer does is not determined by what she does), she has to time her path through the restaurant and the sequence of her actions in a way that not only optimizes her own workflow but also takes other flows into account. Missing a cue, being interrupted or delayed, serving a dish before the customer is ready – are all misalignments of timing that have ripple effects down a series of other actions. Being skillful in this respect requires acquiring rhythm. As Ingold (2000) has discussed in many different ways, rhythm is not about counting. "A metronome, like a clock, inscribes an artificial division into equal segments upon an otherwise undifferentiated movement; rhythm, by contrast, is intrinsic to the movement itself" (p. 197). When you are in a rhythm, all of the different flows are coordinated and incorporated one into the other through an understanding of "windows of opportunity," chaining (actions that are prerequisites and causes for other actions), entrainment (assuming the same period as different system), and the principles of economies of scale (or spreading the overhead costs) and opportunity cost. Take the example of Double Dutch, a game of skipping rope played in schoolyards all other the world. The feminist writer Kyra Gaunt accurately describes the crucial junction of entering and exiting the ropes being turned:

> To anyone who has failed at either the physical or social skills of performing double-dutch, myself included, the real art of play is learning how to get into the ropes and learning how to do a good 'dismount': exiting the ropes without interrupting their constant flow, so the game can proceed seamlessly, non-stop, into the next turn. (Gaunt, 2006, p. 137)

There is a "window of opportunity" in which the turning ropes can be entered without interruption. Learning when to enter is not about perceiving any "things," that is, looking at and finding out the properties of the rope or investigating the persons turning arms and hands or the ground will tell you nothing about *when* to enter. "Seeing things" is of no use whatsoever. Getting ready to enter means assuming a certain stance and counting in "1, 2, 3 – GO," that is, acquiring the rhythm of the ropes by making mock attacks by each count and releasing the tension by the actual attack. There is no "thing" to be situated anywhere despite the linguistic demands that we speak of *something*. If anything, there are inflection points (points at which the rope stops travelling further away and starts travelling back towards the jumper) that delimit the window of opportunity. The rhythmic repetitions or

[116] Whether "skill" should be considered a type of knowledge warrants separate discussion that cannot be undertaken here.

oscillations of the rope compound (entrainment) through visual, auditory, and haptic clues that serve as a baseline from which an attack can be timed and launched. This attack stands out on the background of the baseline and is easily recognized as "in step," syncopated, or off-beat. It is in the same way that the experienced waitress carries a perpetually changing baseline of rhythms and patterns that combine, recombine, or collide. These are not computed, as much as they are committed to, for instance taking a specific route on the floor. The waitress learns that the bell from the kitchen means an order is ready to serve, which creates a window of opportunity. Rerouting from her current position in the restaurant, there may be several actions that should have already been taken care of, e.g., placing eating utensils and napkins, such that the rerouting interferes with other ongoing chains. She grabs extra utensils and places them on a table on her way (economies of scale) and says to a customer "I'll be right with you" (opportunity cost). Timing is intrinsic or situated in a way that Ingold (2011) has likened to walking or sawing a plank:[117]

> In walking, every step is a development of the one before and a preparation of the one following. The same is true of every stroke of the saw. (p. 53)

Gaunt (2006), turning to a different type of children's game, also identifies rhythm as intrinsic to the game rather than something that can be captured in an algorithm: "Girls' handclapping games are an example of the lack of dependence on an externalised beat (such as tapping one's toe). Rhythmic sensibilities are developed and sharpened as part of play, not separate from it" (p. 29). Perception, cognition, and linguistic commands are not part of descriptive regimes that turn situations into cognitive schemas or models of the situation. They are calibrations of a system seeking equilibrium (e.g., a steady work pace), optimization (maximum yield from minimum effort), or local optima (personal job satisfaction).

It is this type of sequential thinking, which Wallace (1978) points to when claims that there are different modalities for the engineer and the scientist. "Having the knowledge of" and "being able to" are equivalent in an approach to praxis that emphasizes skills. Asking a practitioner to explicate his knowledge creates a detour through a cognitive process that is extraneous to the skill, at best, and destructive of rhythm, balance, and timing at worst (Gallwey, 1974). Conversely, insisting that a practitioner's knowledge is inexplicable (implicit) is bowing to the same ideal of theoretical knowledge. The transition to a different type of format consists in choosing the appropriate data structure, that is, developing a new vocabulary. The example of timing made use of, for instance, the term "window of opportunity," which clearly illustrates that we cannot ask "where is the window of opportunity?" or "what does it look like?" Invoking a different vocabulary is therefore also invoking a perspective that has ceased to look for things and, rather, prepares the practitioner to see and act, that is, one that has educated her attention.

[117] The image of a Wankel engine (an internal combustion engine) illustrates how every state can simultaneously be a preparation, execution, and conclusion of an action (https://en.wikipedia.org/wiki/Wankel_engine).

Conclusion

Showing how dichotomies are possible as the recursive application of the same format is an economical "solution" to a complex problem. It does not solve any problem *per se*. It insists on explaining how the problem is possible and resists the temptation to engage in actually solving or overcoming a specific dichotomy. Furthermore, setting up the countermeasure, that we should not even engage in the problem of the dichotomy, is a way of avoiding the affirmation of the format of things responsible for the dichotomy. The idea that things are how we see, not what we see, is incredibly potent. Coupled with the claim that there are other modalities available, the perspective of this article promises a renewed sensitivity and ability to recognize "what one does while one does it" – so to speak. Becoming sensitive to something as powerful as the format of things allows us to abandon longstanding philosophical debates on dichotomies, to explain their genesis, and point out why they are insoluble. It also reopens the world to "other formats," as suggested by the analysis of praxis above. It gives us leave to enter a world where the power of language has taken a more balanced role as a helpful extraneous device, but not one that monopolizes the knowledge, meaning, or understanding of a situation. Language can suggest how to practice, but it has no control over it.

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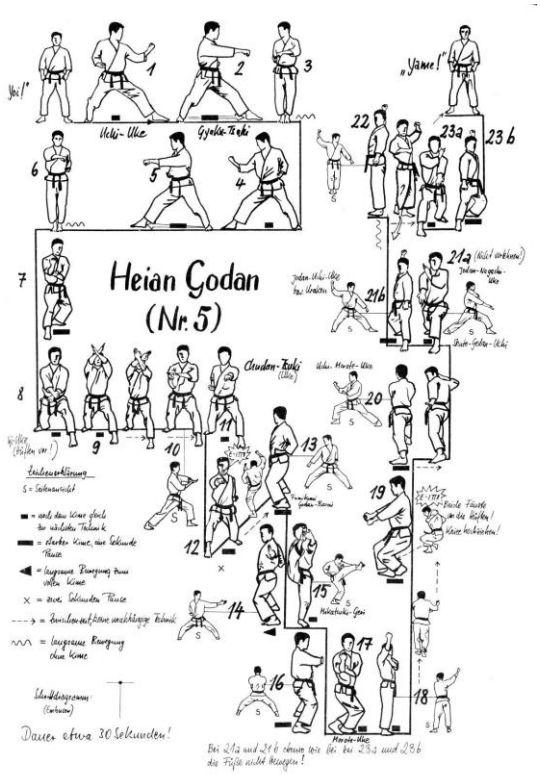
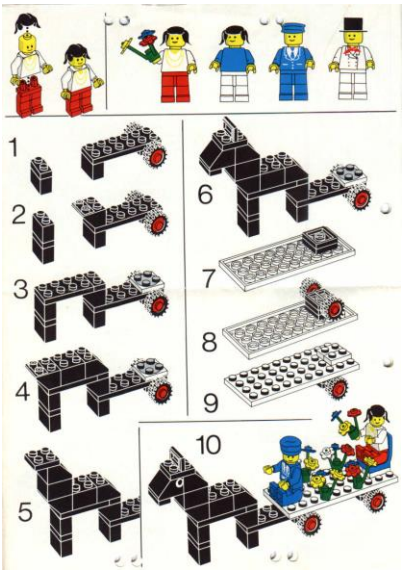
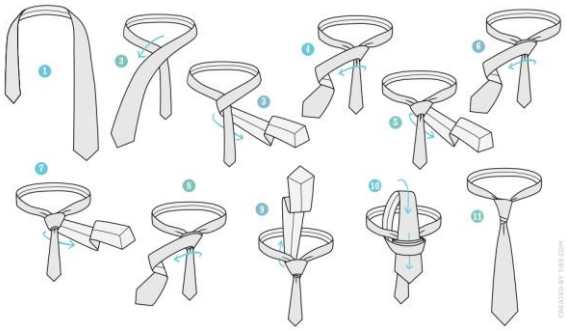
Appendix I (article 1)



Direct instructions. Source: http://www.trinityshotokan.com/kata_diagrams2.html





Indirect instructions. Source:
http://lego.brickinstructions.com/en/lego_instructions/set/1592/Castle_Town_Square
http://www.ties.com/how-to-tie-a-tie/van-wijk

Appendix II (article 1)

On the face of it, a restaurant is a structured environment. The physical layout guides movement and behavior, and the various conventions associated with dining out are well known, to customer and waitress alike. But when analyzed in terms of the interrelated demands of the work itself, the environment, particularly at peak hours, becomes more complex, with an unpredictable quality to it.

Consider the restaurant in terms of multiple stream of time and motion. Customers enter with expectations: they will be seated without much delay and, once seated, a series of events will unfold along a familiar time line, from ordering through salad, entrée, dessert, delivery of the check. Their satisfaction – physical and emotional – is affected by the manner in which these expectations are met. But customers are entering the restaurant at different times, each with his or her own schedule, so tables (or places at the counter) proceed through meals at different paces. This staggering of customers facilitates the flow of trade but also increases the cognitive demands on the waitress: what she must attend to, keep in mind, prioritize. This situation intensifies during peak hours, for the number of customers expected can be estimated, but not known – coffee shops and family-style restaurants typically do not take reservations. If the numbers swell beyond capacity or an employee calls in sick or is late or quits, then, as the younger waitresses I interviewed vividly put it, you're 'slammed,' abruptly pushed to the limits of physical and mental performance.

Another timetable kicks in as soon as an order is placed with the cook. Different items have different prep times, and once the item is prepared, there is a limited amount of time – pretty restricted for hot items – during which it can be served. As well, the serving area needs to be cleared quickly so that the cook can deliver further items. The waitress, therefore, is aware of the kitchen as she moves among her customers. (Rose, 2005, p. 6)

Appendix 2 – Article 2

What is an interface? Introducing metaphors as an analytic tool

Abstract

Why is the question of an interface set up as a representational problem, and what is an interface?

This article proposes a model of what an interface is and how it comes to be. HCI designers will immediately think of computer interfaces such as the desktop metaphor or WIMP (Windows, Icons, Menus, Pointer). These are *not* the focus of this article. Although most designers involved in interface design have little patience for philosophical considerations, it is often possible to trace a set of theoretical assumptions in their work. The article is premised on the idea that the study and design of modern interfaces can be informed by studies of much older "interfaces." These interfaces are found in a philosophical mindset that asks questions of what the world is like (ontology), how we come to have knowledge of it (epistemology), and how to model it (methodology). The claim is that interfaces are already implicated in philosophical problems *qua* the assumptions upon which they are built. The article offers an analysis of a basic model of what an interface is. It does so with a particular reflexive and methodological problem in mind. When it comes to examining their fundamental assumptions, designers face the same problems as philosophers. *The conceptual tools under scrutiny (their own ideas) are the very tools used for examination.* Rather than press forward with an answer to what an interface is, the article asks whether we have the question right. The article takes a different path and introduces the use of metaphors as an analytic method. Instead of attempting a direct exposition of an interface, a series of metaphors are presented that are together aggregated into a model. The model as a whole showcases what an interface is while also providing an explanation of what and how an interface arises. As such, it demonstrates the idea of things as *sui generis* meaning. Importantly, metaphors are not treated as denotative of something else. The principle of symmetry is employed across all modes of being. Perceptions, practices, sketches, daydreams, metaphors, and drafts are treated as equal. Metaphors are thus seen as expressive in their own right in an *ostensive* or *expressive* way. Six metaphors are presented, and together, they answer the questions of why interfaces are thought of as representational problems, what an interface is, and how it comes to be (its genesis). As part of the presentation of the model, several traditional notions surrounding interfaces are dismissed. First and foremost, the representational relationship between words and things is brought into question. It is claimed that phenomena cannot represent each other. For phenomena to be related, they have to be transforms of each other. It is also denied that meaning can be transported. Rather, it is claimed that the purpose and effect of communication is to interfere (create changes), not to create things (words, ideas, pieces of information).

Keywords: Human-Computer Interaction (HCI); Interface; Rigorous Metaphors; Redundancy

Introduction

Like all craftsmen, designers depend on an intimate knowledge of the tools of their trade. Most designers in the HCI field can claim insights into the workings of their computer, on different types of software, and some into the workings of the behavior of people. However, fewer would be able to profess a deep and intimate knowledge of the tools they use every day in order to make sense of the world around them, to grasp a problem, or grapple with a solution. The "tools" I am referring to are ideas, concepts, and patterns of thought. In relation to these tools, the designer faces the same difficulty as the philosopher. *The tools they are attempting to examine are the very tools used for examination.* A philosopher attempting to get a grasp of the tools at her disposal does not have the luxury of being able to step out of her perspective and point to the tool as she would with a piece of software or a paintbrush, canvas, and easel. One cannot see the tools (in the act of) producing the ideas because the idea that would convey such a thought would already be the result of the tool having been used (the production is always over before it can be captured, so to speak), or if we did see it (the act of production), it would eclipse the idea we were trying to delineate. How therefore can a tool examine itself?

This article seeks to propose a theory of interfaces with this problem in mind. The concept of "interface" is used in a very specific way. Most HCI designers will immediately think of computer interfaces such as the desktop or WIMP (Windows, Icons, Menus, Pointer). These are *not* the focus of this article. The article is premised on the idea that the study of modern interfaces can be informed by studies of much older "interfaces." These interfaces are found in philosophical questions of what the world is like (ontology), how we come to have knowledge of it (epistemology), and how to model it (methodology). Their common denominator is that they all deal with how different phenomena are generated and explained. It is the "generation of phenomena" that connects these philosophical interfaces with the particular outlook of designers who generate ideas, sketches, and concepts and eventually realize certain phenomena for a living. The common denominator is that interfaces are where ideas, concepts, and solutions are generated. As such, I take a provisional definition of an interface as "enabling the generation of phenomena." The thoughts and ideas we have are enabled by an interface; so are the perceptions we have and the models we build.

What I am proposing in this article is presented as a series of ideas or, rather, metaphors. Each of these is put forward to be thought through. All carry with them further questions that are then posed, and answers are attempted with yet other metaphors. Six different metaphors in total are chained together. What are the metaphors about? Overall, they seek to answer the question "what is an interface?" However, they do so from a position that is dissatisfied with the presuppositions in how the question is posed and how current answers to the question are given. Thus, the article does *not* accept any assumption that the question of an interface is straightforward and that only different answers need to be assessed. Instead, the article proposes a rethinking of the question. The investigation opens with: "why is the question of an interface set up as a representational problem?" In the most common model of an interface, we can easily recognize the problematic philosophical relation between subject (human) and object (computer) (or between words and things or

representation and represented)." By questioning the question, we also question the means with which we seek an answer. The suspicion is that there are assumptions at work in answering the question in a straightforward manner, which inevitably lead us to recognizable philosophical positions and, therefore, recognizable solutions. The series of metaphors is a step away from that. The metaphors provide "ostensive" explanations, if you like. They show the ontogeny of the idea of the-interface-as-a-relation (between human and computer), that is, they provide the opportunity to follow the question from its origin through to its development into a full-scale philosophical problem. Through this unfolding, an explanation is given that first allows us to see subject and object (or words and things) as *duplicate phenomena* and yet explain how they are different. The second aspect is to demonstrate that the explanation itself is an interface at work.

The theoretical backdrop

The subject of interfaces is difficult. Given the definition that "an interface enables the generation of phenomena," two questions collide. The epistemological question "How do things appear to us?" coincides with – to the point where it becomes almost indistinguishable from – the ontological question "How do things come into being?" Stated without further qualification as they are, both are open to interpretation to such a degree that almost any philosophical theory can be made to apply. The question of "what an interface is" is equally open when simply stated. This is evident in the most widespread model of "what an interface is," which reproduces a wide array of classical philosophical discussions:

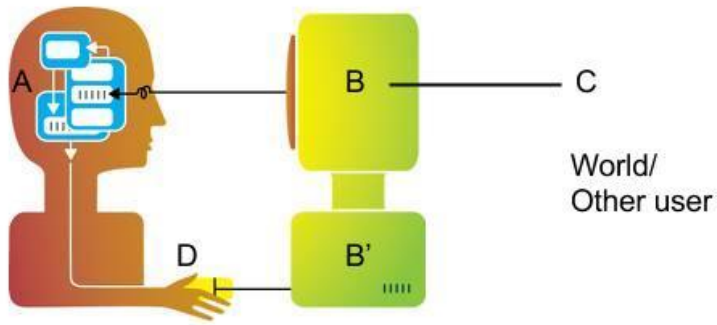


Figure 13 (1 in article). Typical model of a human-computer interface (source: http://mkhares.kau.edu.sa/Pages-cpis354-e.aspx reworked)

In this model, we could read the distinction between subject and object (A vs. B), mind and body (A vs. D), and the pairing or entanglement of man (A) with technology (B/D). The computer is also often referred to as a communicative medium through which the user is either communicating with the computer through the interface and vice versa (B' behind B) or communicating through the computer with another user somewhere else (C via B). There are numerous versions of representation vs. represented; the mind (cognition, A) representing the world (B or C) – either the mind in relation to a computer (B) or directly in relation to the world (C); the computer as an (external) medium (B) representing the world (C) – where the computer (B) is understood as a representational medium on par with language (text and speech), and the world (C) is that which is referred to – or the computer (B) represents externalizations of thought or cognitive content (A); or even the special case

where (B) is understood as the interface representing the computer (B') – the outward appearance of what is going on inside.

There are good reasons for interface designers to be interested in such foundational philosophical issues, including notable early precedents for drawing on philosophical theories in human-computer interaction (Dourish, 2001; Dreyfus & Dreyfus, 1986; Ehn, 1990; Winograd & Flores, 1986). The main promise is that philosophical theories will already have dealt with issues that partly or *en bloc* are relevant for interface designers. This is also the claim here. The main impetus of the proposed model comes from a host of theoretical developments that seek to settle many of the above mentioned discussions by related and overlapping insights. These theories stem primarily from, but are not restricted to, the cognitive sciences (Barad, 2007; Bateson, 1972; Chemero, 2009; Clark, 1998b; Gibson, 1986; Hutchins, 1995; Ingold, 2000; Noë, 2004; Varela, Thompson, & Rosch, 1991). Several aspects of these theories will be discussed in what follows. Space does not permit a full overview of these theories in this article (see e.g., Menary, 2010; Ward & Stapleton, 2012), however, two mainstays of these theories should be highlighted at this point. The first is their common conviction that cognition and perception do not take place in an isolated mind – a singular subject. The second is the rejection of "the idea of a world or environment with extrinsic, pregiven features that are recovered through a process of representation" (Varela et al., 1991, p. 138). Instead of relying on two separate domains – the subjective inner world and the objective physical outer world connected by lines of perception, communication, or a representational interface – these theories attempt to see what we, in colloquial terms, might call *cognition in the world* (or what amounts to the same, the world in cognition). Gibson (1986) provides an example of this, which is known to many within the field of HCI. In *The Ecological Approach to Visual Perception*, he proposes the idea of direct perception. It is the idea that the qualities of the world – or what he calls "affordances" – are directly perceived. The idea has been popularized in the HCI community by Norman (1988). It is easily misconstrued as claiming a particular privileged access to the world or mistaken for naïve realism, that is, the claim that the world is simply given to us because the world simply *is* as it seems to us (Noë, 2002). However, the proposition is much more radical than this. Not only is there no sense data or representation in the mind, cognition is not to be understood as taking place "in the head," but rather, the world as it appears to us *is* cognition taking place. The challenge is to not simply see things in the world "out there" but to understand that the act of cognition – and in this case perception – is taking place "out there" as well, in a manner of speaking. We might say that the subjective and objective worlds have been folded one on top of the other and merged together, but Gibson (1986, p. 129) would ideally like to dispense with the subjective-objective dichotomy altogether:

> An affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer.

Thus, in this framework, when we see a thing, we should recognize that we see a cognitive act taking place. Furthermore, the cognitive processes involved are not simply processes of seeing; they relate to other parts of our cognitive apparatus such as our motor skills and our proprioception (internal sense of body). Tied into seeing are therefore also skills such as navigating or manipulating objects in the world. This prompted Norman (1988) to translate affordances, somewhat misleadingly as "actionable properties." An object not only appears in our visual field to be seen but also to be walked around, picked up, or sat upon. Its properties are therefore, on the one hand, its own (a fact of the environment) and, on the other, related to what we do or can do with it (a fact of behavior). It affords picking up or sitting upon – we can *see* directly whether an object is walk-around-able or sit-upon-able. We will return to this idea later.

Reflexive problems

These theoretical ideas have so far not been developed particularly in relation to interfaces. As mentioned above, there is a problem of how to approach the problem of a tool investigating itself. Since representations are traditionally deemed capable of "referring," the consequence of examining the act of referring gives rise to a peculiar "reflexive" condition. If the phenomena we are dealing with are in fact affected by what we do, then it would seem that any current ongoing process (such as the one you are experiencing in this article as you are reading it) not only circumscribes a phenomenon (cognition) contingent upon it (the process) but also defines itself in the process (since it is a cognitive process). The current process (understanding this article) therefore seems contingent upon itself for determining what it is as well as upholding that very phenomenon (*that* it is). If that is the case (a very tentative "if"), whatever it determines itself to be was either the case before it was settled (which violates the premise that the phenomenon is contingent upon the process), or it *became* the case precisely at the moment it was settled (which seems counterintuitive). The conundrum is well-known and well described as reflexive paradoxes, antinomies, or even Buddhist Zen koans, that is, riddles used by Buddhist teachers to allow students to reach enlightenment (Priest, 2014). The theoretical physicist and feminist Karen Barad (2007) masterfully explicates the position of reflexivity in Western thought as a product of representationalism, which, as mentioned above, places her alongside other authors who reject this idea. She uses the term "reflexive methodologies" to denote and denounce the idea that it is possible to reflect on and take into account "the investigator's role as an instrument in the constitution of evidence" (p. 86):

> [R]eflexivity is founded on representationalism. Reflexivity takes for granted the idea that representations reflect (social or natural) reality. That is, reflexivity is based on the belief that practices of representing have no effect on the objects of investigation and that we have a kind of access to representations that we don't have to the objects themselves." (p. 87)

Barad places the discussion of this idea in the much broader and more complicated discussion of Bohr's principle of complementarity and Heisenberg's uncertainty principle,

which obviously cannot be dealt with here. The popular account of these two principles are, however, quite sufficient to understand the main idea. It is not possible for an instrument to simultaneously measure and be the object of that measurement (p. 161), so an instrument cannot measure itself measuring. In "interface" terms, this means that it is not possible to set up an interface that simultaneously creates and reveals itself. The attempt to do so is an ambition harbored by the theorist who dreams of a complete enumeration of the world, that is, one who takes herself into account.

One could argue that studies of language, cognition, or speech achieve precisely that or that communication is self-referential by nature, but that would miss the point. This line of thought is subject to a reflexive condition. If we assume that every phenomenon that arises within a perspective is the result of a "tool" at work, then that includes a perspective that produces the idea of a tool. Thus, when we answer the question "how was an idea made?" – by presenting the idea of a tool that made the idea – it begs the question: "How was the idea of the tool made?" If we are to avoid the consequences of the reflexive condition, we are forced to deliver an answer that not only speaks of the solution but also exemplifies it directly without recourse to an underlying phenomenon. This means that we cannot simply say that every phenomenon arises from an apparatus at work and then investigate that apparatus. We therefore have to ask questions slightly differently than the norm. Bateson (1979, p. 39) expresses the idea when he states that "[t]he *processes* of perception are inaccessible; only the *products* are conscious and, of course, it is the products that are necessary."

This is another restatement of the claim that we cannot simply step out of our perspective and investigate "what we do." We have to accept that the "apparatus" at work is only investigable through its consequences. The designer, as well as the reflected philosopher, therefore has to work from the inside-out. If we are to find out anything about the apparatus, we have to look at the phenomena we encounter for clues to their *ontogeny*. This is the biological term for the origin and development of an organism (see Oyama, 2000). It is used here to refer to the *genesis* and development of these phenomena, that is, their unfolding from inception to full-fledged phenomena. We have to ask where ideas come from, not in the sense of being creative (to get new or better ideas), but in the sense of asking what apparatus is in place in order for ideas to be produced at all and for the ideas to become ideas, to be what they are, and to hold any promise. Why are ideas the way they are? Again, not asking in an everyday sense, but in an almost technical sense – why do they have the format they have? What is made possible by conceiving of the world in this way rather than another, and what is made impossible? Can the tools be changed? What happens to ideas and concepts if they are?

There are two consequences to be drawn from this. The first is that the model or theory presented here is *not* to be considered a representation on two levels. On the content level, it is *not* a model/theory that refers to a phenomenon from which it differs and to which it refers. Rather, it is itself an exhibit of an interface at work. It showcases an interface rather than representing it. On the form level, it is *not* to be considered simply a text or model to

which we have privileged access. The meaning as well as the words, letters, signs, or patterns of syntax on this page are considered as phenomena themselves, as much in need of explanation as the phenomena they purportedly describe. In other words, what we call representations become mysterious anew; *why should anything be anything but itself*? The point is that the model/text accomplished here is not separate from the world, and if phenomena are not explained by reference to representations, then perhaps representations should not be explained as referents. This also means that phenomena that are not normally considered under the same heading are treated as equally in need of explanation. Perceptions, maps, objects, speech, thoughts, people, and text are usually juxtaposed in pairs such as internal/external, representation/represented, and subject/object. In this article, they are treated as side-ordered, that is, as phenomena with equal ontological weight and in equal need of explanation. While phenomena can be linked to each other, each phenomenon requires an explanation as to how it was generated. If they are linked, the connection should also be explained.

The second consequence is that the phenomenon in which you are currently engaged is performative. Barad (2007) describes it as a direct material engagement with the world:

> A performative understanding of scientific practices...takes account of the fact that knowing does not come from standing at a distance and representing but rather from *a direct material engagement with the world*. (p. 49, emphasis in original)

This view is closely related to the term "enactment" (Stewart, Gapenne, & Di Paolo, 2010; Varela et al., 1991) as well as Hutchins' (1995) claim that cognition is distributed. It is the view that there is no separation between static objects and the things we do with the objects. Rather, we are part of "making" and sustaining the objects as we perceive them and think of them. The world is performed or enacted, if you like. A straightforward analogy is this text; it is not just a piece of paper with marks on it. You are reading it and are thereby part of the performance of the text. The approach requires a different way of *looking at each phenomenon and seeing the interface that gives rise to it*. The Chilean biologist Humberto Maturana recounts a similar shift in approach when he worked out the theory of autopoiesis:

> In 1960 I asked myself 'what should happen in the manner of constitution of a system so that I see as a result of its operation a living system?' This was a strange question in a period in which every scientist knew that to know something about something one should go and look what was already there without interfering with it. I was not making a hypothesis about how the system was. I was proposing that the relation between the internal dynamics of the systems and the result of that internal dynamics in the domain in which I observed it, would tell me what the system was. *I had to create the system to know it.* (2002, p. 5, my emphasis)

Instead of asking "what is there" or "how did it become that way," he asks: "how is what I do connected to what is?" It is a way of becoming aware of what one is doing *while* one is doing it. In this way, "taking oneself into account" does not mean identifying a subjective

"factor" and including it in the equation. It means recognizing one's own handiwork in what is. Just as a skilled craftsman can see the signs of craftsmanship in ships, houses, spoons, and bicycles and infer what has been done, we should look at perceptions, thoughts, ideas, sketches, and texts and see the evidence of our craft as thinkers.[118]

Zero distance

The theory I am about to propose aligns itself with these theoretical insights. One extremely important consequence of doing so is to accept the idea that the distance between one's thoughts and the phenomena in which one is currently engaged is *reduced to zero*. This is not as enigmatic a statement as it appears. It simply means that whatever it is that you do in order to experience a phenomenon, you must already have done it, since you are experiencing a phenomenon.[119] In fact, you must still be doing it. It is another way of saying that whatever phenomenon you are experiencing is contingent upon your "experiencing it." It does not mean that you are the cause of it or that there are two phenomena, that is, a process of experience (process) *and* a phenomenon (result). Just as there is a song as long as you are singing, there is a phenomenon as long as you are experiencing. You cannot take the singing away and expect to be left with the song or, for that matter, ask someone to sing but "to dispense with the song" in order to focus on the singing. This does not mean that the tree or house outside my window is not a tree or house until I have interpreted it as such. It means that there is not a tree and *then* my perception of it. There is not a house and *then* my thoughts about that house (the house is perceptible – affords being perceived – in so far as we perceive). In practical terms, this means that there is not a phenomenon *there* in front of you, which you somehow relate to *here* from the center of your perspective. Just as there is no distance between you and whatever current thought you have *hic et nunc*, there is no distance between the process of a phenomenon and the phenomenon "itself." "No distance" means that what the world is like (ontology), in a very particular respect, is contingent upon what we do (epistemology). This has prompted some authors to state that we, in a sense, create the world in which we exist (Maturana, 1987; Spencer-Brown, 1972), which I agree with, although cautiously, because a less than rigorous understanding of "no distance" either leaves us with classical philosophical conundrums such as the risk of ending in solipsism or with the world as an unreachable Kantian ding-an-sich – both of which are avoidable. I will return to these matters.

Building a model

The idea of "zero distance" is important because it suggests that we might be able to infer what has been done (and is being done) from the phenomena themselves. It is a way of investigating what it is that we do without running into reflexive problems. In what follows,

[118] Shaffer and Clinton (2006) are on their way to stating something similar when they say "just as tools are externalizations of human designs, thoughts are similarly internalizations of our actions with tools...We thus suggest that rather than seeing tools as static thoughts – objects distinct from human subjects – we grant tools and thoughts the same ontological status. That is, we posit that tools and thoughts are fundamentally the same kind of thing" (p. 15). Unfortunately, they are still mired in a vocabulary that makes use of the dichotomy of external and internal as well as thinking of both (tools and thoughts) in terms of things.

[119] To be precise, it is not simply what we do that matters, as will become apparent, nor is it a combination of something "out there" and "in here." The phrasing is simply used to put emphasis on the performative aspect of the proposition.

I build a model based on this idea. Instead of attempting a direct exposition of a method, I present a series of metaphors that together elucidate a model. The model as a whole produces phenomena and at the same time attempt to provide explanations of said phenomena, which are not separate from the phenomena (zero distance). I take as a starting point the rather vague definition, given earlier, that an interface enables the production and explanation of particular phenomena. Since the goal is to produce an explanation that is not separate from that which is explained, I state two criteria for what constitutes an explanation in relation to an interface. First, explaining an interface is explaining how a particular set of phenomena come into being *qua* the phenomena. Maturana (1987, p. 73) asserts that "[A] scientific explanation entails the proposition of a mechanism which will generate the phenomenon." To this I add that if the mechanism *is* the phenomenon itself, the criterion has been met *eo ipso*. An interface thus embodies a particular genesis (story of creation) in the form of the particular phenomena that are produced. Second, working from the inside-out, the model has to be built subject to its own conditions (to counter reflexive problems). Every developmental step of the phenomenon has to be encompassed by the preceding step.

Why metaphors? This question is pertinent given the overall questioning of a representational frame for answering what an interface is. The use of metaphors takes Lakoff and Johnson's (2003) assertion seriously that metaphors are "conceptual in nature" (p. 159) and that "a given metaphor may be the *only* way to highlight and coherently organize exactly [certain] aspects of our experience" (p. 156, my emphasis). It is, however, not the perception of the metaphor as "seeing one kind of thing in terms of another kind of thing" (p. 193) that is of interest. The metaphors in this article are employed in an *ostensive* or *expressive* way, as explained by Goodman (1978):

> The distinction between saying or representing on the one hand and showing or exemplifying on the other becomes even more evident in the case of abstract painting and music and dance that have no subject-matter but nevertheless manifest – exemplify or express – forms and feelings. Exemplification and expression *though running in the opposite direction from denotation* – that is, from the symbol to a literal or metaphorical feature of it instead of to something the symbol applies to – are no less symbolic referential functions and instruments of worldmaking. (p. 12, emphasis added)

In this sense, the stress is not on what the metaphor says about another subject matter but what it *itself* is able to showcase or exemplify. A short example will serve as an illustration. If we state that a problem is a hard nut to crack, I am obviously using the image of a nut to convey the sense that the problem is difficult. The nut denotes the problem. Obviously, I do not start thinking of the problem literally as a nut. The proposition is slightly different if one says: "the problem of the formation of social strata can be illustrated by a river that acts as a sorting mechanism." DeLanda (1998) provides this equilibristic example:

> Rivers transport rocky materials from their point of origin to the place in the ocean where these materials will accumulate. In this process, pebbles of variable size,

> weight, and shape tend to react differently to the water transporting them. These different re-actions to moving water sort out the pebbles, with the small ones reaching the ocean sooner than the large ones. This process is called sedimentation." (p. 32)

In this case, we can still maintain that there is a river that acts a metaphor for the problem, but unlike the case of the nut, it is possible to claim that the river, in fact, manifests the problem. We can stay with the image of the river and examine it to gain a further understanding of it and, consequently, of the problem. Two objections can be raised. First, we can do the same thing with the nut. The only difference is that it is a simpler metaphor. While this is true, we would still never claim that the problem was, in fact, a nut. The second objection is that what I am talking about is not a metaphor but an exemplification. The reply is that if I was talking about the geological phenomenon of sedimentation, then yes, a river is an example of this. However, I am attempting to elucidate a problem using the image of a river to bring insights into the structure of the problem. The river represents what Bateson (1972, p. 407) calls a "rigorous metaphor" or a mapping of the problem. The important part is that the relations in question remain constant under transformation. That is, changes in the sorting mechanism (e.g., describing a different river flow) have to stay equally descriptive of the phenomenon in question.[120] In contrast, if I am asked whether by "the problem is a nut" I mean that it has an outer shell and edible content, I would most likely respond that we should avoid straining the metaphor.

In Simon's (1996) terminology, "simulation" is the proper term for the understanding that rigorous metaphors provide. "Imitation is possible because distinct physical systems can be organized to exhibit nearly identical behavior" (p. 13). There is perceptual similarity but essential difference or "resemblance from without rather than within" (p. 13). From such a rigorous perspective, all the metaphors to be presented will elucidate the problem of "why the problem of the interface is set up as a representational problem." In the process, they will also shed light on many attendant questions (how do words and things duplicate phenomena? How are they different?). Taken at face value, the metaphors employed have nothing to do with each other. However, when they are read with the problems in mind, they coalesce into a series of images that do actual *work* together. They become a model or a machine that in fact produces or generates phenomena. It is in this way that the model is also intended as an exemplification of an interface.

Throughout the article, the model is built by repeating the same pattern. First, a question is introduced that guides the development in that particular step. Second, a metaphor is introduced that functions as an explanation. Third, through the explication and discussion of the image, a principle is reached, which leads to further questions, and so on. For parts of the article, conventional usage is maintained in relation to indicating on the one side A) an inner mental or cognitive side and B) an outer physical reality. This is purely for

[120] Note that this type of rigor is a type of codification. Ong (1982) points to the same type of rigor when he characterizes the "critical and unique breakthrough into new worlds of knowledge" (p. 83) achieved within human consciousness by the introduction of writing. Interestingly, it is "not when simple semiotic marking was devised but when a coded system of visible marks was invented whereby a writer could determine the exact words that the reader would generate from the text" (p. 83)

convenience and in order to make the writing as plain as possible. It should not be interpreted as defending any epistemological or ontological claim. Rather, as should become apparent, the terms are used only with reference to our "everyday conception" of the world and our place in it. The model should make it progressively clear how and why the introduction of such a dichotomy creates problems. Without further ado, I will present the first question.

The first question is "how do phenomena arise?"

The first interface you ever encountered is the same one that greets you when you open your eyes every morning. To simply look out the window is a way of understanding the world. Being used to the view, it might be too abstract a thought to ask "but why is the world as it is?" and "why do I see it in this way rather than a different way (and what would that way be)?" If we approach this question from the side of the world (B), the question is not about selecting an object and providing an explanation of how it was created or what it is made of. The question, rather, is how do we even know how to pick out an object? What to include and what not? Plato famously likened what we do with a butcher carving out objects from the meat of the world.

> First, the taking in of scattered particulars under one Idea, so that everyone understands what is being talked about...Second, the separation of the Idea into parts, by dividing it at the joints, as nature directs, not breaking any limb in half as a bad carver might. (Plato, Phaedrus, 256e)

Therefore, the odd question I am asking you to pose is how do we know where to make the cut?[121] Plato's answer is that nature already provides those joints in which to cut (forms). We cut out a tree from its surface and separate it from the rest of the world. We are used to thinking of the surface of an object (its form) as demarcating it, but as several authors have argued, the outline of an object seems to be an arbitrary cut (Barad, 2007, p. 153; Bateson, 1972, p. 460; Gibson, 1986; Ingold, 2011, p. 86). There are many organisms for whom a tree is not a relevant perceptual category (does an earthworm perceive trees?). There are equally many phenomena that we cannot meaningfully demarcate (gasses, waves, feelings), many of which are not easily delimited (swamps, furry creatures, the coast of Britain (Mandelbrot, 1967)), many that are entangled or part of an assemblage (is the technology of a car simply given by its shape, or should we somehow include roads, gas stations, traffic rules, etc.?). There are also phenomena that hover indecisively in between conceptual borders: if I define a human being by a shape that extends 5 cm out perpendicular to every skin surface and call it "personal space," have I defined an objective or subjective form?

Overwhelmed by these questions, we could consider the same question from the cognitive side (A). The question would then shift and become one of how we come up with the idea or information. As with the forms carved out, it is not a question of selecting an idea and

[121] As Bateson (1979, p. 47) puts it: "The division of the perceived universe into parts and wholes is convenient and may be necessary, but no necessity determines how it shall be done."

explaining its origin or composition; it is a question of how an idea is formed at all. It is still possible to rely on the notion that nature or reality provides the idea or information. In this case, the information is "out there," ready to be picked up by us. However, if we think of ourselves as cognitive processing machines (Fodor, 1975; Newell & Simon, 1976; Putnam, 1980), or what is better known as input-output machines, it would seem too much of a coincidence that the world seemingly speaks our language. In the words of Varela et al. (1991):

> [I]f we claim that the function of these processes is to represent an independent environment, then we are committed to construing these processes as belonging to the class of systems that are driven from the outside, that are defined in terms of external mechanisms of control (a *hetero*nomous system). Thus *we will consider information to be a prespecified quantity, one that exists independently in the world* and can act as the input to a cognitive system. This input provides the initial premises upon which the system computes a behavior – the output. (p. 139, my emphasis)

The point is that an input-output machine requires input of a certain type. In order for the world to feed us that input, it would have to provide information that was already encoded or formatted. It is like building a computer and discovering that the world was already encoded in, say, the programming language C++. We could reverse the order and claim that the computer was built to fit the world's code, but then we would have returned to the question of how we discover that code (where to make the cut?). This problem has prompted the development of the theory of autopoiesis by Maturana and Varela (1972, 1992), which was later developed by Luhmann (1995) in the field of sociology. In relation to this problem, the relevant aspect of the theory is that a biological system is defined as operationally closed, that is, the idea that the nervous system operates on signals it generates itself, not on those generated by the world.

> [T]he new approach [operational closure] required us to treat seriously the activity of the nervous system as determined by the nervous system, and not by the external world; thus the external world would only have a triggering role in the release of the internally determined activity of the nervous systems. (Maturana & Varela, 1980, p. xv).

This means that there is no input or output *per se*. Nothing passes in or out of the system (that is, across a border such as the skin; the left of Figure 2), but the system is continually in a state and is able to alter that state based on signals it produces itself (the middle of Figure 2). The point where the black arrow touches the border signifies a trigger – or the point where the system A comes in contact with the world B.

Figure 14 (2 in article). Input/output vs. operational closure vs. enactive

With the world reduced to the role of triggering or "perturbing" (disturbing or irritating) the system, the problem of solipsism, that is, the idea that only one's own mind exists for certain, looms heavily in the background. The idea is further developed in the enactive approach that states that "cognition is grounded in the sensorimotor dynamics of the interactions between a living organism and its environment" (Stewart et al., 2010, p. vii), or to put it in colloquial terms: "we see what we are capable of doing." The affinity with Gibson's (1986) perspective is clear. In relation to thinking in terms of a system, it means that the system is still operationally closed, but the system includes both the organism and its environment (the right side of Figure 2). The blue arrow is a sensory input that guides an action signified by the green arrow. The action modifies the environment, and the sensory input is thereby changed, and so on and so forth.

> First, the sensory inputs, S, must be used to guide the actions, A, in a particular way so as to maintain autopoiesis….the actions A modify the environment and/or the relation of the organism to its environment, and hence modify in return the sensory input. Together with the first part, this closes the loop and sets up a dynamic system. Now the key point is this: what the world 'is' *for* the organism amounts to neither more nor less than the consequences of its actions for its sensory inputs; this in turn clearly depends on the repertoire of possible actions. Without action, there is no 'world' and no perception. (Stewart, 2010, p. 3, emphasis in original)

Unfortunately, the problem of where the cut comes from remains diffuse. If the world only triggers the system, it seems incredibly lucky that it triggers the system precisely so that an accurate worldview is created. If we made up the cuts ourselves, the system appears even more improbable. Neither from the side of the world (B) nor the cognitive side (A) are we given any explanation of how we know where to make the cut. In the following six metaphors, I offer a model that produces and provides an explanation of phenomena (eventually leading to an answer to where the cut comes from). Let us return to the starting question: How do phenomena arise?

Metaphor 1: The double-slit experiment

Young's (1807) double slit experiment will be familiar to some from their high school physics class. It demonstrates the fundamental principle of wave-particle duality, that is, that light and matter can display characteristics of both waves and particles. In Figure 3, a basic setup of the experiment is shown.

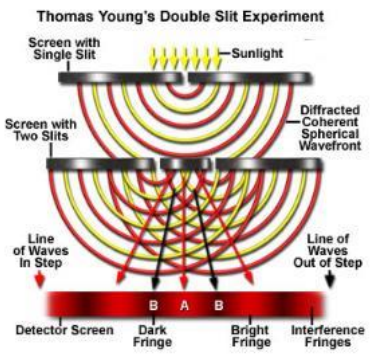


Figure 15 (3 in article). The double-slit experiment setup

Source: (http://micro.magnet.fsu.edu/primer/java/interference/doubleslit/)
A lightsource (in this case, sunlight from the top) passes through a screen with a single slit. The light propagates behind the screen as waves. These waves hit a second screen with a single slit. Behind the second screen, the light also propagates as waves, but this time creating interference. An interference pattern is observed on a screen (red bottom bar) where alternating lines of bright and dark bands appear. Interference is the phenomenon of overlapping waves either reinforcing themselves or cancelling out. I will return to the phenomenon of interference shortly. The surprising part is that the light behaves as waves but are detected as individual particles on the end screen. An interference pattern arises even when the experiment is adjusted to only allow a *single* photon at a time to travel through a slit, and measures have been taken to ensure that the photon only travels through one of the two slits. Our intuition tells us that a single phenomenon has to travel through one or the other slit, so how can it do both in order to, apparently, interfere with itself? There are, as mentioned, profound questions asked in this experiment that have been treated by Karen Barad in her work *Meeting the Universe Halfway* (2007). The use of this experiment here as a metaphor is rather more modest.

The metaphor is simply that any phenomenon needs constraints in order to arise. In this case, it is the arrangement of a lightsource, double-slits, and an endscreen that is required in order to create the phenomenon of the interference pattern. The principle is this:

1. **Whenever we encounter a phenomenon, we can infer that constraints are in place in order for it to arise**

The idea that constraints are productive is by no means novel. Bateson (1972) speaks of restraints (I use these terms synonymously) throughout his main oeuvre in order to shed light on cybernetics and systems. He regards “restraint” as an approximate synonym of pattern, redundancy, information, and meaning (p. 130). He gives the example of a monkey hitting a typewriter and producing an exact copy of one of Shakespeare’s novels. In this case, we should look for restraints in the way the system is set up (Bateson, 1979, p. 406). For example, the typewriter is only capable of producing Shakespeare’s novels. In other words, where there is order when one could just as easily have expected disorder, something or another constrains that order. It is important to stress that constraints are not put forward

as negative in the sense of limiting or oppressing. It is rather in the way Foucault (1991) understood power to be productive. Power is constraints on action that both enable and delimit what can be done. Biskjaer and Halskov (2014) bring constraints to the fore in interaction design and remark that "constraints both restrain and impede and enable and advance a creative course such as a design process" (p. 27). Boden (2004, 2010) uses the same insight in creativity research: "Constraints on thinking do not merely constrain, but also make certain mental structures – possible…" (2004, p. 58), and Leonardi, Nardi and Kallinikos, (2012, p. 10) have a direct material take on the same thought: "Rather than being simply constrained by structure, as the typical conventional interpretive understanding wants us to believe, human choice and agency are made originally possible through the very resources that objects and structures dispose." As Biskjaer and Halskov (2014) point out, there is very little consensus on the subject of constraints, but from the selection of quotes, it should be apparent that I do not discriminate between social, material, economic, or other types of constraints at this point.

Note that constraints are *not* part of the phenomenon. Interference patterns can be observed in many different situations. Constraints are not to be considered causes of the phenomenon. They did not create as much as enable the phenomenon. There is no similarity or correspondence between the phenomenon and its attendant constraints; the constraints were not "prior" to the phenomenon. Had I presented two slits without shining light through them to a random person, there is very little chance any observer would have identified them as constraints of anything. The slits and the entire setup can only be considered constraints relative to the generation of the phenomenon. It should also be noted that the metaphor does not assign roles to any part of the setup. The experimental setup is not equivalent to our cognitive apparatus; the interference pattern is not equal to a thing or an object observed. The metaphor simply states that constraints have to be in place in order for phenomena to arise.

The second question asked is "where is the phenomenon?"

The inference from the last remarks is that whenever we deal with a phenomenon, there is an urge to try and situate it in a familiar landscape (answering what is it, where is it, etc.). In particular, the urge to situate phenomena is strong (Malafouris, 2013, p. 37, calls the resistance of this urge "antilocalization."). It is very evident in the case of perception where we speak of, for example, a mailbox "out there" and our perception of it "in here" or "in our head." Following our question of how we know where to make the cut, it would seem that if we decide in advance to place the phenomenon on either side, we automatically generate the problem of what is on the other side. We may have "solved" the problem of where the information comes from (either nature tells us how the world looks, or we tell nature how it should look to us), but we seem to have simply substituted it with other problems (how can I be certain the world is as it appears? Why do we make errors? How can anything refer to something else?).

Metaphor 2: Echolocation

The phenomenon in question in Young's (1807) double-slit experiment was an interference pattern (or diffraction). A different phenomenon exhibiting the same type of interference patterns is echolocation. It is known to occur in bats, dolphins, and even humans who are able to use sound to perceive and locate objects (Kolarik, Cirstea, Pardhan, & Moore, 2014). Interference patterns arise when you combine waves of the same or nearly the same frequencies.

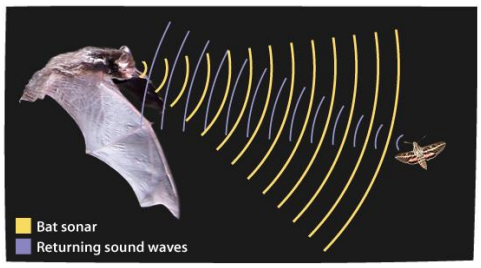


Figure 16 (4 in article). A model of echolocation (source: http://askabiologist.asu.edu/echolocation)

A bat "sees" objects by producing sound waves of a certain frequency. Any object hit by the sound wave produces a return echo with a frequency slightly different from the original. Combining this return frequency with the original will produce an interference pattern. In systematic terms, we might say that a frequency is folded on top of itself and made to interfere with itself to yield a specific pattern. This is of course a very simplified account of echolocation. Bats are able to differentiate the distance, size, position, place, and direction of the object and whether it is moving. If we take echolocation to be a metaphor of how phenomena arise, the bat seemingly has the advantage over the double-slit experiment that well-known positions are established. The bat is in the perceiving position while the moth is being perceived. However, it is premature to assign positions in this manner. The focus is still on the phenomenon of an interference pattern. The double-slit and echolocation are the same in the sense that a single phenomenon, an interference pattern, is created. The point of origin of waves has shifted from a light source outside the interference pattern to being centered in the pattern (the bat). The interference is, in both cases, the result of the same wave interfering with itself. In the slit experiment, the light is "split" in two while, in the bat experiment, an original signal is combined with the same signal returning.

It is tempting to place the moth in the position of the light source, in which case, the interference pattern would have been given what is normally referred to as a "cause." The moth apparently "causes" the interference pattern. However, it would be more correct to state that the bat stands proxy for one wave emanating from one of the two slits while the moth stands proxy for the other wave. The interference pattern needs two waves in order to interfere. Without the bat's sound emission, there would be no sound at all. Without an object from which the sound could bounce off, there would be no return echo and thus no interference. We could insist that the interference pattern is clearly "created" in the bat's position (i.e., in its brain) since this is where the interference pattern terminates. We could equally clearly argue that the pattern is "created" in the moth's position since this is where the difference takes place. Moreover, the bat clearly does not locate the phenomenon (the

moth) in its own brain as this would make no sense. The apparent separation of the positions of the bat and the moth is equivalent to insisting that there must be two phenomena in the double-slit experiment because there are two slits. There is still only one interference pattern. In both positions, the "other" wave is implied. The difference between metaphors one and two is that we have simply rearranged the constraints in question.

We are therefore currently in the situation of recognizing that there is only one phenomenon – but two locations in which it is traditionally located. The discussion is mirrored in countless forms across subject/object discussions, nature/nurture debates, and map/territory arguments. We could argue that there are in fact two different phenomena that are in reciprocal presupposition or that co-constitute each other. This however cannot be the case in the bat metaphor because if there was only one wave, no interference would arise. We *can* say, at this point, that constraints must be in place that allow *us* to place the phenomenon in either position. This is visually clear in the use of the metaphors. In Figure 3, we were quite content with identifying and locating a single phenomenon (interference pattern) in the bottom of the figure. In Figure 4, we locate the bat (place of interference) and the moth (source of interference) in different places. This is also clear conceptually when we associate the bat and the moth, respectively, with a wave. The trouble seems to be that once we have identified anything (bat, wave, location), the tendency to treat these as separate phenomena is overwhelming. Consequently, the trouble of asserting the unity of the phenomena becomes extremely complex.

In the foreword to the seminal work *The Ontogeny of Information* (2000) by the philosopher Susan Oyama, the evolutionary biologist Richard Lewontin writes:

> There are no 'gene actions' outside environments, and no 'environmental actions' can occur in the absence of genes. The very status of environment as a contributing cause to the nature of an organism depends on the existence of a developing organism. Without organisms there may be a physical world, but there are no environments. In like manner no organisms exist in the abstract without environments, although there may be naked DNA molecules lying in the dust. Organisms are the nexus of external circumstances and DNA molecules that makes these physical circumstances into causes of development in the first place. They become causes only at their nexus, and they cannot exist as causes except in their simultaneous action. That is the essence of Oyama's claim that information comes into existence only in the process of ontogeny. (2000, p. xiv)

James Gibson (1986) gives the exact same account:

> The fact is worth remembering, because it is often neglected that the words animal and environment make an inseparable pair. Each term implies the other. No animal could exist without an environment surrounding it. Equally, although not so obvious, an environment implies an animal (or at least an organism) to be surrounded. (p. 8)

While one may agree with the basic tenet in these two quotes, there seems to be something askew in going to great lengths of differentiating two phenomena and then going to equally great lengths of affirming their inseparability.

From the first principle, we can infer that for all phenomena we encounter, constraints have already been in place in order for them to arise. We have in this case already labored under the constraints of language and particular writing/reading. We can see this by the fact that we have already had several opportunities to attempt to single out and locate different phenomena. In Figure 3, we could have asked where phenomena and constraints were located in respect to each other, but we refrained given the argument that constraints only enable (they are not "part" of the phenomenon). A relation of production was devised, which did not make the constraints the cause of the interference pattern, and we accepted that the light travelling through the two slits were to be treated as the same phenomenon rather than two different phenomena. In contrast, the appearance of two poles of attention (the bat and the moth) rapidly created a conflict of what produced or was the cause of what, and in the case of them co-constructing each other, what came first – the chicken or the egg?

What we should note is that we are perfectly content that the first and second metaphors are both about a *single* phenomenon *until* we direct our attention to any of the parts of the metaphors. In the words of Clark (1998a, p. 11):

> For as soon as we formulate a thought in words (or on paper), it becomes an object for both ourselves and for others. As an object, it is the kind of thing we can have thoughts about. In creating the object, we need have no thoughts about thoughts - but once it is there, the opportunity immediately exists to attend to it as an object in its own right.

In other words, there is something about our focus (formulating a thought) that constrains the situation and prompts us to look for (separate) phenomena. We have carved out a phenomenon. No sooner have we carved out the parts of the phenomenon did they become separate phenomena. The simple way of stating this is that it is not possible to speak, think, and talk of something without using at least a word or image; even a single word produces a phenomenon (don't think of a pink elephant). This is not to say that we produce a new phenomenon every time we speak (except in a very trivial sense). If what we are saying contributes to an ongoing phenomenon, there seems to be no problem. The problem of sorting out the relationship between organism and environment seems to revolve around the claim that there are *two* phenomena and yet that they are somehow "the same" (correspond or corroborate). Furthermore, the problem is exacerbated by the relation of production set up between them, making one or both a representation or cause of the other. However, we are getting ahead of ourselves here. The second metaphor is maintained to be about a single phenomenon although the introduction of the bat and the moth provides a temptation to isolate two phenomena (or poles of attention). The second metaphor allows the recasting of the first metaphor and to point out that the rise of a phenomenon is not a passive matter but

an active one. In the metaphor, this means that the bat does not see if it does not call out. The second principle stated is that:

2. **It is not possible to concern oneself with a phenomenon without *producing* a phenomenon**

A different way of stating the second principle is given by the mathematician Spencer-Brown (1972), whose work inspired, among others, Maturana and Varela (1992) in their work on the autopoiesis theory, as well as Luhmann (1995), who took the idea of autopoiesis into the social sciences. Spencer-Brown (1972) holds that "a universe comes into being when a space is severed or taken apart" (p. v). Maturana and Varela (1992) use the less enigmatic concept of "distinction" to express the same idea: "The act of indicating any being, object, thing, or unity involves making an *act of distinction* which distinguishes what has been indicated as separate from its background" (p. 40, emphasis in original). They continue that "a unity (entity, object) is brought forth by an act of distinction. Conversely, each time we refer to a unity in our description, we are implying the operation of distinction that defines it and makes it possible" (p. 40). What is meant by distinction is very close to the sense in which I intend the question of where to make the "cut." In other words, it is the aforementioned idea that we somehow create the world, but it is neither creation in the sense of the omnipotent God, nor is it the social construction of reality imagined by Berger and Luckmann (1966). We create the world not with an emphasis on "the world" but on "create." Our engagement in the world is, as mentioned earlier, performative or enactive. The bat performs or enacts its world by calling out. Without the call, there would be no "world."

> [P]erceiving is a way of acting. Perception is not something that happens to us, or in us. It is something we do….*What we perceive* is determined by *what we do* (or what we know how to do); it is determined by what we are *ready* to do...we *enact* our perceptual experience; we act it out. (Noë, 2004, p. 1, emphasis in original)

Noë's statement elaborates on what was stated earlier that: "when we see a thing, we should recognize that we see a cognitive act taking place."[122] Thus, the phenomenon of the interference pattern is a single phenomenon, but constraints are in place in this investigation so that we are inclined to identify two separate phenomena, that is, what are traditionally referred to as the process and the result. We have so far mentioned the temptation to locate the "two" phenomena, but let us refrain from deciding on that issue for a short while longer. If we take the bat's perspective for a moment, it is seemingly "obvious," in an everyday sense, that it "perceives" a moth and that speaking of an interference pattern is representational since the bat does not perceive an interference pattern as such.

[122] Maturana (2002) expresses the same idea that there is a fundamental change of perspective in a performative or pragmatic outlook: "To adopt the epistemological grounding entailed in these changes meant that henceforth I would not ask 'what is?', but I would ask myself 'what criterion do I use to validate my claim that something is what I say that it is?' Furthermore, to do this entailed a fundamental ontological change, namely, the fundamental question was no longer '*what is the essence of that which I observe?*' but rather '*how do I do what I do as an observer in observing?*'" (p. 6)

The third question asked is "what is the interference pattern to the bat?"

We should reiterate the premises of the echolocation metaphor. An interference pattern is created when a sound wave of a certain frequency emitted from a bat is combined with a return echo of a different frequency, which is produced as the wave hits an object. This of course means that if it does not hit an object, there is no return signal and no interference pattern. It also means that if a signal was returned of the exact same frequency (the signal does not travel, which means the object is right in front of the bat), the signal would cancel out and again result in no interference pattern. This is another way of saying that the bat does not hear "sound" as such. The soundwave itself is imperceptible; only an interference pattern is perceptible. Gibson (1986) uses light as an example, but the reasoning remains identical for sound. Gibson distinguishes between stimulation and stimulus information and states that we *do not* see light (p. 54). He imagines a fog-filled room called a Ganzfeld,[123] (from German, "complete field"). It is what you would see if you cut a ping pong ball in half and placed either half over your eyes. In technical terms, you would be perceptually deprived by an unstructured, uniform stimulation field. All you would see would be a uniform "whiteness" (Noë, 2004, p. 4) in which "[t]he receptors in the retina would be stimulated ... but the light entering the pupil of the eye would not be different in different directions; it would be unfocusable, and no image could be formed on the retina" (Gibson, 1986, p. 53). There would be stimulus of the eye, but there would be no stimulus information. The eye would "receive" light but would not see anything. Seeing only whiteness, we would be just as blind as if we were in a completely dark room. The information that is needed in order to see comes in the form of differences made by the light bouncing off objects and surfaces in a normal environment (Chemero, 2009, p. 107).

Metaphor 3: Communicating with beats

In the bat metaphor, the uniform whiteness is the sound returning with the original frequency, then cancelling out. The unreturned frequency is equal to complete darkness. In between these two are opportunities for interference patterns and therefore information.

In Figure 5 below, the original bat call can be identified with grid pattern 1 on the left. The return signal is grid pattern 2 in the middle, and the resulting interference pattern is depicted on the right. The pattern is also called a moiré pattern or beats. Overlaying the two patterns at an angle or giving them slightly different sizes creates interference patterns. The resulting small circles inside the figure on the left are beats that form a recognizable pattern. The circles are not *there* in any conventional sense. We see circles because of the interference between the two grids, but close inspection (for example by zooming) will reveal that there are no circles drawn, only the lines from the two grids. If the grids were superimposed precisely on top of each other, no pattern would emerge.

[123] A phenomenon of perception caused by exposure to an unstructured, uniform stimulation field. See http://en.wikipedia.org/wiki/Ganzfeld_effect

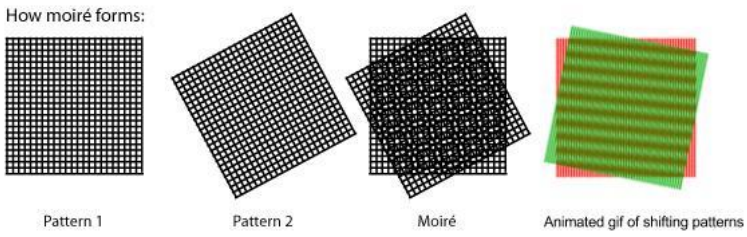


Figure 17 (5 in article). An explanation of moiré patterns. (Source: https://support.nikonusa.com/app/answers/detail/a_id/9544/~/what-is-moir%C3%A9%3F)

It is important to note the wording "in a conventional sense." The circles are there precisely in an enactive sense. It is because we are looking that "there are" circles. "There are" – is in inverted commas because it is difficult to know in what sense the circles "are there." We can also note that in order to "see" the two respective patterns (1 and 2), the figure provides pictures of grids, but as per the above argument, each of these would not be "visible" for a bat calling out. Only the interference pattern (circles – 'Moiré') would stand out. Therefore, how should we understand the interference pattern? An object at different distances gives rise to different interference patterns. As a bat approaches an object, it intensifies its calls, as shown below in Figure 6.

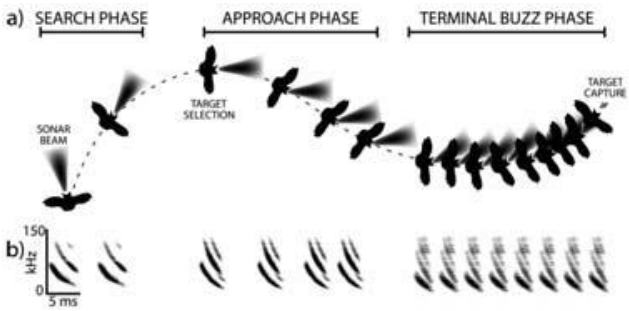


Figure 18 (6 in article). Different call intensities and frequencies in hunting. (Source: http://www.batlab.umd.edu/project/melproject.html)

What the bat "sees" are shifts in patterns or what are called *beats*. An approximate illustration is seen in the animated GIF in Figure 7.[124] As the return frequency (green) changes, the interference patterns shifts with it (the original frequency – red – is kept constant). In order for the bat to catch the moth, it has to "chase" the situation where the interference pattern cancels out. When the return signal (green) equals the outgoing signal (red), the signal does not travel anywhere – and therefore no beat can arise – which means that the object is at a minimum distance.

[124] If Figure 7 is not animated, you are likely reading a paper version or a pdf. Go to: https://en.wikipedia.org/wiki/Moir%C3%A9_pattern (the Wikipedia article on moiré patterns) and see the figure under "rotated patterns."

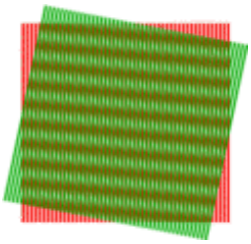


Figure 19 (7 in article). An animated GIF of shifting interference patterns

What we should imagine with the GIF is that the bat "sees" its prey as the interference patterns (horizontal lines) and chases it by attempting to cancel out the pattern (when the lines are most abundant, the prey is far away. As the prey comes closer, it appears as if we are zooming in on the lines in the middle until they disappear.) Clark (1998b) describes a similar mechanism employed inversely by baseball players:

> Consider the act of running to catch a ball. This is a skill which cricketers and baseball players routinely exhibit. How is it done?... Recent research suggests that a more computationally efficient strategy is to simply run so that the acceleration of the tangent of elevation of gaze from fielder to ball is kept at zero. Do this and you *will* intercept the ball before it hits the ground. (p. 27, emphasis in original; see also Clark, 2011, p. 16)

In other words, if you can run so that the ball does not appear to accelerate, then you will catch the ball. The animated GIF in Figure 7 can be interpreted as an object at a distance, which repeatedly comes very close and flies away again. The rhythm in which the horizontal pattern appears and disappears is what gives the interference pattern the name "beat." A beat can be considered a wave in its own right, although at a much lower frequency than the waves producing it. It is not a soundwave in itself as such; rather, it is referred to as a *beat envelope*. We can see it in a sense because the GIF rhythmically produces the interference pattern, but it is not equivalent to the interference pattern. It is equivalent to the *rhythm* of changing interference patterns. To us, a beat envelope would sound as if somebody rhythmically turned the volume up and down at a regular interval.

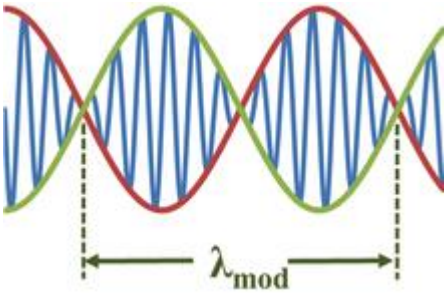


Figure 20 (8 in article). Beat envelope marked by green and red lines (source: http://en.wikipedia.org/wiki/Envelope_(waves))

To the bat, the beat is information. The extended metaphor of the bat is this: if we think in terms of perceptual phenomena, instead of recognizing waves and their frequency, I would, as a perceiving system, do myself a favor and recognize interference patterns and more specifically the different beats. Of course, the metaphor at this point extends only to distance

in relation to objects, but similar interference phenomena could arguably be identified for other types of phenomena.[125] More interestingly, if this is what I "recognize" as a perceptual phenomenon and what constitutes information, the beat is also what I would expect to enter into communication. Bateson (1979) describes a basic mechanism of how a beat can be used to think about communication:

> Interesting phenomena occur when two or more rhythmic patterns are combined .... In the case of rhythmic patterns, the combination of two such patterns will generate a third. Therefore, it becomes possible to investigate an unfamiliar pattern by combining it with a known second pattern and inspecting the third pattern which they together generate. (p. 91)

Usually (left side of Figure 9), we have an original (pattern A) and a return signal (pattern B) that give rise to interference (the squares in pattern C). If we only have an original frequency (A) and no return frequency, but are given the information of a beat envelope (C), we can recreate the missing information of the return frequency (B). The trick is that we do not have to recreate the frequency. Since we do not see signals (A and B), but only interference (squares in pattern C), we can simply let A serve as a reference signal and alter it according to the interference pattern. We see the same result as if B had interfered with A, but without B. The missing return signal (B) has become redundant. Furthermore, we can change the interference pattern and thereby explore phenomena we have never laid eyes upon (instead of B, would it be X?)

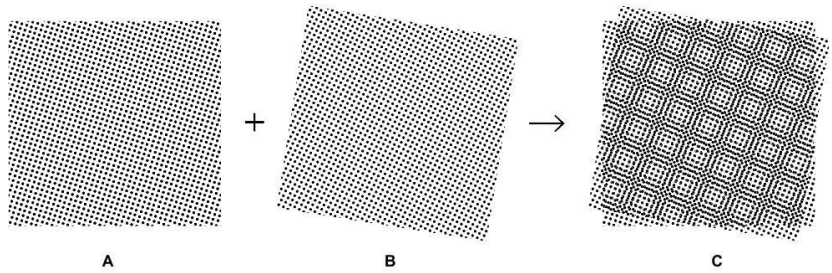


Figure 21 (9 in article). Interference patterns

The term "redundancy" is usually used to mean superfluous, but here it has a very precise meaning. As mentioned earlier, Bateson (1972) considers "restraint, pattern, redundancy, information and meaning" as synonyms:

> Any aggregate of events or objects (e.g., a sequence of phonemes, a painting, a frog, or a culture) shall be said to contain 'redundancy' or 'pattern' if the aggregate can be divided in any way by a 'slash mark,' such that an observer perceiving only what is on one side of the slash mark can guess, with better than random success what is on the other side of the slash mark. We may say that what is on one side of the slash contains

[125] In his famous paper, The Chemical Basis of Morphogenesis, Turing (1952) presents his hypothesis of pattern formation. The paper uses mathematics to discuss a mechanism by which "the genes of a zygote [an embryo] may determine the anatomical structure of the resulting organism" (p. 5). The paper later gave rise to research into pattern formation on animal fur, and his hypothesis has been verified in the case of the ridges in the roof of the mouth of mice (Economou et al., 2012; Holehouse, 2012).

> information or has meaning about what is on the other side. Or, in engineer's language, the aggregate contains 'redundancy.' (p. 131).

To align the quote with our metaphor – we would normally say that information (C) is produced by the interference of A and B. When we communicate using beats, we give information (C) and relate it to a reference signal A, and we still have all the information we need in order to chase moths. These are of course imaginary bats that are able to relay interference patterns to each other. The imaginary bats do not hear their fellow bats call. They only hear when their own call is interfered. If we imagine an imaginary bat to silently hum its own call continuously (providing a reference signal A), all we need to do is to add interference (C) to the call and the bat would "perceive" phenomena.[126] Interestingly the idea of vision as rays shooting from the eyes was supposedly offered by Democritus (see Rudolph, 2011). The idea is analogous to the call of bats. Rays shoot from the eyes with a certain frequency, and rays return with a different frequency to produce interference. The combination of a "normal" ray leaving the eyes (reference signal) and being interfered by a beat would result in an interference pattern, that is, a phenomenon seen.

It is extremely important that the beat itself is not considered a phenomenon (just as the outgoing and ingoing signals are not phenomena).[127] One is easily misled into thinking that communication consists in calling out the beat, but the point is not to *hear* a beat. It is to resolve it. "Resolved" means that the original frequency is interfered with (perturbed) to produce the interference pattern. In other words, having the original frequency and the beat envelope does not constitute information. Only when the original frequency has been changed into an interference pattern that is harmonized with the beat envelope (that is, produces the beat) can we say that there is information. It *is* possible to attempt to see or hear the beat. One can use a so-called envelope detector circuit to produce a sine wave at the beat frequency with an oscillator. However, producing this wave would mean nothing to a bat. It would not know that this sound was to be treated differently from any other sound. The resulting sound or image is therefore not the beat. We will return to this issue shortly. However, it seems counterintuitive that in order to perceive a phenomenon, you would need to perceive a phenomenon that is subsequently used to see a different phenomenon. From this metaphor, a third principle is drawn up.

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[126] Dretske (1998) describes an experiment with frogs that illustrates this point: "If the function of the neural detectors on which the frog depends to find food is merely that of informing the frog of the whereabouts of small moving dark spots, then the frog is not misrepresenting its surroundings when, in the laboratory, it starves to death while flicking at shadows. For the internal representation triggering this response is perfectly accurate. It indicates what it is supposed to indicate: the presence and whereabouts of small, moving dark spots. The shadows are small moving dark spots, so nothing is being misrepresented" (p. 69). The difference lies in what is inferred from the experiment. It is not stated here that the bat sees "small dark spots." The small dark spots are interferences. The introduction of interferences is the same, regardless of whether they are introduced as shadows or flies.

[127] Recalling the second principle, we have to interact with them as separate phenomena as soon as they are focused on.

3. **The purpose of information (a beat) is not to produce itself (become visible). Its purpose is to interfere (to make visible) and thus create a pattern.**

The preliminary answer to the third question "what is the interference pattern to the bat" is that the bat continually sees a particular thing (or locates one) as long as it maintains an interference pattern. We can also note that we have now identified two ways of producing an interference pattern. One is when a return signal is produced (in this case, by a moth). This way is known in everyday parlance as "seeing an object." In autopoietic terms, it would be considered a perturbation or triggering of the system. The other way is when one imaginary bat communicates a pattern to another bat by way of a beat envelope (from an everyday perspective, when a subject communicates with a subject). The two ways produce the "same" phenomenon (i.e., a perception of a phenomenon) but in radically different ways.

The first way of producing a pattern would be a perceptual situation. The second would be a communicative one. Each of the ways carries an association with the traditional division between subject (bat) and object (moth) and between representation (words) and represented (things). However, this does not mean that we have corroborated the division. On the contrary, it is maintained from the beginning of the series of metaphor – and despite the temptation to identify two phenomena – that only *one* phenomenon has been postulated. If we leave the first for a moment to focus on communication by way of beats, a new question opens up. We have yet to determine *how* a beat is communicated. We can be certain that the bat does not "see" or communicate the beat "itself" (in traditional terms, this would be the idea that communication is "carried" by words that we perceive and then interpret). Since we have posited that things (phenomena) are the result of interferences, then interferences cannot themselves be things (because they would require a different set of interferences to see, and so on).

The fourth question asked is "How and why does an interference pattern (a beat) become a phenomenon itself?"

If we take beats to be equivalent to words (spoken and written), the question, from an everyday perspective, becomes: is it really the case that we read words and hear sound when we communicate?

There are two very popular accounts that answer this question. The first is referred to as Aristotle's hylomorphic model (Ingold, 2011). It takes its name from the Greek "form" (*morphe*) and "matter" (*hyle*). It simply says that there is an underlying material that we shape. Think, for instance, of modelling clay. This idea is applied in the field of linguistics by Saussure (1986, p. 66):

> A linguistic sign is not a link between a thing and a name, but between a concept and a sound pattern. The sound pattern is not actually a sound; for a sound is something physical. A sound pattern is the hearer's psychological impression of a sound, as given

> to him by the evidence of his senses. This sound pattern may be called a "material" element only in that it is the representation of our sensory impressions. The sound pattern may thus be distinguished from the other element associated with it in a linguistic sign. This other element is generally of a more abstract kind: the concept.

Without entering into the very complex discussion of this quote, we can point to what is important in relation to this examination. The claim is that we recognize a sound pattern *and then* associate it with a linguistic sign, just as we recognize matter *and then* imprint form on it. In the bat's case, it would be that in order to communicate a beat envelope, we would have to first hear a beat *and then* interpret it.

The other account is what I would call the "transparency model." It posits that whenever we are engaged in the world, we should think of ourselves as tools. When a hammer works, we do not see it (it is transparent); however, when the hammer breaks in two (it breaks down), it suddenly becomes visible. Winograd and Flores (1986) use Heidegger's (1962) concepts of being ready-to-hand (Zuhandenheit) and present-at-hand (Vorhandenheit) to signify the two.[128] The order from the first account is reversed, but the proposition is the same, that underneath any phenomenon lies the use of a different phenomenon. Heidegger himself would likely protest this line of reasoning. In a passage in his main work *Being and Time* (1962), he argues against the idea of "pure" sensations used as "springboards" to attain information about the world:

> What we 'first' hear is never noises or complexes of sounds, but the creaking waggon, the motor-cycle. We hear the column on the march, the north wind, the woodpecker tapping, the fire crackling… It requires a very artificial and complicated frame of mind to 'hear' a 'pure noise.' The fact that motor-cycles and waggons are what we proximally hear is the phenomenal evidence that in every case Dasein, as Being-in-the-world, already dwells alongside what is ready-to-hand within-the-world; it certainly does not dwell proximally alongside "sensations"; nor would it first have to give shape to the swirl of sensations to provide a springboard from which the subject leaps off and finally arrives at a 'world.' Dasein, as essentially understanding, is proximally alongside what is understood. (p. 207)

There are numerous other arguments against this line of thinking. Gibson (1986), for example, argues against the "little man in the brain" theory that if in fact an image is formed in the brain as a consequence of seeing, then there had to have been a little man (a homunculus) looking at it. The idea however is very deeply seated in theories of all sorts. It is the idea of a tool or a medium that carries something else (an image, meaning or ideas). Speaking of the significance of matter in the origin of the hieroglyphs, the Egyptologist Jan Assman writes:

[128] Although Heidegger never used the term, the concept of breakdown is unmistakably unfolded in *Being and Time* (Heidegger, 1962). See Koschmann, Kuutti, and Hickman (1998) for an account.

> The concept of materiality includes the second aspect and everything that serves as a physical carrier of meaning. This carrier can be formed one way or another without necessarily influencing the functionality of the sign. An 'R' can be chiseled in stone, written on paper, carved in bark, printed in Gothic, Bodoni, Garamond, or Helvetica type without having its meaning, its reference to the phoneme [r], affected in the least. Its distinctiveness is crucial: it must not be confused with a 'P' or a 'B.' (1994, p. 18)[129]

The argument has already been made that we cannot claim a neutral medium. Both the hylomorphic and transparency models have to be wrong. If we rely on interferences to pick out things in the world, then those interferences cannot themselves be things (that had to be picked out). We would never get started. It would simply not be ingenious to repeat, in the process of perception, the problem we had of perceiving something in the world. For instance, the "rebus principle" holds that script was invented when people stumbled upon the notion that "things could be used instead to represent the sound of the word for that thing – a sound which could be homophonous with words or parts of words for other things" (Ingold, 2000, p. 371). This principle is put into question as well as the entire idea that we "read" letters or "hear" soundwaves *and then* arrive at meaning. This entails that there is no choice of medium and no "arbitrary" assignment of meaning. However, if we do not perceive beats as phenomena, why are we so adamant that there are words; why do they even enter the picture?

Metaphor 4: Redundancy

To answer this question, we have to make the communicative situation slightly more complex. The example of the bat's communication was simple. A beat was communicated, which interfered with a reference signal and produced an interference pattern (it was resolved). What happens when we make the communication more complicated? Capuchin monkeys have different alarm calls in response to aerial, arboreal, and terrestrial threats:

> Whenever they encounter one of these threats, capuchin monkeys show different escape strategies and utter one of several types of alarm calls. (Fichtel, Perry, & Gros-Louis, 2005, p. abstract)

[129] The term "double articulation" is used in linguistics. Technically, it is used to distinguish between a meaningful level of articulation and a meaningless ditto. "Within the linguistic theory associated with the French linguist André Martinet (1908–99)...the term ... refer[s] to the two levels of structure in which language is organized: speech can be analysed into the meaningful forms of language (i.e., morphemes, words, etc.), and this constitutes a 'first' articulation; these units are then capable of further analysis into the meaningless sound units of language (i.e., phonemes), and this constitutes a 'second' articulation. A corresponding term in more widespread use is duality of structure" (Crystal, 2003, p. 34). Deleuze and Guattari (2002) use this idea of a double articulation in their work *A Thousand Plateaus*).

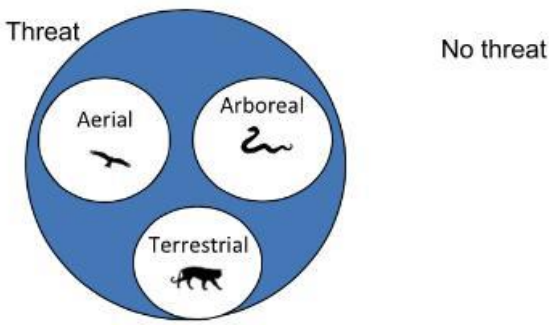

Figure 22 (10 in article). The alarm calls of the white-faced capuchin monkeys

Each of these (aerial, arboreal and terrestrial) is an interference pattern. For the sake of simplicity, the three interference patterns are signified by "a," "r," and "t." As argued above, the option of simply picking out patterns and assigning them to "a," "r," and "t," respectively, is not available. Furthermore, it seems unlikely that a behavior as important as escape strategies should rest on a learned association between a call and a threat. If however the interference patterns in question are somehow both associated with an escape strategy *and* an alarm call, the alarm calls are explicable in the line of thinking established so far. The reasoning is this: if resolving a call (a beat envelope) interferes with the state of the monkey in such a way that it enters a particular behavioral pattern (an interference pattern), then hearing the call is the same as entering the escape strategy. In like manner, seeing a threat shifts the monkey into the escape strategy. The two ways of producing an interference pattern are in this metaphor translated into 1) seeing a threat or 2) hearing somebody who has seen a threat; both trigger or shift the monkey into the same interference pattern, which to the monkeys is a particular escape strategy.

For this to work as an effective system of communication, the calls and threats both have to eliminate ambiguity. It would not, for example, be of any use simply to have a generalized "danger" call since a monkey would not know how to react (which way to run) to increase its chances of survival. In the first way (hereafter a "direct" perception), spotting a leopard perturbs the monkey's system into a specific interference pattern. The monkey sees a leopard (that is, enters state "t") and thereby removes any ambiguity of whether it sees a snake or an eagle (state "a" or "r"). The second way (hereafter an "indirect" perception) is rather more complicated. In the case of alarm calls, the monkey does not choose between the three calls depicted in Figure 10 and then interprets the call. Hearing or, as we have called it, "resolving a call," simply eliminates the possibility of the two other calls. We have already touched upon the concept of redundancy that provides the mechanism for this elimination. The last sentence in the Assman quote above goes to the heart of the matter. A signal must be distinctive and must not be confused with another. Saussure (1986) expresses it in this way:

> What characterises those units is not, as might be thought, the specific positive properties of each; but simply the fact that they cannot be mistaken for one another. Speech sounds are first and foremost entities which are contrastive, relative and negative. (p. 117)

The explanation proposed by Saussure is that signs (or speech sounds) are negative, that is, they do not so much point to something (a positive) as they eliminate what it is not. An illustration of elimination would be a relief carving. The "raised" figures in a relief are achieved by chiseling away the background. You see the figure as raised because the background has been eliminated. Bateson (1972) subscribes to the same idea in regard to information:

> In accord with the negative character of cybernetic explanation, 'information' is quantified in negative terms. An event or object such as the letter K in a given position in the text of a message might have been any other of the limited set of twenty-six letters in the English language. The actual letter excludes (i.e., eliminates by restraint) twenty-five alternatives. (p. 408)

If we start a word with the letter K, all alternative words starting with the twenty-five alternatives have already been eliminated. In a similar way, entering into the state "r" eliminates the possibility of entering into the state "a" and "t." Seeing a snake precludes seeing an eagle or a leopard. Thus, when a monkey resolves a beat "t" from another monkey, prompted by a threat X, then "t" is resolved as not-"a" and not-"r," which means that the monkey enters the state "t" without having seen any X. It enters the state by default because it is the only state left to enter.[130] Solving the beat of a call is therefore a significantly different way of producing an interference pattern than the perturbation of a system by a threat. There is, however, an aspect of the use of the word "negative," which is problematic. Eliminating ambiguity means that the calls are mutually exclusive of each other. The point is to create redundancy. Having heard the leopard call, it is no longer necessary to go check for yourself. In informational terms, the problem with the above explanation is that it is uneconomical. It will not do to state that the letter "k" is equal to "-a" and "-b" and so on. This would give us much *more* data to keep track of and no gain in information. The reason the letter "k" can eliminate twenty-five alternatives is that there is only one spot open for an opening letter of any word. With that constraint in place, *any* letter eliminates all other alternatives.

A small example is illustrative:

If we imagine a lottery where 27 people draw lots with one winner, a simple way would be to have each person pick a number between 1 and 27 and then draw one number out of a bowl containing the same numbers. Each number will be mutually exclusive of 26 other numbers.

A different way of doing the same thing would be to have each person pick a number between 1 and 3 three times, not allowing doublet combinations, so that every person has a

[130] Bateson (1972) likens the method with the logical proof *reductio ad absurdum*: "In this species of proof, a sufficient set of mutually exclusive alternative propositions is enumerated, *e.g.*, 'P' and 'not P,' and the process of proof proceeds by demonstrating that all but one of this set are untenable or 'absurd'" (p. 406).

combination of numbers, such as “2-3-1” or “1-1-3.” Every combination “x-x-x” is still exclusive of 26 other combinations (there are 3x3x3 combinations), but only three numbers are now in the bowl. The winner can therefore be picked by drawing a number three times (returning the number each time). We can note that the method of determining the number is irrelevant. We could have three switches with three settings and a system that randomizes which setting each switch is in. It can also be noted that although this second way of determining numbers implies additional work, it has actually reduced the workload. Instead of keeping track of 27 alternatives, the system only has to keep track of three. The remainder has been distributed to the system, that is, there are three predetermined spots that only allow one out of three settings. Not only has the workload been reduced, but the amount of information available has been increased, or rather, the information we have has been made available and more fine-grained. Each time a switch is flipped, two-thirds of the population is eliminated.

In both cases, the purpose is to shear away as many alternatives as possible, as efficient as possible, while accurately entering the requisite state. If we imagine the number of threats to the capuchin monkey raised from three to 27 (and disregard the naïveté of the example), we can reinterpret the metaphor. In both the direct and indirect cases, there is only information insofar as one state is entered and a number of other different states excluded, that is, in the *change* or difference between the state before and after a beat has been resolved. As we have seen, there are marked differences in how this is brought about. The change occurring when “seeing” a threat (an animal) and excluding its alternatives is straightforward, identifiable with the arrival of the animal. We might say that the animal triggers or presents a specific sequence of numbers when it is seen (for example, a leopard triggers “2-3-1”). What the beat does is the same as these numbers being triggered. Critically, however, it does not do so by “using” words, numbers, or other types of representation. *It does so by flipping switches.* The beats are not the words/numbers. The beats are what the words/numbers *do* (the flipping of the switch). As the beats are resolved, the switches are flipped, so a beat could be translated into: switch position 1 to “2”, position 2 to “3,” and position 3 to “1.” Ambiguity is avoided because each switching of position is not one that is interpreted; each switch *is the change* to the position. The numbers signify (for us) any of three states the switch can be in, but each switch and each state is oblivious to numbers, states, and leopards. Bateson (1972) describes a switch from the system’s perspective (the circuit):

> At first thought a ‘switch’ is a small contraption on the wall which turns the light on or off. Or, with more pedantry, we note that the light is turned on or off by human hands ‘using’ the switch. And so on. We do not notice that the concept ‘switch’ is of quite a different order from the concepts ‘stone,’ ‘table,’ and the like. Closer examination shows that the switch, considered as a part of an electric circuit, does not exist when it is in the on position. From the point of view of the circuit, it is not different from the conducting wire which leads to it and the wire which leads away from it. It is merely ‘more conductor.’ Conversely, but similarly, when the switch is off, it does not exist from the point of view of the circuit. It is nothing, a gap between two conductors, which themselves exist only as conductors when the switch is on. (p. 120)

Resolving a beat thus results in a state change, which is another way of saying that the monkey-threat system is thrown into a particular state. Redundancy is the answer to the question "how is a beat communicated?" The system only knows differences (or flipping switches) as it resolves a beat.[131] As a monkey calls out, switches are flipped in all of the attendant monkeys as if they had seen the leopard themselves. The monkeys do not hear "sound" and then interpret it. They do not hear a representation of a leopard or form a representation of one. They do not even hear changes. *They change*.[132] Each of these changes is what Bateson (1972, p. 315) calls "a difference that makes a difference."[133] Change is not a thing in itself. Bateson (1979) writes:

> Difference, being of the nature of relationships, is not located in time or in space. We say that the white spot is 'there,' 'in the middle of the blackboard,' but the difference between the spot and the blackboard is not 'there.' It is not in the spot; it is not in the blackboard; it is not in the space between the board and the chalk. (p. 109)

Lewontin (2000, p. viii) uses an example of travelling that illustrates the idea: "If I drive eighty miles west and twenty-five miles north, it is impossible for you to know that I will arrive in Brattleboro, Vermont, unless you know that I started in Boston." The travel directions consist of changes, but we will not be able to depart or arrive before we have a starting point. When he later states that DNA only becomes "information" about the organism "in the actual process of cell function" (p. xiii), this is what is meant. DNA or any other change that is inert is not information (that would be a change that does not change). Information is *change*. When changes are put on hold, they become instructions waiting to be resolved (switches waiting to be flipped), also known as information.

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[131] There is a problem here, of course, that the phrasing suggests that there is a beat first, which is then resolved. This is due to the nature of creating changes. There is not a non-positive way of provoking the change that "flips the switch" in order for you to think "beat." We could say that beats are "the event of change" or, to use Bateson's (1979) phrase, "news of a difference" (p. 460; see below).

[132] In A Stroll through the Worlds of Animals and Men, von Uexküll (1992) develops an early idea of an animal having an Umwelt, that is, a specific perceptual world in which an organism exists. He imagines each animal surrounded by a soap bubble: "When we ourselves then step into one of these bubbles, the familiar meadow is transformed. Many of its colorful features disappear; others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble, we see the world of the burrowing worm, of the butterfly or the field mouse; the world as it appears to the animals themselves, not as it appears to us. This we may call the phenomenal world or the self-world of the animal" (p. 319).

Uexküll differentiates between perceptual tools and effector tools, which loosely translates into input and output for an animal. When input and output coincide, the two "together form a closed unit, the world" (p. 320) similar to the one described by Stewart et al. (2010) earlier. As an example of this, Uexküll describes a tick clinging to a branch, only releasing its grip when triggered by sensing butyric acid from a mammal walking underneath (p. 321). From a tick's perspective, no such thing as an animal exists. There is an object that triggers release, and this thing is not a concept or an idea (no such thing comes into being), but it (the thing) is exactly the release of the trigger. In other words, the genesis of the world that becomes meaningful for the tick is the performative or operational sense in which differences in perception are differences in acting (there is not a perception and then an action; rather the two coincide or, even better, should not be considered two). The tick's perception is its release.

[133] Saussure (1986) also uses the term "difference:" "In the language itself, there are only differences... although in general a difference presupposes positive terms between which the difference holds, in a language there are only differences, and no positive terms.... In a sign, what matters more than any idea or sound associated with it is what other signs surround it" (p. 118).

These “instructions waiting to be resolved” are what we see when we look at the signal, the words, the call or the interference pattern. As stated above, we do not “read” letters or “hear” soundwaves *and then* arrive at meaning. It is in fact the other way around. We “see” a leopard, and when we ask “why?” we only find a word; if we look at the word more closely, we find the letters “l-e-o-p-a-r-d,” but the leopard is nowhere to be found. To understand this, we have to return to the bat and the moth. The change from metaphor one to two showed that the moth was essentially a reconfiguration of constraints. Similarly, in relation to the process of understanding (resolving a call), the words are part of the constraints that have to be in place. Just as the entire system of bat-call-moth-interference has to be in place to create a specific interference pattern, the entire system of us-cognition-writing has to be in place to create the specific interference patterns you are experiencing right now. Moreover, like the bat-moth example, it is tempting to place the “source” of information in the words “out there” and our understanding (the creation of interference patterns) “in here.” In both cases, we are dealing with a type of metonymic reasoning (Krippendorff, 2006; Lakoff & Johnson, 1980). More specifically, a part-for-whole thinking – “what the grammarians call “synechdoche” is the metaphoric use of the name of a part in place of the name of the whole, as in the phrase ‘five *head* of cattle’” (Bateson, 1972, p. 421). We point out a part and let it stand for the whole. The moth is a part of the entire system that stands for the whole system that produces the interference pattern. In the case of writing, speech, and other means of communication, the text is the part we focus on, but we have forgotten the whole system that allows it to become interference patterns.

Given this understanding, the reason an interference pattern (beat) becomes a phenomenon itself (such as a word or sound) is that we do the same thing with the beat that we do with the leopard. We try to see it (differentiate it). When we try to see it, we no longer treat it as a beat (we stop trying to resolve it) and treat it as a thing (like a moth, a leopard, a word, or a number). As stated above, we do not see a signal (for instance, A or B in Figure 9), but we see because there is an interference pattern. If we attempt to see the signal, it requires a different beat. When reading this text or hearing somebody speak, switches are thrown rapidly. If, instead, you try to listen to the sound of the voice or to notice the font of this writing, etc., those switches are easily interrupted.[134]

Things are not (only) what we see but *how* we see the world. Instead of thinking of changes or beats, it is perhaps better to think of “instructions on how to see” (like Lewontin’s driving directions). When you “see” the instructions, you are not following them. The bat instructs itself by its call, and we instruct ourselves and each other through language.

[134] A different way of putting it is that animals present (what we find to be) differences that elicit changes. Language is (what we find to be) a different set of differences that elicit the same (or similar) changes. However, this has the distinct disadvantage and gives the impression that, once again, there are two “things” – differences and changes (and these are quickly “located” “out there” and “in here” like the moth and the bat). This is of course due to the present constraints of writing. To create change (have thoughts), we need to present differences (these marks) and so we take the differences for the change.

It is quite understandable that we try to "see" words. We are using the very same "tool" with which we see leopards in the attempt to "see" words, soundwaves, and brain waves.[135] As Ong (1982, p. 90) puts it: "All script represents words as in some way things, quiescent objects, immobile marks for assimilation by vision."[136] It is true that we produce (what retrospectively can be seen as) objects, but only to create beats. We cannot hear a beat. We can only resolve it. Therefore, whenever we produce a beat, we resolve it in the same instant. We do not find an object, interpret it, and then arrive at meaning that refers us to another object. The reason we want the words to be different from the leopard is that the objects we find seem to magically provoke ideas, concepts, and images in our head. When we examine them, they show us nothing but more matter. We want to show off the "beat," but we cannot produce the beat without resolving it or abandoning it. We either have to accept to change with the beat or "arrest" the beat in order to "see it" (thereby interrupting the change). We thus adopt the thinking that the matter (print, sound waves, brain waves) "carries" the information. Alternatively, we attempt to pass off information as "negative." However, information is not "negative" as opposed to positive; it is "negative" as in "inverse" – like a negative to a developed picture.[137] If you resolve a negative (that is, develop it) – then you get a picture. If you chose not to develop it, then you can examine the negative as an object. *What we see depends on what we do*. In any case, even if we dub the objects "negative," they do not contain information (as they are proxies for change). Therefore, when you start with the negative as an object and claim that that is what you see first and then extract information from, then you have reversed the order. Regardless of what we choose to focus on, there is no "carrying" of information.[138] There are beats that, when we resolve them, inform us. There is nothing in between. On the basis of this, we can state a fourth principle:

[135] As a side note, we could ask: why should the tools that allow us to work out a particular subject area also work as tools to give us insights into the workings of those same tools? How can it do so if not by doing what it always does? If you asked a hammer to "examine" itself, it would treat itself as a nail.

[136] Also, "Writing makes 'words' appear similar to things because we think of words as the visible marks signaling words to decoders: we can see and touch such inscribed 'words' in texts and books" (Ong, 1982, p. 11).

[137] This oppositional way of thinking can be found in Bateson's (1972) adoption of Carl Jung's distinction between Pleroma and Creatura: "The pleroma is the world in which events are caused by forces and impacts and in which there are not "distinction," Or, as I would say, no "differences." In the creatura, effects are brought about precisely by difference. In fact this is the same old dichotomy between mind and substance" (p. 462). Ryle (2000, p. 21) attempts to point to the negative in a different way: "The workings of minds had to be described by the mere negatives of the specific descriptions given to bodies; they are not in space, they are not motions, they are not modifications of matter, they are not accessible to public observation. Minds are not bits of clockwork; they are just bits of not-clockwork."

[138] There are definitely ways in which systems can be considered to "carry" information. Shores (2009) gives an example: "[W]e might consider the amplitude modulation of radio waves (AM radio). Through this process, an original sound signal is communicated by modulating (varying) the amplitude of a much higher frequency radio-wave. Because this radio carrier-wave is so much 'denser' than the original sound signal, when we modulate its amplitude at-pace with the sound-wave, it behaves as though it were a material' that we carve, so it bears (carries) the lower-frequency sound-signal. (The dense modulated radio-wave is broadcast through the air so that AM radios may demodulate it back-into the original signal, just as our turn-table needles 'extract' the signal by sensitively detecting modulations in the record-groove)" (par. 14). It should be obvious that the problem of carrying information is that it makes both the information and the carrier objects of sorts.

4. In order to constitute information, a phenomenon (an object) needs to exclude alternatives

The above provides an explanation for why (and how) the beat is treated as a phenomenon in itself. It also brings us closer to showing why – despite only having one phenomenon – there is a temptation to place it in two places (or postulate two phenomena). The object, or things, metonymically signifies the introduction of a threat (a return signal is provided). The subject, or words, metonymically signifies the introduction of changes (a beat is provided). They both produce the same result – an interference pattern – but they achieve it in very different ways.

The most difficult thing in discussing *change* has been that we have to state *something* in order for us to discuss the resolving of beats (that is, to trigger changes of state) – so anything will do because it exemplifies a change; conversely, nothing will do because it shows us something rather than the change.[139,140] We find ourselves speaking of "beats," "differences," and "calls." The second principle showed us that we could, of course, not concern ourselves with these without producing a phenomenon (we have to write, think, say something), but as the third principle tells us, the purpose of the beat is not to produce itself but to make visible. The beat is the *change*. As we resolve the beat, we shift into patterns of understanding (interference patterns). It is when we *decline* to resolve the beat, but instead attempt to *see* the beats, that we see words, sound, or writing (objects). Insisting on capturing the beat *itself* (and not just a proxy of it) triggers the reflexive problem that the article opened with. Therefore, one could claim that the words *and* the things are both expressions of a phenomenon, not the phenomenon itself. Alternatively, one could agree that both phenomena are about the same but insist that they are still different phenomena. In both cases, the relationship between the two remains diffuse. We thus have to pose an additional question if we insist that the two are simply two ways of producing one phenomenon:

The fifth question asked is "What is the relationship if not a relationship (representational) between word and thing?"

To recap what has been established so far: constraints are in place (we restrain ourselves among other things) in order for certain phenomena to arise. The phenomena were not there in advance since restraints are needed for them to arise. There were no constraints before the

[139] Like Hegel's man who rejects apples and pears because he wants fruit (cited by Heidegger, 2002, p. 66) or Ryle's man who is looking for the university but only finds buildings (Ryle, 2000, p. 18).

[140] Garcia (2010) has produced an entire treatise revolving around this problem. He attempts to "pay equal attention to everything that is something" and arrives at the term "no-matter-what" to signify that there is not a single attribute or element that can give us a "common denominator" of everything, yet in the midst of all things they are all things? "Everything that is – even if it is vacuous, false, nothing, or groundless – is *something*. [...] One cannot prevent anything from being quite simply 'something,' even if it is something illusory, a chimera of the human mind, or a mirage. Give me something, and this will never be no-matter-what. However, you can give me no-matter-what thing. Nothing that you can give me can avoid being something" (p. 23) and yet he also states "Something is never 'no-matter-what.' I could not find something in the world which would be no-matter-what" (p. 21). Thus, the no-matter-what signifies the abstaining of attributing anything to what a thing "as such" is and yet maintaining that we can talk about it.

phenomena arose. The phenomena were *not* created in or by the mind (inside world) because the phenomena metonymically associated with the mind, subject, or words are *changes*, not phenomena. The phenomena are not simply "located" in the world (outside world) either. Rather, what is metonymically associated with the world, object, or things are constraints, without which there would be no return signal (like driving directions with no departure point).[141] Furthermore, we produce (or enact) phenomena whenever we concern ourselves with them either by resolving beats (communicating indirectly) or seeing phenomena (directly). What is at stake is the extremely strong intuition that words and things are related.

For all intents and purposes, when seen as objects, words and things seem very much alike. Let us return to the explanation of going from words as triggers of change to phenomena in the world. In the explanation lies a way of differentiating between "negative" and "positive" phenomena. The philosopher Alan Garfinkel proposes a theory to explain why explanations explain anything at all. The idea is that an explanation always takes place relative to a space of alternatives, a contrast space. He gives an example of a bank robber, when asked by a vicar "why he robbed banks," who answers, because "that's where the money is" (Garfinkel, 1981, p. 25). The vicar's contrast space is "why do you rob banks when you could do so many other things?" The contrast space the robber hears is "why do you rob banks as opposed to convenience stores, gas stations, etc." The difference in the vicar's and the bank robber's contrast spaces gives an explanation of why the question asked by the vicar was different from the explanation provided by the bank robber.[142] This provides an easy way to tell whether or not a change is being resolved or whether a difference has been introduced. When we see a phenomenon as an "object in the world" or a positive phenomenon, the object differentiates itself from a background. Its contrast space is "everything else" or "the rest" (like a traditional ground-figure dichotomy). The chair stands out from the background that includes the carpet, the window behind it, the table next to it, etc. When we consider a phenomenon as a change or a negative phenomenon, the object eliminates other alternatives. Its contrast space is "the other." Thus, a chair could have been a stool, a highchair, a sofa, or some similar type of furniture, just as the leopard *was not* the eagle or the snake.

This way of looking for contrast spaces can be brought to good use. In both the direct and indirect cases, we are enacting the same state change (an interference pattern), but what has been sheared away are completely different in the two cases. When we look at the indirect case and consider words as triggers of change, each word eliminates other alternative words. The word "moth" has, for instance, many alternatives, for example, when one changes a letter ("Both"). As soon as we look at a specific – WORD – it very clearly stands out from the page and the rest of the surrounding words. We now see it as part of a sentence and a part of a continuing effort to effect different understandings in a text. This inversion is extremely interesting. As we turn to the direct case, we see the obverse case unfolding. We would usually look at a leopard as it stands out from the background of the jungle. When we

[141] This also makes our own presence in the scenario a constraint.
[142] Garfinkel's theory is of course a reconceptualization of the concept of redundancy.

invert the contrast space, we see the leopard relative to the other threats it could have been. Immediately as we do so, the leopard stops being a leopard "as such" and becomes "an example of a threat." Its contrast space are the other threats (eagle and snake). Doing so has "semiotized" the leopard, making it equivalent to a sign. Switching the contrast space of words and things shows that the two are equivalent phenomena, that is, each are phenomena in their own right with equal ontological weight and in equal need of explanation. They are not linked by a relationship of representation. The word and the thing are two ways of producing the same interference pattern. Both effect changes (eliminate alternatives), but they do so in different ways.

Metaphor 5: Origami crease patterns

How should we then understand the relation between the word and the thing? To bring light to this aspect, I invoke the metaphor of an origami crease pattern (hereafter CP). An example of a CP is shown on the left side of Figure 11. When a figure is folded according to the pattern, an origami figure emerges (right side Figure 11). The origami master and mathematical scholar Robert J. Lang attempts in his writings to answer the conceptual question of "what a crease pattern is." Lang suggests that one's perspective on origami and CPs is connected as much with what you know as your relationship with the piece of origami. In a narrow *dictionary* definition, a CP is "a set of lines that is a representation of some subset of folds in an origami shape, real or imagined" (Lang, 2015, par. 1). On a *personal* level, for the origami folder, the CP is a mnemonic device that aids in the recording of ideas and the relationship between ideas at a level of detail that is "too great to carry around all at once" (Lang, 2015). To a *community* of folders, the CP is a guide of how to fold an object that can be communicated and put forward for others to examine. To a broader *audience*, it is a "proof certificate," or

> an indication that a folded object really is what it claims to be. Even though the observer can't make the connection between specific lines in the pattern and folds in a figure, he or she knows that such a connection exists and that any given line, if investigated deeply enough, would correspond to some feature in another representation of the subject of the fold. The proof certification can be appreciated even if one does not see the folded object or even if the object does not yet exist: there is the knowledge that it is connected to something immanent. (Lang, 2015, para. 4)

Finally, to the general *public*, it is a beautiful pattern that works just as well as a piece of art. The viewer may have an inkling of an inner order or logic without being able to fully understand or follow it.

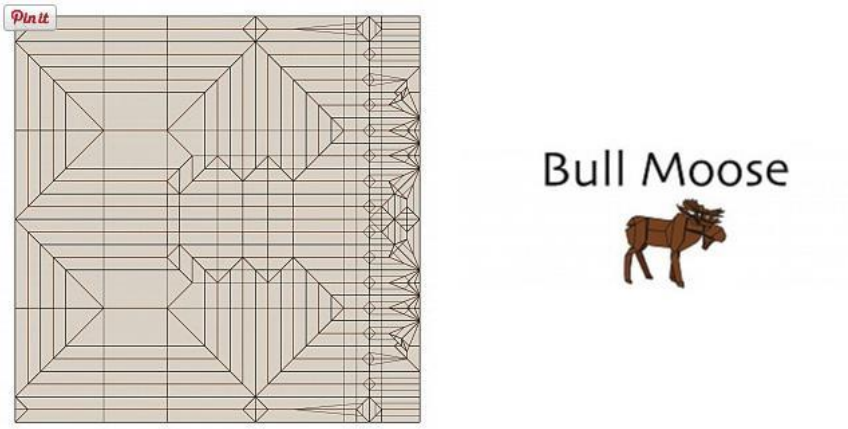

Figure 23 (11 in article). A crease pattern (CP) of a bull moose Source: (http://www.langorigami.com/art/creasepatterns/creasepatterns_art.php)

The metaphor is obviously that words are to things what the CP is to the folded origami form. On the right side of Figure 11 is the folded origami form. We might have expected a similar review from Lang on different perspectives on the folded origami form, but they all seem to collapse on one another since the bull moose so clearly is the shape of a moose. To eradicate any doubt, the caption boldly states that this is a bull moose. The metaphor seems clear. The CP is in the "place" of the word/bat/monkey/cognitive process, and the folded form is in the place of the thing/moth/leopard/cognitive result. As stated earlier, there is no representational relationship between the CP and the folded form. The CP does not "represent" the form. No one without knowledge of origami would ever look at the CP and say "that's a bull moose." However, it is not possible to claim that the CP somehow summarized the idea of a moose, which was then thrust upon the world as, say, a social construction. What ties the two together are folds. When we look at the folded origami form, it is obvious that it would not be what it is had it not been folded. Each fold in the bull moose has been *folded*. Unfortunately, it is necessary to state the obvious in this way because in this lies the crux of the entire investigation. As we see the bull moose (right side of Figure 11), it steps out from a background. Its contrast space is "everything else." Every fold aids in the process of recognizing the form of the moose. The folds (differences or beats) have been resolved in a double sense. They have been resolved by us who see what was intended to be seen and they have been resolved by the folder who took pains in bending each fold. The origami form not only tells us what is there, but it also becomes testimony of what has been done in order for it to be there as a sort of historical affordance. Seeing the bull moose in this way reiterates a point made earlier that the objects are not "just there" to be (passively) perceived. They have been (actively) perceived to be there. For the knowledgeable, the process is evident in the form (folds) of the object. Just as the craftsman, spoken of in the introduction, looks at a house and knows what has been done and what comes next, the origami folder looks at a form and knows what folds have been made and what base form the form is derived from. He can see errors and problems negotiated and evaluate the chosen solutions. We can then shift our attention toward the folds and how they were made. When we do so, the contrast space shifts imperceptibly as we become aware that every fold could have been otherwise. The contrast space of the bull moose becomes other choices, other changes. Each fold is then seen, first and foremost, as expressive of a

change, a process, an enactment. Seeing the bull moose this way is equivalent to looking at the CP. We thus shift our attention from the folded form on the right of Figure 11 to the CP on the left. The CP is equivalent to what we earlier called "instructions waiting to be resolved." Each line is an enactment waiting to happen, but it would be an error to think that we have somehow captured a process, an act, or a "becoming" of the bull moose and only laid it dormant. As the arguments have shown, the beat cannot be seen, only solved. As we also saw, resolving the beat does not mean creating a representation of a phenomenon; it meant *changes* whereby a system shifted into a specific interference pattern. What we attempt to "see" with an "instruction" are the triggers of change. I use the word "trigger" purposefully. Just as the leopard was said to trigger a specific sequence (2-3-1) by its arrival, the numbers in a call "2," "3," and "1" trigger the appropriate changes, which amount to the same sequence. In other words, both the phenomenon (direct) and the communication of a phenomenon (indirect) have a positive version (where we see an object) and a "negative" version (where we "see" the trigger) – which was also established earlier. The CP and the folded form trigger in different ways, but they trigger the same pattern. The answer to the question of "what is the relationship between word and thing if not a relationship" is that they are *transforms* of each other. The two are *commutable*. If you fold the CP, you will have an origami form. If you straighten (unfold) the form, you will see a CP.[143] To spell it out: there are not two phenomena to be compared. There is a single phenomenon captured in two different ways. We can see this in this metaphor of CP vs. moose. We can capture this phenomenon as a CP, and we can capture it in its folded state, but *we cannot have both at the same time*. It is only the static image of print that allows us to "see" them side by side. Just as there were not two interference patterns in Young's (1807) double-slit experiment (and thus not two phenomena), it is a misunderstanding to compare the CP with the moose as representation and represented. Lang uses "object or concept" to convey the same idea: "[A] CP serves as yet another imprint of an object or concept, just as the folded form is, itself, an imprint of an object or concept" (Lang, 2015). On this basis, we can form a fifth principle:

5. **Phenomena cannot represent each other. For phenomena to be related, they have to be transforms of each other.**

[143] We can take note of the fact that a CP does not include all of the possible creases in the folded artwork – it is "something more than a hint, but less than a full plan. With suitable interpolation, it can be followed to create a representation of the creator's original concept" (Lang, 2015). Lang's article is, among other things, dedicated to examining the art of encoding information into a CP. In the world of origami, there are two main differences we should note. There are "mountains" or "peaks," and there are "valleys." Of course, these are respectively a fold rising towards you or one dropping away. The pair is a prototypical example of mutually exclusive alternatives. If a fold is a mountain, it cannot be a valley and vice versa. Traditionally, the two have been marked by patterning lines – dashed lines for valleys and dot-dot-dash lines for mountains. Lang experiments with using different coloring for lines (brown and blue in Figure 11). When we look at the CP with that knowledge, it turns from being an aesthetic experience to a guide or set of instructions. Note also that an origami form can be folded "freeform" without a CP (the lines) drawn up. The lines give us a positive version (which we see as a synechdoche – a part for the whole), but an experienced folder will "see" the lines without any marks, just as an experienced painter or sketch artist "sees" suggestive lines and forms on a blank canvas. Michelangelo famously supposedly said: "To sculpt means to take away, not to add, because the sculpture already exists inside of the marble. The only thing the sculptor has to do is liberate the figure imprisoned in the marble."

“Being transforms of each other” means that the same phenomenon is produced (interference pattern) but in different ways. Lang’s (2015) way of putting it has the unfortunate side-effect that one is tempted to think that there is a common or underlying idea. This is understandable since the second principle ensures that if we want to think of their commonality, we have to think of something. However, every single version we can produce (in this case, it has been produced by writing, but it could just as well have been thought up in “your mind’s eye,” so to speak) must abide by the same reasoning. It will be a transform (what is in front of you is also a transform). What is common to related transforms is that *we* are part of the constraints needed to produce the interference pattern. What is different in each case is the way the phenomena are triggered and the material constraints involved. In the case of the origami form, the material constraint is paper, but in two radically different ways. One (the CP) provides a uniform backdrop for signs or lines to be made. The other (the model) provides physical qualities that are at once pliable and sufficiently rigid to support the figure. In the case of the bat call and the moth, the differences are even more pronounced. However, the differences in, for instance, material constraints, have a system to them; they are all geared toward producing the same phenomenon (for instance, an interference pattern), so the differences across transforms amount to a commonality (they are different, but different in the same way). Regardless of whether a phenomenon is produced perceptually, in writing, in thought, in images, etc., what is of essence is that what we might call “the code of production” remains the same (that it is translatable). That the code is the same in the CP and the folded bull moose is obvious from the folds since these are “the same” lines. That the two are subject to different constraints is evident from Lang’s deliberations on how to construct a CP. Lang operates with a concept of a path. Paths are all possible connections between points:

> Between any two points in the pattern there was a line, called a path, and each path was associated with a condition, called a path constraint. Even before we construct folds, we must look at paths in the origami design. Paths have a minimum length; those that are too short are invalid; those that are as long or longer than the minimum are valid; and those that are precisely the minimum length are active. (Lang, 2015)

“Too short” or “minimum” refers to the constraint that a fold has to be foldable. The pattern generated by tracing out paths is not intended to be folded; it serves more as a theoretical tool of informing the folder of the options at play. When some lines are selected over others, an actual CP is constructed, complete with all of the trade-offs in designing a particular solution. In the CP, the lines and the paper on which they are traced serve as material constraints on “seeing” the instructions. In the case of the folded form, the lines are folds and creases. The physical composition of paper determines how flexibly it bends, how rigid the structure is, and so on.

An immediate counter argument to this solution would be that we have in fact pointed out a common underlying ground: “the code.” If we maintain that there is not a “view from nowhere” that ensures a truth or a way to see across all different “versions” of a code, how are we to understand that phenomena are transforms of each other?

The sixth question asked is "How are we to understand the creation of phenomena if there is no common underlying ground?"

Relative to this discussion, the code can be equated with changes (words) or differences (things). The example of driving directions given by Lewontin (2000) was a way of stating that the differences in a system are simply switches changing position. "DNA molecules lying in the dust" are, in a sense, not DNA. It is also a way of saying that beats and languages, in a very specific sense, have no semantic content. To put the statement on its head: changes and differences are the only meaning we can expect. Saying that words and things are transforms of the same code does not reduce them to the same meaning. That the word "bull moose" connects with the folded image of an origami bull moose means that both have been utilized to differentiate the animal. As illuminative as the origami example is, however, it is also potentially misleading. What is easily overlooked is that *we want to* see the same bull moose. It is the positioning of the word vis-à-vis the thing that creates the problem of *how* they are the same. The archetypical example of the representational relationship is the map/territory relationship. If anything, the idea presented in the metaphor of the origami, that a CP and a folded form are transforms of each other, applies to map and territory.

Metaphor 6: Map vs. territory

Figure 24 (12 in article). A map and the territory (The Matterhorn) (Source: http://www.perceptionstudios.net/about-nlp-the-map-is-not-the-territory/)

Bateson (1972) famously quotes Alfred Korzybski when he says that "the map is not the territory" (p. 180). The quote prompts the question why it should be necessary at all to point out that the two are not the same? Many would insist that the one represents the other. It was made very apparent with the CP-origami metaphor that there is no such thing as representation. There are different ways of generating a phenomenon. When I put the map-territory relationship forward as a metaphor, I am asking you to consider the relationship equivalent to the CP-folded form. The map is the crease pattern. The territory is the folded form. A few comments are in order to explain. In the map-territory relation, one is often so preoccupied with clarifying correspondences between the two that it is forgotten that the territory, like the origami moose, has to be folded (enacted) in a specific way to "be"

anything. A case in point: can we identify a singular, uniform reason for looking at the Matterhorn on the right side in Figure 12? Is it not rather that "what we see" shifts significantly when we look as a tourist, as a postcard manufacturer, a geologist, a mountaineer or a chronicler? The same goes for the map on the left side of Figure 12. We are often so preoccupied with how accurate or reliable the map is in relation to the territory that it becomes completely invisible that there is a purpose to why we are looking. Although we can generally say that we look at maps when we are attempting to navigate, a symbol of a mountain has different implications for a car traveler as opposed to a mountain hiker. There are multiple ways the two stop being transforms of each other. A map that only represents a mountain with a single symbol is of no use to a hiker. A postcard manufacturer would be hard-pressed to consider the map a relevant depiction (representation) of the mountain. When the map and the territory are brought together, there is already the assumption that we who see both see with the same interest.

With that clarification, we can focus on how the two are transforms of each other (how the map-territory is like the CP-origami) when the same interest is assumed. In the paper, Entering a Risky Territory: Space in the Age of Digital Navigation, the authors (November, Camacho-Hübner, & Latour, 2010) differentiate between mimetic and navigational uses of maps. The mimetic corresponds with an ordinary representational view while the navigational use "allows a navigator to align several successive signposts along a trajectory" (p. 586). Signsposts are relevant cues that tell the navigator that he is on course. As in the case of the CP, "what gets on the map" (to use a Batesonian phrase), are *possible actions*. For the CP, the possible actions are mountains and valleys (the two ways to fold a paper). For the map, it is information to guide navigation. The map does not say "if you travel here, there will be trees to observe." The map says "if you try to reach this point, there is no road, and you will have to walk." This is also how you use the map. When you are on the mountain, you situate yourself by looking for relevant signposts that tells you your location, and from there, you read your navigational options. "What gets on a map" aligns with the problem that we are trying to solve. The system of map-territory can then, on the map side, be said to consist of a ledger combined with the constraint: only one symbol at each point. The ledger of a map corresponds to all of the possible "symbols" that can be placed on a map, and usually, these are mutually exclusive (allowing only one symbol at every point). On the territory side, the signposts that are picked out are significant "folding points" that allow navigation. Both the symbols and the points identified in the territory are thus translations of the problem: "at every point, I can choose to go in all of the compass directions.

Just as any shape can be mapped in origami with the code: two types of folds, "mountains" and "valleys," any territory can be mapped from the "recipe" of a ledger and the mutual exclusivity of the symbols. The map-territory and origami codes are both generated. A system of changes (or differences) is met with particular constraints. When we see the folded bull moose, we know that a folding has taken place in a two-fold sense. First, we know that someone has physically folded it. Second, we know that our perception has been folded into seeing a moose. The cuts or incisions we make as we carve nature "at its joints"

are decisions of "seeing the moose," but these decisions would be entirely different if we were hunting the moose. We would look for a kill shot, signs of the moose having detected us, or escape routes. The folds that the carpenter makes in the house are seen more like the origami folders who see instructions for folding whereas an unskilled person, like the general audience sees a CP pattern for its aesthetic value, usually sees a pretty house or the comforts of a home. There are thus very important considerations involved in the question "what do you see?" When we approach a forest with a map in the hand, we "see" navigational options. In a much more ephemeral way, when we enter a room, we "see" a social situation taking place – conventions, power struggles, family relations, and business decisions. Much too often, there is a tendency to simply go by the physical objects that can easily be identified (people, furniture, rooms). These will however often simply be part of the constraints and not say anything significant about how the situation is produced, navigated, or affected.

A map and a territory therefore both provide redundancy (information) to the *same* system or code. The system is set up to eliminate alternatives and reduce ambiguity. It follows a logic or an interface, a way of generating the map that solves the same problem "where can I go from here?" At each informational point, a choice has to be made. Thus, in a very narrow sense we can agree that a map *is* representational but only considered as "representing" what you as a navigator or traveler can and cannot do. When a navigator looks at a map and thereafter at the Matterhorn, the two can be considered transforms of each other because they are involved in the same navigational endeavor. Each symbol read or signpost identified triggers changes that eliminate alternatives. Therefore, the map and the territory are different triggers of the same code – like the CP and the folded origami, like words and objects, and like alarm calls and threats.

Stating that the same code has been triggered is not a way of reducing phenomena to each other or of identifying a single unifying or underlying code. It is a way of clarifying how two, otherwise disparate, phenomena can be involved in each other. What therefore does the code do if it does not have a reductive function?

The example of a system for drawing lots showed us that there were more or less complex systems that could do the same job. Three positions with three possible states gave 27 alternative patterns. Consider the same task with Lego bricks. The number of ways to combine six two-by-four studded Lego bricks of the same color is 915,103,765 (Eilers, 2005). Imagine a threat system that instead of keeping track of that many threats "only" needed to keep track of the combination of six Lego bricks. In technical terms, the six Lego bricks are an extremely efficient *mapping* of 915,103,765 possible combinations. In order for Lego bricks to be such a mapping, we would have to accept constraints. There are rules for their combination. The Legos cannot be altered; unattached bricks do not count as combinations, etc. When we accept the constraints, there is no need for a memory bank of the different alternative combinations. The system itself serves as a generative memory (Clark, 1998b). If we resolve a beat that is (enter a specific state), and the constraints are in order, and the rules followed, we are guaranteed that the combination is "valid"; that is, that

the blocks are put together in one of the possible “correct” combinations. Transferring the argument to language use in general, it is easy to see that language is an incredibly versatile and efficient way of creating redundancy. It solves the problem: of mapping a virtually unlimited number of different alternatives with a limited capacity *and* making the process of eliminating alternatives to quickly arrive at a single option extremely efficient. Where therefore does the system come from? How does it arise?

Similar to the case of the bat’s echolocation, the complexity of the system decides how sensitive and granular the mapping is. Consider Figure 13 below: on the left side are stages of complexity in the eyes of mollusks. The image at the top is hardly an eye. It depicts light sensitive cells on the skin of a mollusk. Further down, these develop once the cells are placed in a cup, the light entrance is narrowed, a lens is formed, and finally, at the bottom, an eye comparable to the human eye is recognizable. On the right is a completely analog evolution of the graphics of three beloved computer characters: Mario, Link, and Donkey Kong. Their progression corresponds with the progressive evolution of the eye. As the complexity of the eye is heightened (equal to the system for drawing lots becoming more complex), the character moves from an extremely pixelated appearance to a super smooth rendition of the figures. The bottom appearance of Mario is however not more real or true than the top one. Like the origami moose, the granularity with which Mario is rendered reflects precisely what that eye is capable of perceiving/folding. If human vision were as acute as an eagle’s, we could spot a mouse on a beach from three miles away, but as it is, we would only see a beach and some moving specs.

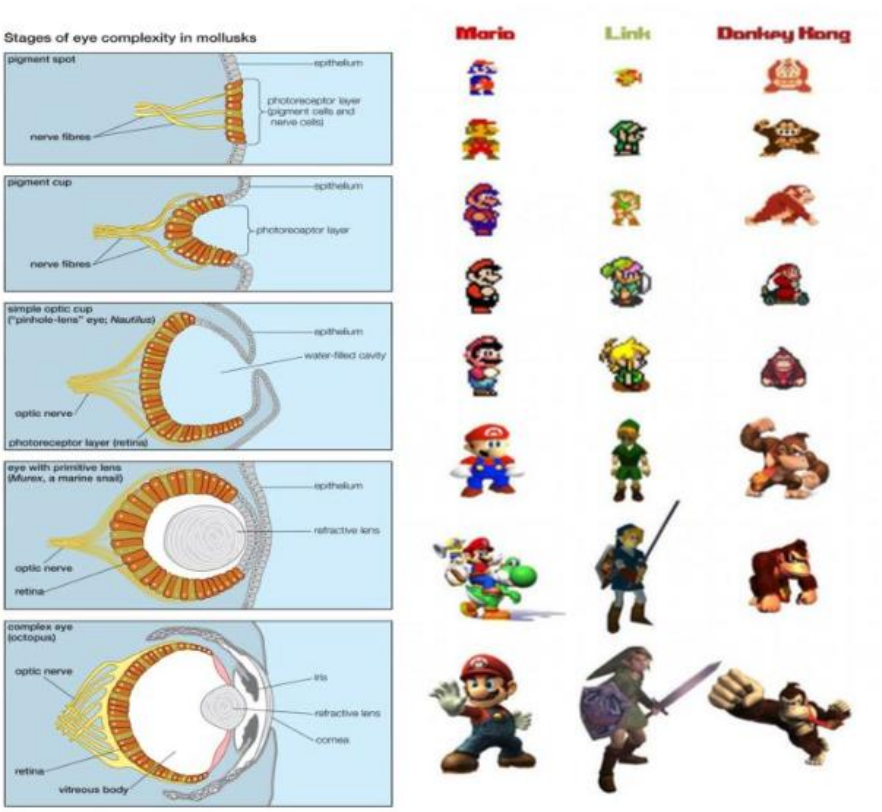

Figure 25 (13 in article). Sensitivity and granularity

As with the word and the thing, the series of images on the left in Figure 13 do not "correspond" or are somehow depictions of the process where the images on the right are the result of that process. The two are, insofar as they relate to one another, transforms of the same phenomenon. The code that ties them together is that they solve the same problem of perception. They organize the same changes or what Edelman (1998) calls 2.order isomorphisms. What differs is their way of production and the constraints laid on that production. Because a system has to follow a logic and because any such logic consists of changes, the flip-side is that regardless of how granular the system distinguishes, given a sufficiently high resolution, the system is imprecise. The famous article: How Long is the Coast of Britain? (Mandelbrot, 1967) bears testament to this. This does not amount to the proposition that we only have access to part of reality.[144] It only amounts to reiterating the point that whenever redundancy is created, "the rest" has to be sheared away. There is no cut we can make that will allow us to include everything – not because that is "too much," but because there is no problem/information that includes everything (it is like the ganzfeld; there would be light, but we would not see anything). The fact that the system is imprecise is not sub-optimal; on the contrary, it illustrates that a system has found an optimum granularity with which to solve problems.

In *The Interface Theory of Perception*, Hoffman (2009) gives a very entertaining example of this. Apparently, the males of a species of jewel beetle living in Western Australia attempt to mate with empty beer bottles. They do so because the bottles are "shiny, dimpled, and just the right shade of brown to trigger, in the poor beetle, a category error" (p. 1). In other words, we would be prone to say that the males mistake the bottle for a female. However, in systemic terms, it is not an "error" as such. Up until the introduction of beer bottles in the Australian environment, the signal was exactly right in terms of beckoning mating behavior for the male beetle. A similar example is given with frogs that have been shown to ignore food right next to them but vigorously "hunt" moving dark spots created by experimenters. "The frog does not seem to see or, at any rate, is not concerned with the detail of stationary parts of the world around him. He will starve to death surrounded by food if it is not moving" (Lettvin, Maturana, McCulloch, & Pitts, 1968, p. 235). In these cases, evolution has provided a system with an optimum solution under the given circumstances; that is, the beetle's and the frog's behavior are both examples of what Simon (1956) calls "satisficing" or good enough and what Clark (1989, p. 64) calls the "007 principle."

If we align the above with the metaphors presented thus far, we can see how the world triggers a system. The moth "triggers" the interference pattern. The leopard triggers the alarm call. The real bull moose and the folded origami bull moose both trigger a visual system that processes three-dimensional images. The real moose is seen in much higher resolution, but the shape of the moose is still recognizable in the folded moose. These triggers are not "laid on top of the world" (or different from the signal). Because they *are* changes, the arrival of the moose *is* the change. The moose is oblivious that its entrance has

[144] It is a widely accepted methodological view and a traditional stance in the philosophy of science that by modeling the world, "you consider only a certain aspect of it which remains more or less invariant while you are using it, even though the phenomenon as a whole is continuously changing" (Heylighen, 1990, p. 8).

caused a change in your system. The world knows nothing of the incisions and cuts we have made, yet it embodies and allows systems to be distributed across many disparate parts. The beauty of the system is that neither the world nor the system needs to "know." The fact that the system-environment differentiates is enough. Brooks' (1990) statement that "the world is its own best representation" is indeed accurate, except that we can dispense entirely with the "representation" part. The system that is triggered is not on the receiving end of anything (messages, information). The system is part of the entire constraint complex that makes the phenomenon possible. There is not "simply" a thing or an object here, there, or anywhere. Objects are what they are because we do something (we are triggered).[145] The answer to the question of what a system or code does is that it makes phenomena possible. It generates phenomena. The "function" of the code (if we are forced to provide one) is to balance decisions of granularity or sensitivity with decisions of "what to do." In what detail are you going to fold this phenomenon? With what sensitivity are you going to approach this problem? In what resolution are you going to see this? How are you going to perceive this (what actions are tied into enacting this or that?).

This leads to the formulation of a sixth principle.

6. **All things (in a world) have to be constructible from the same beginning (code and set of constraints).**

The identification of a code of origin does not simply satisfy a desire for completeness. A code allows the deconstruction of any phenomenon. Whenever we encounter a phenomenon, we can confidently say: a problem has been solved here. We should look for *a* code that allows it to arise, including considerations of constraints and (code-)formats. It is by no means a claim that I have unearthed an ultimate code or even that there is such a thing. Mathematicians have shown that there are many incompatible non-Euclidean geometries that all map the "same" space. The identification of a code does not ensure true results; rather, as with the examples of granularity, it only tells us what trade-offs we have made to allow us to see what we see. In particular, a code allows us to clear up the figure of the interface (Figure 1) with which we opened this article. As argued, so many theories and problems are in play in the simple HCI model that there is no hope of summarizing them in a simple "problem." The point is not to reduce all phenomena in an interface to the same code. This can easily be done and will fall under the category of reductionism. The point is to look for codes and constraints that allow these irreducible dichotomies (for instance, the subject-object divide) to arise. In short, we have to look for an interface. The principles we have identified can be summarized in the following:

[145] It is in this way that affordances become understandable as the reflections of possible actions. Bergson (1991, p. 6) expresses an early version of the idea of affordances: "the objects which surround my body reflect its possible action upon them." Things are seldom "there" just to be gazed upon. They are there to be turned, twisted, grabbed, sat upon, and kicked. Perhaps because Gibson's theory was conceived in the realm of vision, most affordances that are discussed are physical and bodily affordances. There are many other affordances that have not been investigated, but that are equally directly perceived. Texts are readable, movies are seeable, sad people are consolable, contracts are negotiable.

An interface actualizes a generative systems mapping of phenomena within a particular set of constraints.

Conclusion

It should by now be apparent that what is before you, in this very instance, is an interface. It is not a representation. It is itself a phenomenon. I have encoded (written) all manners of changes (beats), and you have resolved (read) those changes. It has of course been an interface all along in several respects. It has been a perceptual interface, a written, perhaps a digital (if you are reading on a computer), but mostly, it has been an interface that sought to tease out a problem and make it visible and tangible. Secondarily, the interface has been set up to answer the question "why is the question of an interface set up as a representational problem?" and, through the investigation, to answer the question "what is an interface?"

The impromptu answer to the first question is obviously that we see two things (human and computer) and something going on between them. This answer relies on a mixture of tradition, an intuition that those are the pertinent elements to what an interface is, with the urge to encapsulate phenomena first and clarify their relationship second. The answer presented here is that both word and object trigger (or generate) the same phenomenon, which is puzzling. They are duplicate phenomena that work on different terms and look nothing like each other. We incessantly examine the word and the object and find ways to call them the same – correspondence, entanglement, inextricable aspects of the same emergent phenomena, socio-material assemblages, etc. The one thing that escapes attention whenever we do so is the genesis of the word and the object. They are already assumed "there" as we start to investigate their relationship. Once they are both triggered, it is clear that all of the philosophical problems mentioned in relation to Figure 1 are generated. The problem with overcoming the problem of representation or the subject-object divide is not that the two do not have anything to do with each other. The trouble is that the problem is constructed to create a deja-vu. If I say "isn't it odd that Helen crossed the room to talk to Michael?" nothing would be amiss. If I say "isn't it odd that Helen crossed the room to talk to Helen?" you would assume that there were two Helens. The (physical) moth triggers the same interference pattern as (the word) "moth."[146] The trouble is not that we cannot differentiate different phenomena (for instance, by placing them "in here" and "out there" or calling them process and result). The trouble is that we are creating conflicting orders. On the one hand, we resolve the beats involved as the same phenomenon, but on the other hand, we have set up a syntactical structure "X talks to Y," which requires two separate phenomena. If we use the metaphor of recipe and cake, we can say that it is like having a finished cake and asking "but when do we add the recipe?" or going through the recipe and objecting: "I don't see any cake anywhere."

The assumption that there is a divide to explain is valid. The oversight is the concomitant assumption that there is a problem that can be solved on the premises upon which it is posed. It is perfectly possible to pose the problem of squaring a circle, but it is not a problem

[146] Reminiscent of Tarski's (1983) truth theorem "'snow is white' is true, if and only if, snow is white" (1933).

that anyone can solve. Any theory that starts with two phenomena to explain a single phenomenon is at risk of creating this problem. The choice of interface is thus crucial from the very inception of phenomena. When you start with a particular problem, you accede to the built-in restraints. Accepting the problem means accepting those restraints and that particular way of folding. These restraints then become decisive in determining how the code folds and unfolds. The article could have started in the context of subject-object, map-territory, and process and result, but it would have rested on an interface that allowed this opposition to *be* problematic. The question of the interface is posed as a representational problem because we accept the positing and setting of two separate phenomena in opposition. Turning the problem on its head, we have explained through metaphors how it is possible to create the problem. Through this explanation, both the word and the thing have been provided with their own genesis (that trigger the same phenomena). They can therefore be considered different phenomena – not related representationally – but considered as transforms of each other. This does not "define" either phenomena. Relative to other phenomena, each of them becomes different and sensitized toward different codes. What is established is that the multiple ways in which phenomena can be considered transforms of each other depend not on the phenomena but on the system drawing them together.

Taken together, the six principles stated read as follows:

- Whenever we encounter a phenomenon, we can infer that constraints are in place in order for it to arise.
- It is not possible to concern oneself with a phenomenon without producing a phenomenon.
- The purpose of information (a beat) is not to produce itself (become visible). Its purpose is to interfere (to make visible) and thus create a pattern.
- In order to constitute information, a phenomenon (an object) needs to exclude alternatives.
- Phenomena cannot represent each other. For phenomena to be related, they have to be transforms of each other.
- All things (in a world) have to be constructible from the same beginning (code and set of constraints).

They are all attempts at throwing light upon what goes on *qua* every phenomenon. The principles take words and things (and all things in between) as side-ordered phenomena, and are able to explain their kinship without resorting to representationalism.

The principles finally lead us back to answering the question "What is an interface?" The question remains perplexing, but it no longer sits at the intersection of epistemology and ontology. It has been shown that it is the inclusion of both in the same interface that coerces us to treat the two as separate phenomena (for example as theories) that has to be reconciled. What has been done in this article, as a countermeasure, is that interfaces have been explained in terms of how a particular set of phenomena come into being *qua* the phenomena. The unusual use of metaphors has been a way of cutting through the Gordian Knot of sedimented assumptions of how to frame the problem and how to deal with it, each

of which demanding recognition and treatment in order to allow a consideration of "what an interface is." In particular, it has been a way of circumventing the inherent reflexive problems of investigating one's own interface, which was discussed in the introduction. The answer that *an interface actualizes a generative systems mapping of phenomena within a particular set of constraints* is a convoluted way of saying that every phenomenon carries its own interface. *Because* there is a phenomenon, we can assume that there is a code of production that delimits it, that it is part of a system of creating redundancy, and that the appearance of the phenomenon is also the enactment of something we are trying to do. Providing every phenomenon with its own genesis allows us to recognize our own part in phenomena at "zero distance." To see what we do, we have to look at "that which we do," not attempt to step out of our own shoes to establish a perpendicular view on ourselves. Maturana's (1987) assertion, quoted earlier, that "a scientific explanation entails the proposition of a mechanism which will generate the phenomenon" (p. 73) has been shown to mean that we are part of that mechanism. The phenomenon in front of you (this text) serves as both an explanation and an expressive exemplification. The result tells us that format is extremely important. The way you choose to carve out the world decides the code. We do this every day. As you approach anything, you are negotiating what interface is at play, that is, what is the problem here? How are you going to handle this? Where should you make the incisions? What do the incisions enact? However, most of the time we employ well-known formats and encounter well-known problems. Bringing attention to the cut is also a call to look for different cuts. For instance, when Ingold (2011) draws a line of a salmon swimming and jumping upstream, he valiantly attempt to shift our gaze. He attempts to make us look for movement in the world rather than things:

> You have rather to look with it: to relive the movement that, in turn, described the vault of my own observation as I watched the salmon leap the falls. In this line, movement, observation, and description become one. And this unity, I contend, is nothing less than that of life itself. (p. 1)

However, as the line he draws exemplifies, the line is static and will always be seen as static by a mind unwilling or unable to relive the movement. Anyone who brings to a phenomenon his own code and own format, will not be able to see beyond it. Attempting to see change or differences as movement, process, or becoming was just an example. Thus, the world does not demand or offer a particular code (or incision). It will readily serve any code (no realism). At the same time, it will also harshly deny codes that render the triggering of phenomena less than rigorous (no social construction). The "science" of phrenology and the astronomer's attempt at ordering the paths of planets according to an Aristotelian worldview failed because "observations" of phenomena were unreliably triggered, subject to the observer's whim, or as approximations requiring auxiliary hypotheses to be explained. The code, on its side, will allow an infinite number of transfigurations, only a subset of which will ever be relevant for practical purposes. However, it allows us imaginative freedom only with the caveat that we cannot alter the format. When we say that only our imagination is the limit, we seldom realize that the format of our imagination has already rendered a multitude of worlds impossible and inaccessible. What other types of formats are available

is the subject of another article. I can only, in the closing remark, suggest what must be the case for the constraints at work in our current conception of (computer) interfaces.

What is the potential of abandoning the human-computer interaction complex for designers and philosophers? The interface of text has served us incredibly well. However, the computer allows for something that text has never been able to do. Text is able to differentiate all kinds of information, but every time it produces new information, it has to add information (make new words). The Library of Congress in Washington, D.C., has a collection of books that stretches about 1,199 kilometers, with 130 million items and 29 million books. Every year, approximately 2.2 million books are added globally to the pool. Any scientific community tasked with analyzing and synthesizing information into plateaus of knowledge is, in this light, hopelessly ill-equipped for the task. For instance, the peer-review system relies on a community to keep up-to-date, assuming a wisdom of the (academic) crowd.[147] Any newcomer to the field is expected to trawl the literature and be able to provide a state-of-the-art or review that is cutting edge. The amount of redundancy and proclivity for error is staggering. For example, it has been established that citations roughly follow Pareto's 80/20 rule or what is called a power-law distribution (20% of the most highly cited articles/researchers are responsible for approximately 80% of all citations. In the field of HCI, see Henry, Goodell, Elmqvist, & Fekete, 2007. In the field of psychology, see Webster, Jonason, & Schember, 2009). If there is such a thing as a state-of-the-art in a field, then a version control system like Git[148] ought to be in place with which the community can work collaboratively. The computer allows, in principle, for the integration of a multitude of information without having to *add* knowledge objects; only existing complexes need to be ordered. In relation to text, this is crudely exemplified when information hides behind a hyperlink. It is also exemplified in dynamic graphs that draw large amounts of data into the same visual graph.[149] We might say, with a nod to Gaston Bachelard, that in this article we have sought out a *differential* theory to complement and allow multiple theoretical insights to be *integrated* into the same complex. The promise of the computer is that once we have determined the data structure, compiling information becomes part and parcel of working with information, not an additional task. This requires us to abandon the HCI complex and with it representational problems, subject-object distinctions, and map-territory disputes. Instead, we should look for the successor to text. We need to find a type of codification that allows for the same flexible and incredibly versatile system of creating redundancy as text. Through such a code, we could map rapidly changing dynamic phenomena that are currently only questionably captured in text. Allowing the computer to trigger changes in new ways could be like playing with Lego blocks, as a rigorous metaphor, with "serious" implications and the ability to establish precise meanings. To do so, we have to develop systems with actions that carry more than

[147] According to Hayles (2012, citing David Hamilton), the percentage of articles never cited in the humanities is 93.1 percent.

[148] See https://en.wikipedia.org/wiki/Git_(software). Some of the important features of Git is that it supports non-linear workflows and that each directory is a complete history with version-tracking capability.

[149] A well-known and entertaining example is Hans Rosling's presentation: http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen

the binary informational value by which our interfaces are presently governed; either you click or you do not click.

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Appendix 3 – Article 3

Analog Computer Interfaces –
Introducing constraints as the foundation of design of interfaces

Abstract

Where should we find the inspiration to redesign the computer as a new medium?

In this article, our current way of making sense of what goes on with a computer, that is, our interfaces, is characterized as linguistic or hybrid-linguistic. This means that the assumptions upon which our current interfaces are built cater to an understanding of the world that can be verbalized or written down as information. However, such descriptions are ill-suited for imagining and creating novel representational forms. In order to develop new representational forms, the article suggests that alternative cognitive styles and formats are available. Specifically, the article considers non-linguistic examples of meaning-making, in the form of analog computers, as a possible way of developing user interfaces. The article opens with the introduction of vocabulary and a series of theoretical considerations of relevance for how to approach this problem. It explains why the claims in the article do not rely on determinism and proposes *constraints* as a viable course for explaining and reimagining the possibilities of the computer as a new medium. It proceeds with a discussion of what type of medium the computer is and whether it is possible to speak of digital materiality. Examples of analog computers are then introduced. These are considered as a type of scaffolding that offloads computational tasks into the environment or embeds them into technology. The analysis of these examples uses constraints as a principle to explain how the computer can be regarded as a new medium. Finally, an outline of requirements for redesigning the computer as a new medium is sketched out. The ambition is to point toward a fruitful path of exploration for the design of new computer interfaces with commonsensical requirements; a new computer interface should, on the one hand, render novel cognitive styles possible, and on the other hand, it should match and possibly surpass the advantages of writing and the ubiquitous desktop metaphor.

Keywords: Analog Computer Interfaces, Constraints, Digital materiality, Redundancy

Introduction

Virtual reality, augmented reality, and hybrid or mixed reality all designate technologies that are about to create a Cambrian explosion in our use of the computer medium. They promise visuo-tactile, indistinguishable from physical reality, literal immersive gaming experiences, as seen in *Star Trek's* Holodeck (Murray, 1997) and the harnessing of computer power in the form of thinking tools of hitherto inconceivable magnitude and complexity. However, before all this can be realized, a different, much more mundane battle has to be waged – one that asks questions of the boundaries of imagination. How can we think up these incredible

tools if our thoughts are somehow both enabled and constrained by the medium of their expression? Bret Victor puts it this way:

> Media matters because media are thinking tools. The representations we use of the systems is how we think about it. Our representations are how we understand the system and what we understand about it. If we want powerful new ways of understanding systems, we need powerful new representations and we need a powerful new medium, so we can create and work with these representations. So much of the way we work with representations today is derived from pencil and paper medium. Even when we're working with the computer we're still thinking in pencil and paper. There's an incredible opportunity to rethink how we think about systems. (2013 video lecture)

In the video lecture quoted, Victor succinctly brings together a series of complex ideas that all point toward reimagining the computer as a medium. The proposition that the computer is a new medium is hardly contested, but what is to be understood by "new" and "medium" is highly contentious. Victor focuses on the idea that "representations are how we understand the system," which, with reference to pen and paper, essentially says that the present boundaries of our imagination are drawn by language (written or spoken words). One could take issue with this idea as a type of technological determinism, that is, the claim that a medium or technology determines what we are able to do and think. However, Victor's purpose is not to engage in a debate on the status of representation in human cognition but to show, quite literally, that the bandwidth of human's ability to make sense of the world is much broader than what is imagined in a pencil and paper type of thinking. There are different "cognitive styles" available, as the anthropologist Anthony Wallace (1978) puts it – such as the mechanical understanding an engineer has of a machine or the embodied understanding a dancer has of a performance. This article aligns itself with Victor's ambition to rethink the computer medium. It seeks to sketch out a possible direction for redesigning the computer interface as a new medium. The problem is not that we cannot access different styles of cognition (Victor refers to this as "switching channels"). The problem is that once we start *describing* what is going on, we have conceptualized our ideas in a linguistic format (a particular cognitive style).[150] From the resulting descriptions, we create models about the world and our perception of it, or rather, we mostly reaffirm existing models. Our current way of making sense of what goes on with a computer, that is, our interfaces, can thus be characterized as linguistic or hybrid-linguistic, meaning that it caters to an understanding of the world that can be verbalized or written down as information. Such descriptions not only fall short of capturing the "goings-on" of other cognitive styles, they are also ill-suited for imagining and creating novel representational forms. In order to develop new representational forms, this article considers non-linguistic examples of meaning-making (analog computers) as a possible way of developing user interfaces.

[150] As Shaffer and Clinton (2006, p. 7) put it: "Writing and mathematical notations are, of course, static representational systems, and therefore thinking in a theoretic culture can be reasonably characterized as the result of human agency mediated by cultural tools."

The article opens with the introduction of vocabulary and a series of theoretical considerations of relevance in terms of how to approach this problem. It explains why the article's claims do not rely on determinism and proposes constraints as a viable course for explaining and reimagining the possibilities of the computer as a new medium. It proceeds with an introduction of examples of analog computers and scaffolding that offloads computational tasks into the environment or embeds them into technology. The analysis of these examples uses constraints as an explanatory principle. Finally, an outline of requirements for redesigning the computer as a new medium is sketched out. The ambition is to point toward a fruitful path of exploration for the design of new computer interfaces with commonsensical requirements; a new computer interface should, on the one hand, render novel cognitive styles possible, and on the other hand, it should, at a minimum, match and possibly surpass the advantages of existing rigorous informational and communicational systems (i.e., writing and the ubiquitous desktop metaphor). I have called this path a visuo-tactile approach.

Determinism and constraints

Implied in Victor's critique of descriptions above is the notion that it matters *how* we conceptualize knowledge. *What* we know changes with *how* we know it. Some phenomena are very poorly captured in words, not because of the phenomena but because of the medium. As mentioned, this can be viewed as technological determinism (e.g., White, 1966), the idea that technology determines or causes particular social changes, user behavior, or simply how people think and interact. More precisely, it would be a form of media determinism. Ong (2002) proposes, for instance, that the thought processes of human beings "do not grow out of simply natural powers but out of these powers as structured, directly or indirectly, by the technology of writing" (p. 77; see also Goody, 1977). McLuhan's (1994) famous dictum "the medium is the message" is another example, which can be translated as the idea that the introduction of a medium introduces changes in how humans conduct their affairs.[151] True technological determinism requires that technology is considered to "be something" in and of itself or to have a particular function or use regardless of the context of use. It also requires some sort of causal effect to take place in the use or by the introduction of a technology. What is claimed here sets itself apart from determinism on both these counts.

The claim is that media (technology) should not be viewed as determining; rather, it should be considered in terms of constraints. In the words of Wertsch (1998, p. 39), media "constrain or limit the forms of action we undertake." He gives the example of pole vaulting. Providing an overview of the historic development of an event that started off as leaps across streams with wooden poles and later transforming into a modern Olympic

[151] McLuhan considers a medium an extension of ourselves, e.g., a hammer extends our arm, and a message is the change of scale or pace or pattern, so the introduction of a new medium enables, enhances, accelerates, or extends what is already being done (Federman, 2004) – i.e., we are able to deliver a blow with our arm, but the hammer focuses and augments the power delivered in a novel way.

discipline, he identifies a succession of different materials used for pole material (bamboo, steel, aluminum, and finally the fiberglass poles used today). The point of the example is that the different poles all enable and constrain "vaulting." Constraints are not put forward in a negative sense, but in the Foucauldian understanding of power as productive (Foucault, 1991; Fraser, 1989; Shogan, 1999). Power is constraints on action that both enable and delimit what can be done. The flexibility and strength of the different poles allowed for different vaulting styles, culminating with the fiberglass pole and the easily recognizable technique where the athlete "slingshots" over the bar, bending the pole almost 90 degrees in the process. The style and the result obtained with the fiberglass is not possible with the other types of poles. The constraint of a fiberglass pole enables vaulting over heights previously unattainable with other poles. It also enables, in the sense, as it makes the act of "vaulting with a pole" possible as a phenomenon. The constellation of man-pole-bar-mattress makes the discipline possible. At the same time, actions are also limited by the material. The human body combined with the pole makes some grips of the pole optimal, others possible but impractical, and so on. There are other constraints at work such as rules of the game and the psychology of competition, etc., but for the present purpose, the focus is on explicating the idea that different choices – here material choices – constrain what can and cannot take place. The pole does not "determine" the style or the result, but it makes some events possible. At the same time, other events are made impossible. The constraints (in the sense of limitations) of each pole are clearly seen once they have been surpassed in terms of results and replaced – while constraints-as-enabling is seen in the potential of the new pole. At any given time, a situation will be constrained in certain ways, allowing for an array of possible actions and outcomes.[152] If we look at the development of pole vaulting in terms of the material constraints of the poles, one can follow the substitution of different constraints across time (diachronic), each substitution making new clusters of outcomes available and others unlikely, unfeasible, or impossible. Locally, at a specific time and place, there are a given set of options available. At such a moment in time, while some events are highly likely, others appear fantastic. The limits of what is humanly possible appear almost set in stone. Fast forward to a different era with different materials, different training facilities, professionalization of athletes, etc., and former world records are routinely beaten. The point is that the material does not *determine* what happens. It constrains, that is, makes possible, enables, and limits.

Constraints & goals

Shifting from a deterministic view to a constraints-based approach requires a few further comments on what is meant by constraints. As stated above, the view on constraints is based on Foucault's (1991) understanding of power as productive, that is, something comes out of constraining action – a pattern, order, structure, information, or meaning. A fitting metaphor

[152] There are more constraints at work besides the conspicuous pole. The bar, the mattress, the athlete himself, the judges, etc., all of these can in some way or form be considered constraints that have to be in place in order for the event of pole vaulting to take place. As noted, there are social constraints, but also constraints in terms of skills and techniques. A shift in results, comparable with pole vaulting, can be seen in the discipline of high jump where the introduction of a new technique, the Fosbury Flop, in 1968 opened up an entirely new series of record setting and, overnight, changed the standard technique for the sport. These results were "available" in the existing set of constraints but untapped by existing techniques.

might be building a dam across a river. The dam (a constraint) impounds water and gives rise to reservoirs that can be used for irrigation, consumption, and hydropower generation. Without the constraint, these possibilities would not be accessible or would be greatly reduced. There was also the above example of pole vaulting and the materiality of the pole. However, the constraints at work need not be material. The division of labor is an example of a social structure that constrains people's actions. We can see the division at work when we observe that the ongoing actions taking place are co-dependent and that results are only achievable through team effort. Regardless of whether the constraints considered are material or not,[153] overall, in any given situation, there will be an array of constraints at work. If we are digging a ditch, the division of labor is only part of the constraints at work. For example, the machinery at our disposal, the permeability of the ground, the position of the ditch, and the eventual use of the ditch all play a part in how we go about the task. Each of the constraints play a part in enabling a pattern (e.g., we want the ditch to be straight and drain water). Because the constraints make *concrete* patterns possible, there are other patterns that are made impossible, implausible, or unfeasible once a course of action has been chosen. This can be seen directly when, for instance, in the case of the ditch, it is no longer possible to walk across that field in a straight line – we have to walk around or jump over the ditch – and it can be seen indirectly in the sense that the constellation of ditch-digging constraints are not very suitable for, say, building a bridge, staging a theater play, or warming a meal. Constraints therefore both enable and delimit what can be done (Biskjaer & Halskov, 2014; Boden, 2004, 2010; Leonardi, & Kallinikos,, 2012). Bateson (1972, 1979) uses the term "restraints" as an approximate synonym of pattern, redundancy, information, and meaning to cover the same idea (1972, p. 130). He provides the example of a monkey that produces an exact copy of one of Shakespeare's novels by hitting a typewriter. As this is a statistically unlikely result, we look for restraints in the way the system is set up (1979, p. 406). The typewriter could, for example, be set up to only produce Shakespeare's novels[154] – in other words, finding order where we could equally have expected disorder, something or another constrains that order.

Constraints are neither to be considered conditions or causes of phenomena, nor are they necessarily part of the phenomenon in question (unless one considers all elements of a situation part of the assemblage where the phenomenon takes place). The shovel is not a necessary or sufficient condition for digging a ditch, and its appearance at a scene does not cause a ditch to appear, nor is the shovel part of the ditch. As such, constraints do not "determine" anything. On the contrary, they are, in a sense, determined by the phenomenon in question. Constraints are revealed (or informed) by the goal or general "gist" of what is "going on." This is not intended in a teleological sense wherein a thing is given its meaning *qua* its purpose. It is in a much more loose sense, a "matter of concern" for someone (Latour, 2003), or what an organization is preoccupied with – what the sociologist Everett Hughes calls "going concerns" (1919), or what Ingold (2000) is getting at when he speaks of

[153] There are good arguments in favor of not differentiating between the social and material or to consider them as intertwined (Barad, 2003; Orlikowski, 2007; Pickering, 1993; see also Jones, 2013).
[154] Note that the system is already constrained by our assumptions surrounding the typewriter, the paper, the alphabet, the English language, etc.

livelihood, dwelling, and skill. In everything we do, there is something at stake, something we are trying to accomplish, or something we desire, shy away from, or use. "It" is what we care about in a Heideggerian (1962) sense (sorge) but also what we assemble around and negotiate for in the old Nordic sense of Thing – an assembly in session (Heidegger, 1971; Latour, 2003). "Thing" denotes "anything that in any way bears upon men, concerns them, and that accordingly is a matter for discourse" (Heidegger, 1971, p. 172).

Take the simple example of a piece of fruit hanging from a tree. Let us say that a person comes along and decides to grab the fruit. The "Thing" for him becomes possession of the fruit. The height of the tree, the height of the person, the position of the fruit, and his ability to grab things all constrain the situation, that is, deciding whether or not he is able to pick the fruit. If we imagine that the fruit is out of reach, the person might decide to introduce a further restraint, for instance, a stepping stone, enabling him to reach the fruit. The stone affords stepping up (i.e., it has affordance), which we will return to momentarily. Alternatively, he could decide to make a box or a ladder to stand on, which would constrain the situation in a similar fashion and enable him to reach the fruit. The point is that the constraint the person is looking to introduce is not identical to the stone, box, or ladder, nor is it necessary for the task at hand (he might decide to get a fruit picker to reach the fruit). The fact that these different items serve to constrain the situation depends on the overall ambition of getting the fruit. If the person suddenly lost interest in the fruit, the stone, box, and ladder would no longer constrain in the same way or perhaps not at all (perhaps, they would be navigation obstacles or would restrain the situation in a different way).[155] The proposition is that what we want and how we understand the situation determine whether or not, for instance, a stone is a constraint and how it constrains. When we stop wanting something or we begin to understand the situation differently, the constraints in place either change or stop constraining. For instance, if we were trapped in a room, everything would become a potential tool for digging, breaking locks open, or delivering messages to the outside world. At other times, effects beyond our personal control amass to consequences that no individual is pursuing, for instance, in the tragic cases of crowd disasters. Constraints that, for instance, gave access to an area such as a tunnel are suddenly recognized as constraints of how many people can flow through an area (Helbing & Mukerji, 2012). It is in this way that constraints are determined by the phenomenon in question (the "Thing" we are trying to do).[156]

[155] This appears to differs from Gibson's (1986, p. 129) own perception of affordances as "in a sense objective, real and physical." However, reading on, Gibson states that affordances are "neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer." Unlike the widespread reading due to Norman (1988) that an affordance is a property of the object, the quote is suggestive of Gibson's grappling with the shortcomings of our vocabulary and linguistic mindset. The affordance is real because it is direct. It "points both ways" because both the so-called physical and mental worlds constrain the situation.

[156] There is also negotiation aspects of "Things" that are not touched upon here. It can be said of most situations that there are many different viewpoints at work concurrently differing in their perception of what is "going on" and what to take into account (Star & Griesemer, 1989). That is, there are many voices in an assembly deciding what it is "that is going on."

The “Thing” can be very explicitly stated, well-defined, and surrounded by conventions of use, categories, rules and sedimented, embodied, or embedded in material objects, e.g., any established sport is a “Thing” in this sense (win the game, get the prize). We can speak of the “object of the game” or “having a *thing* for X” where “X” is something for which one has a penchant. As such, one can consider human activity inherently object-oriented, as in the case of cultural-historical activity theory (Leont’ev, 1979; Vygotsky, 1978): “Leont’ev (1979: 52) pointed out that the concept of object is already implicitly contained in the very concept of activity; there is no such thing as objectless activity. An object is both something given and something projected, anticipated and constructed” (Engeström, Puonti, & Seppänen, 2003, p. 152) However, in order to preserve the looseness implied in a “going concern,” it has to be stressed that what a “Thing” is about can be (and often starts out as) a very vague notion or inclination. When, for instance, a designer starts a new project, she may have some ideas sketched out, some inspirational clippings, or a short brief describing the client’s wishes. As different ideas are drawn up, tested, and revised, the design develops in relation to what Arnheim (1993) calls a “guiding image.” Curiously, this image is not known precisely from the outset, yet it is still what is aimed at. It is potentially present in every sketch and image produced, and even though it is unknown, it is recognizable once the designer is satisfied that *this* was what she was looking for. Arnheim invokes the mathematical discipline of topology to clarify this. He explains: “As long as the guiding image is still developing it remains tentative, generic, vague. This vagueness, however, is by no means a negative quality. Rather it has the positive quality of a topological shape” (p. 16). A topological shape is, somewhat simplified, a range of shapes that are considered the same if each can be transformed into the other by molding the shape without rupturing it. Famously, a donut and a coffee cup have the same topological shape because one can be turned into the other through a series of deformations. The metaphor is that “[A] topological shape stands for a whole range of possibilities without being tangibly committed to any one of them. Being undefined in its specifics, it admits distortions and deviations. Its pregnancy is what the designer requires in the search for a final shape” (p. 17). In other words, in the early days of a project, sketches and ideas are vague, not because of confusion or indecision but because there are still so many possible versions in contention of becoming the chosen solution. As the design progresses, more and more choices are made, deciding on the features of the design. Other possibilities are also eliminated by those decisions (reducing the overall set of possibilities available). Constraints thus cut away certain possibilities while enabling others.[157]

In this account, “Things” can be vague and yet have direction. Because of this direction, whatever “enters the picture” can be construed as a potential constraint. The kind of constraint it becomes is not determined by an end goal since this goal is only approximately and cursorily known. Keller and Keller (1993), in describing how a smith thinks and acts with iron, speak of forming an “umbrella plan” (p. 135). Their idea dovetails with

[157] DeLanda (2002) provides a much more sophisticated version of the same idea wherein cascades of symmetry-breaking phase-transitions produce differentiated geometric spaces.

Arnheim's (1993) notion of a designer who begins with "a center, an axis, a direction," from which the design takes on increasing level of detail and sophistication as it unfolds (Liedtka, 2004). The designer follows a "structural skeleton," that is, a "property that makes the pattern distinct, organized, identifiable" (Arnheim, 1993, p. 18). In other words, there is an idea that guides the development, but one that is only known and identified as the design progresses and unfolds, not one that is known beforehand. We thus have the intention of something, only not something clear and specific.[158] There is an intentional arc extended, to borrow a term from Merleau-Ponty (1962, p. 136), under which actions and events take place. However, this is not intentionality driven or qualified by its goal because there is no clear goal. Rather, anything that appears and is introduced during the process reveals itself in terms of constraints relative to this uncertain but progressively clearer end goal.

To reiterate, the materials or technologies working as constraints are not causes or conditions of the events taking place. Other materials and technologies can be used to the same or similar effect (as is clear in the case of poles for vaulting). The materials are not inherent constraints of this or that. The same material (e.g., fiberglass) can, in a different context, be put to a different use and constrain different events (e.g., for Kevlar suits or canoes). Different sets of constraints may reach comparable results (e.g., mining with pick axes as opposed to longwall mining; see Reveley & McLean, 2004). In all cases, what is "taking place" is not determined by the material but by the "Thing" that is taking place. The material constrains (verb) what is taking place (and as such, decides what is taking place).

Material constraints & affordances

In the above example, taking the role of designers, we (humans) control all constraints of relevance. In reality, the vast majority of constraints playing a role in any given situation are either predetermined, determined by (or in collaboration with) others, constantly shifting, or simply out of human hands. The task at hand becomes dynamic in those real-life situations. We are kept on target by our intentional arc, but every bump in the road and every contingency calls for readjustment. We maintain a kind of entelechy, that is, Aristotle's concept for the work done in order for a thing to be what it is or stay the same (its "being-at-work-staying-the-same"; Sachs, 1995). Reparations and work-arounds (Alter, 2014) keep a car running or a process online despite obstacles or inexpedient technology. Most of all, we are resourceful and imaginative creatures who will bend, break, and transform constraints in pursuit of a goal. A trivial example are the many ways we reach our destinations. In the face of obstacles, we will build bridges, tunnels, and roads, climb fences, and find an alternative route around traffic jams. In this dynamic shifting world, we find ourselves situated (Suchman, 2007) in an environment where things, materials, and other people's expectations present themselves as "already-made." Here, rather than designing constraints, we gauge how suitable our surroundings are for a given purpose. We do so without the designer's

[158] It could be argued that what allows actions to have direction without being specified is a generalized ambition and a prototypical approach that rely on the sedimentation of conventions and expectations for what a designer delivers and the chain of production of which the design is part. This seems reasonable. The argument here is not that we cannot identify aspects of a telos but that the explanation is not teleological. Constraints are not functions or realizations of a given purpose.

awareness that constraints can be different, but directly with an eye to the next step that brings us closer to our goal. If we return to the fruit picking example, introducing the stone was clearly an attempt to reach the fruit. The stone is "step-up-able," or it *affords* stepping up upon, to use Gibson's (1986) famous concept. Gibson introduced his concept relative to perception in an attempt to show that we see things and what they are to us *directly* (not via a process of physical stimuli that are then interpreted in the brain, i.e., indirectly).[159] As such, many of his examples revolve around navigating a physical environment. The point of bringing Gibson's affordances into the equation is that constraints do not present themselves as constraints – they constrain (verb). Like a stone exhibits the affordance of step-up-able *directly* as we try to reach the fruit, a constraint (such as the pole for vaulting) *directly* impacts whether a stream seems passable. The stream affords passing and also acts as a constraint (limit) on the act of passing. However, as mentioned, affordances are mostly brought up in relation to directly visual or perceptual scenarios – what is thought of here has a broader scope. If we intend to cross the Gobi desert, we are constrained by our bodily needs, our physical shape, the climate, the topology, our available resources, etc. We bring provisions, shelter, maps, communication devices, and so on. Each of these acts as a constraint that impacts our assessment of whether the desert is passable. In this array, most of the constraints seem given until we consider a constraint such as "we have to pass the Gobi desert on foot" versus one that says "pass the desert in a Jeep" or "pass over the desert in a plane." Clearly, many of the constraints shift considerably in terms of their significance and even their relevance, depending on the scenario. The Gobi desert affords passing, given appropriate constraints, but changing what is meant by "passing" shifts the constraints at work. One can instantly shift the material constraints at work in a room by hanging a $100 bill from the ceiling and declaring "whomever can reach it can keep it."

There are no simple answers to what a material "is" in a constraints-based approach. Materials can be ideally suited for specific purposes or indispensable *sine qua non* conditions of things taking place. Even where materials seem utterly immaterial, situations are constrained in specific ways. The corrugated metal, sheets of plastic, cardboard boxes, and plywood used for shanty towns strike the appropriate balance between being manipulable, sturdy, and available for make-shift shelters. The bricoleur (Levi-Strauss, 1966) or scrounger is perhaps the clearest example of a working understanding of constraints across available means. Matter therefore matters, but not in a sense where we should set out to uncover the properties or qualities of the material to determine their impact on a given situation. Matter matters because, like other constraints, it has an impact on what is possible and impossible. In the words of the authors of *How Matter Matters* (Carlile, Nicolini, Langley, & Tsoukas, 2013, p. 3): "In the end, matter matters not only as an intellectual effort, but also in an ontological and practical sense, i.e., it generates consequences for how we experience and act in our world."

[159] There are multiple interpretations of what affordances are (Bærentsen & Trettvik, 2002; Jenkins, 2008; McGrenere & Ho, 2000) and many different interpretations of how they arise (Chemero, 2003; Stoffregen, 2000; Turvey, 1992). Most notably in HCI is Norman's (1988) reinterpretation of affordances as an object's action capabilities and his differentiation between perceived affordances and false affordances. Curiously, Norman considers affordances a property of an object in direct contradiction with Gibson (1986, p. 129).

Constraints on ideas – Exploring the statespace

It is this type of thinking about constraints that is brought to bear. Media and technology, seen as constraints, limit and enable what and how possibilities are actualized. The material is part of the constraints; as Leonardi, Nardi, and Kallinikos (2012, p. 10) assert: "Rather than being simply constrained [limited] by structure, as the typical conventional interpretive understanding wants us to believe, human choice and agency are made originally possible through the very resources that objects and structures dispose." As such, media are not simply the work mule of communication, that is, the neutral medium that moves information – in the process, adding and subtracting nothing to the content but, at most, distorting the message. By extension, the computer is not simply a collection of hardware that produces 0s and 1s to be used for whatever content we choose. Rather, computers are like the medium of speech and writing responsible for "what information can be perceived, what processes can be activated, and what structures can be discovered from the specific representation" (Zhang, 1997, p. 179). In other words, computers constrain like other media. What do they constrain? Not the situation, per se, but media constrain what "Thing" we are engaged in by way of how a situation is delineated in processes of thought, imagination, talk, or writing. Each of these may be directed at the same content, but they delineate the same situation by different means. It is in this way that media constrain what situations can unfold. A few examples will serve as illustration.

Zhang's view quoted above, which he dubs "representational determinism," aligns with that contended here, save for the use of the word "determine" rather than "constrain." He offers the development of writing and of the Arabic numeration system as examples of how a medium constrains cognition. In the case of writing, thought becomes visible and manipulable. Text, for instance, has the practical consequence of making meaning transportable. Sentences are immutable mobiles (Latour, 1986); they can be moved without changing content. More importantly however, text affords talking and thinking about thinking. As thought patterns are embedded in physical structure (text), our cognitive apparatus is relieved of the task of sustaining that particular thought. We can, with text, examine other thoughts and even the structure of language (sentences, words, syntax, phonemes, etc.) without having to maintain the particular structure in question. The crux of the matter is not the invention of the semiotic mark but our confidence in and ability to encode and decode meaningful patterns in the medium. This confidence is the reason Ong (2002) considers the invention of a turning point for a new type of human consciousness:

> The critical and unique breakthrough into new worlds of knowledge was achieved within human consciousness not when simple semiotic marking was devised but when a coded system of visible marks was invented whereby a writer could determine the exact words that the reader would generate from the text. (p. 83)

In other words, we accept what is written as equivalent to what is (or would have been) said. In the case of Arabic numbers, the mathematical historian Arthur Mazer provides the example of the powerful shift between a mathematical problem presented as a "word problem" and its algorithmic equivalent:

> What is the square which when taken with ten of its roots will give a sum total of thirty nine? Now the roots in the problem before us are ten. Therefore take five, which multiplied by itself gives twenty five, an amount you add to thirty nine to give sixty four. Having taken the square root of this which is eight, subtract from this half the roots, five leaving three. The number three represents one root of this square, which itself, of course is nine. Nine therefore gives the square.
>
> Today we would simply write the problem and solution as algebraic expressions:
>
> $x^2 + 10x = 39$" (Mazer, 2010, p. 97)

Similar to writing, mathematical notation (equations) makes something, which is embedded in the stream of words, not only visible but also subject to our control. We are relieved of holding the problem in our head and hand over part of the responsibility for solving the equation to the notation itself. As in the case of writing, we are confident that the words, problem, and equation are equivalents. However, confidence is not based simply on trust. What is enabled and limited by the medium in both cases is systemic. There is a code for how a phenomenon is encoded (written) and decoded (read). This code depends on the medium in terms of constraints regarding its realization. Writing requires a legible, often flat, and inscribable surface. A tool for inscription is also required. The result is a *static* display of marks or symbols. This is what is meant by considering media as constraints (in both an enabling and limiting sense). We may describe anything and everything as long as we do it with those means. To set up a contrast, we can for instance point to the possibility of capturing dynamic phenomena in a way that directly shows movement, which was not possible until the invention of the camera. It is not that dynamic phenomena cannot be described. It is simply that when they are described, this is done using static means (e.g., the word "moving" denotes something dynamic, but it does not move). Thus, there are systemic choices made in media constraints. The choices are in *format* rather than content, similar to choices made in, say, photography: we choose the speed, the contrast, and white balance when we take a photo and the color saturation, cropping, and focus when a film is developed. These choices constrain what images we craft, but they in no way affect *where* we choose to point the camera or *what* we do in front of it. A photograph allows us to capture the world on very particular terms, and as with other types of constraints, in those choices also lies the abandonment of other possible ways of capturing the world or aspects of it (e.g., there are no sounds, smells, tactile sensations, or temperature in a photograph).

The particular effects of a medium therefore lie in its codification (choice of format). Unlike the codes of spies and wartime movies, what is important about code lies not in the messages they conceal but in the choices made in codification (i.e., format) and the consequences for what is possible to capture and what we are capable of doing with what we have captured. For example, an algorithm is not simply there for us to peruse, decipher symbolically, or read out loud. The notation allows us to calculate and assign meaning to different spatial positions. It matters *where* you write mathematical symbols. There is a difference between an expression being on one side of the equal sign or the other. There are rules on how expressions can be moved and what happens when one does so. A simpler

example is the potency of the Arabic numeration system relative to Greek or Roman numerals. In the Arabic system, the position of a number assigns a systematic meaning or value to the number, e.g., “29” is different from “92.” This so-called “positional notation” or “place value system” is absent from Roman numerals, e.g., the Xs in the first position in either of the numbers “XXIX” and “XCII” do not have the same meaning (value) and one cannot, for instance, make a subtraction based on their position.

92	XCII
- 29	-XXIX
=63	XCIX(?)

Figure 26 (1 in article). Example of subtraction based on positional notation in Greek and Roman numerals

In other words, as one writes Arabic numbers, one is already in the process of calculating and can, *qua* the encoding, rely on a consistent system for doing so. Evident from this is that constraints should, in this account, not be thought of as limiting the content of our thought; they both enable and limit *what we can do* with our thoughts. Lego bricks can be seen as a metaphor for media constraints. You can build almost anything with Lego bricks as long as you accept the brick as the basic format: whatever you build will be “blocky,” of certain colors and materials, and the strength of your construction will rely on the patented system for coupling bricks. The system’s *forte* is that if you accept the format, you are assured that any piece you grab is compatible with all other existing pieces – just as when you use meaningful words and proper syntax, you are assured that you utter a well-formed sentence (although not necessarily a meaningful or appropriate one).

The effects of a medium thus lie in its codification. The proposition is that when you change medium, you change code (format). The Zhang (1997) article quoted above investigates precisely how different forms of representation impact how effectively one is able to solve a problem. In an experimental setup, students were introduced to the well-known game tic-tac-toe wherein players take turns in placing Os and Xs in a three-by-three grid. Part of the experimental setup examined the representational effect, that is, “the phenomenon that different isomorphic representations of a common formal structure can cause dramatically different cognitive behaviors” (Zhang & Norman, 1994, p. 88). The mathematical example above is illustrative. Although the formal mathematical properties of the problem are the same, the two different ways of presenting the problem have a dramatic effect on how difficult the problem is perceived to be and how it is solved. Zhang uses the concept of a “problemspace” to illustrate this point. A problem space is a representation of all possible states of a problem (or a system). One can think of a problem space as nodes in a network. A problem will always be in one (and only one) possible state (occupy one node). Each node (state) is connected by an operator (a line) that specifies a change of state (a move in the game). Therefore, when a move is made in tic-tac-toe, the problem space changes position from one node to another along the line of the operator. A problem space is an abstract structure “usually only conceivable to theorists because task performers usually only deal with the specific representational and implementational contents in which the abstract structures are only implicitly embedded” (Zhang, 1997, p. 184). In plain terms, this

means that those who play the game see different embodiments of the game (for instance, a grid with Xs and Os, numbers, or geometric figures), not a problem space. Systemically, the different embodiments are identical, that is, they are isomorphic representations of the same system, but separately, each representation gives rise to different behavior. Zhang shows that depending on which representation students are presented with, different patterns of operations are activated and different strategies are discovered. As in the case of the math problem, it matters whether you are given a word problem or an equation to solve. One goes about solving the problem and one discovers different ways of solving the problem depending on the form of representation. The crux of the article is to show that without a particular way into a problem (a particular form of representation), some ways of solving the problem may never be accessed.

> Without the change of representational forms, some portion of the task space may never be explored and some structures of the task may never be discovered, due to various constraints such as the complexity of the environment and the limitations of the mind. (Zhang, 1997, p. 213)

Such problems are well known in theories concerning problem solving. If, for instance, you adopt a strategy for finding the highest point in an area that specifies that you should "always walk to higher ground," you may end up climbing a hill that, in that particular area, is the highest but, in a global perspective, turns out to be a small bump compared to the mountain next to it. The mountain never enters the picture (that area of the problem space is never explored) because you are convinced that your current strategy is optimal. Changing the representational form allows one to see the problem in a new light and explore a different part of the problem space. "Cognitive behavior is much like constraint satisfaction, with many local minima, some of which may never be overcome without a change in representational forms" (Zhang, 1997, p. 213).

This strikes the overall theme of the article that our present thought patterns are as they are, contingent upon media whose problem spaces are constrained by human vocal chords and the hand-eye coordination of inscribing marks on uniform surfaces. If we allow for the basic idea that a material (sound waves, vocal chords, paper, pen, vision, hearing, etc.) constrains a medium in ways that allow for different *types* of making meaningful events take place,[160] then constraints in the form of spoken and written words make certain patterns of thought more readily available than others. The expressive qualities of both media are boundless, but as in the case of Legos, they deliver meaning in a specific format (words stringed into sentences). As in the case of the math problems, it is possible that the representational form makes some parts of a problem space and some strategies for making sense of things more obvious than others. As Victor (2013) points out, quoting the mathematician Richard Hamming, "Perhaps there are thoughts we cannot think?...Evolution, so far, may possibly have blocked us from being able to think in some directions; there could be unthinkable thoughts" (Hamming, 1980, p. 89). If we follow this line of thought, what "Things" are

[160] Most of the examples discussed pertain to writing. A non-trivial example of the features of spoken language that enable memorization and improvisation is the use of rhyming and metrical patterns that allowed Homeric and medieval epics to be learned, sung, and developed through purely oral-formulaic traditions (Lord, 1960).

made possible should be viewed as a contingent matter. Some thoughts and ideas (or ways of thinking) may not currently be accessible to us to think because our thoughts, as we know them, are primarily constrained by the requirements of speech and writing. We think in words. Our thoughts are primarily tuned into being or becoming expressed as words, rather than, say, images or movement. In this line of thinking, we should think of writing and speaking as media that are perhaps local optima that, at any time, could potentially be replaced by the discovery of different plateaus of achievement, that is, new media that allow us to discover new parts of problem spaces.

Where therefore should we turn to discover new potentials? Is there not a built-in contradiction in trying to express such new potentials in this medium (writing)? The short answer to the last question is "Yes." The longer answer depends on the answer to the first question. For a start, we can attempt to unfold what kind of materiality a computer is. However, as our investigation has already established, there is nothing to be found in material properties to determine how they constrain a Thing. Instead, we turn to real world examples of successful encodings of matter, that is, analog computers, devices, and models. The task is to examine the examples for properties that will allow us to point in a fruitful direction in the development of the computer as a new medium. The daunting criteria for such an ambition is to match the existing media in terms of expressiveness. In at least one respect, it has to surpass the capabilities of existing media.

Digital materiality

From the above, it should be apparent that the constraints approach is anti-deterministic. However, it does not rely on a hylomorphism (Ingold, 2012) that separates form and matter and sees matter as the passive recipient of form imposed upon it. Once a medium or material is mobilized in a given setting, the constraints that are realized very much depend on the material in question. Again, these cannot be inferred from an analysis of the material "as such." This would amount to a form of material determinism. Just as in the case of technology, there is no decontextualized matter.[161] The characteristics of the matter as constraints are exposed in relation to unfolding events; but exactly what kind of material/medium is a computer? In the infancy of computers, Licklider and Taylor (1968, p. 22) envisioned the computer as "a plastic or moldable medium that can be modeled, a dynamic medium in which premises will flow into consequences, and above all a common medium that can be contributed to and experimented with by all." Interestingly, Löwgren and Stolterman (2004) claim that "[d]esigners of digital artifacts face a particular difficulty. The material they use, that is, the digital technology – can in many ways be described as a *material without qualities*" (p. 3, emphasis in original). What they seem to have in mind is that (like language) it is possible to "create almost anything" with a computer. However, if that is the case, they appear to confuse the generative aspects of language with its material aspects. The rules of grammar allow an infinite number of sentences to be made and thus an infinite amount of phenomena to be described. Löwgren and Stolterman (2004, p. 4) cite

[161] There are also no set contexts. It is tempting to translate "Thing" as a certain context and to allow constraints to be determined by such a context, but this would simply push the burden of proof onto the context. "Things" – here described as assemblies – are more like boundary contexts (Johansson, Lundh, & Snis, 2011. Star, 1990).

“novels, manuals, instructions, prayers, fantasy worlds, poems and constitutions” as examples. However, there is considerable lack of clarity in what is meant if we claim that these examples of different literary productions validate the assertion that language can “create almost anything.” It is of course not to be taken literally. The phenomena described are not physically recreated. A likely reading, from a constraints perspective, is that none of the phenomena described *constrain* the medium as such. Once we have stated that a phenomenon exists (i.e., given a description of something), we are bound by logical rules and expectations formed by experience to keep the description within boundaries. As Bateson (1972, p. 178) puts it: “the word ‘cat’ has no fur and cannot scratch.” We may be constrained to look for a cat, but the word itself puts no constraints on the medium or the situation. Like an “etch a sketch” toy, for every new description, we can simply shake the toy and start over from a blank page. Kay and Goldberg (1977) enter the same territory as Löwgren and Stolterman when they state that “the ability to simulate the details of any descriptive model means that the computer viewed as a medium itself, can be *all other media*” (p. 31, emphasis in original). Both quotes speak to the same point that *within the parameters* of the medium, there are no limits to its descriptive or simulative power. However, the quotes also seem to be getting at something that does not pertain to expressiveness. After all, if the computer did not provide new opportunities, one could object that the same argument about expressiveness applies to speech and writing.

In a different line of thought, it might not be all that attractive to have a medium that “has no qualities.” As stated earlier, the material matters. Part of the insight gained from seeing cognition as embodied, embedded, extended, and distributed is that it is possible to see that our thought processes are not simply about the world, but inextricably conditioned by it.

> [W]ork materials are more than mere stimuli for a disembodied cognitive system. Work materials from time to time become elements of the cognitive system itself. Just as a blind person’s cane or a cell biologist’s microscope is a central part of the way they perceive the world, so well-designed work materials become integrated into the way people think, see, and control activities, part of the distributed system of cognitive control. (Hollan, Hutchins, & Kirsch, 2000, p. 178)

It matters how we choose to constrain our cognitive processes – not in the sense that we have to choose wisely so that we can express what we want to say effortlessly – but in the sense that how we choose establishes a creative potential of thoughts we have not thought and perhaps are not yet able. Designing digital materiality is thus about designing constraints.

What is special about the computer lies not in its generative expressive potential but in its ability to emulate all other *constraints* (not phenomena). This is most easily seen for material constraints. Physics engines recreate the behavior of all kinds of material. Scenarios of all sorts are made for games. There is a plethora of social rules, media formats, taxonomic categories, measuring units, standards and all sorts of triggers, rewards, incentives, and limits that are attempted replicated in interfaces, although in a much more

intuitive way. These are harder to see, but software for doing your taxes, social media, inventory systems, etc., all have built-in rules and standards into their architecture. The computer's ability to emulate all other constraints means that our capacity to explore and navigate any given problem space is virtually boundless, but only in the same way our imagination is boundless – it usually still relies on well-known formats and templates. The potential could prompt us to delve into the countless possible uses. If we extend the possibilities of the computer into the near future, there are those who expect humans to be able to emulate almost any environment in virtual reality, a vision that prompted Janet Murray (1997) to take the Holodeck – a fictional virtual reality facility – from the TV series *Star Trek* as a model for future uses of the computer as a new medium. However, seen from a constraints perspective, focusing on uses or results would be getting a hold on the wrong end of the stick. Examining a medium's expressive capabilities through its expressions disregards considerations of which constraints are in place for those expressions. It would be like putting "research into the TV interface" on your resume for all the TV you have watched in your life – technically not incorrect, but a misrepresentation at best. For something to be knowledge, we have to couple *what* we need to have access to with insights on *how* to make that happen. The computer appears to have no set representational form but instead offers the possibility of endlessly modulating our representational constraints. The computer promises to give us renewed access to hidden corners of a given problem space.

Analog computers

Consider an example of particular restraints that have an impact on a problem space, which are not representational in a classic sense, but viewed as constraints, can be seen to create the equivalent of a representational form. I am thinking of a slide rule – a type of analog computer. Irwin (2009) distinguishes between two different branches in the computer family. One branch descends from the abacus whereby fingers (digits) are used for computation, i.e., digital computers. The other branch descends from:

> the graphic solution of problems achieved by ancient surveyors. Analogies were assumed between the boundaries of a property and lines drawn on paper by the surveyor. The term 'analogue' is derived from Greek 'analogikos' meaning by proportion...When an analogue device can be 'programmed' in some way to perform different functions at different times, it can be called an analogue computer. (para. 6)

A map is obviously an analogy in the described sense, but it is also closely connected to traditional ideas of representation versus reality. Conversely, slide rule is for many non-mathematicians a slightly incomprehensible tool. In its most basic form, it allows rapid operations that are difficult and time consuming to perform on paper, such as multiplication and division of numbers. More advanced slide rules allow calculations of square roots, exponentials, logarithms, and trigonometric functions.[162] The main thing to understand about slide rules and any other analog computer is that they build "computational

[162] See https://en.wikipedia.org/wiki/Slide_rule

constraints of the task into the physical structure of the artifact" (Hutchins, 1995, p. 96). In the case of the slide rule, the constraints are built in using scales. Different logarithmic scales stand in calculable relationships with each other. Usually, a slide rule consists of two fixed outer strips interlocking with a movable central strip. Reading the slide rule consists in aligning a mark on a fixed strip with one on the sliding strip and then observing the relative position of other marks on the strips. The slide rule works because of the fixed scales and the invariant conversions that can take place between the scales. Instead of calculating, one simply moves a strip and reads off results. "In an analogue computer the process of calculation is *replaced* by the measurements and manipulation of some continuous physical quantity such as mechanical displacement or voltage, hence such devices are also called continuous computers" (Irwin, 2009, para. 7, my emphasis). The crux of the matter is that the results can then be used *analogously* in the real world. The relationships in the world stand in the same relationships as the ones on the scale. The relationship between the device and the world is not one of representation but one of analogy. Manipulating the slide rule gives us results that can be used in the real world. There are three important elements to this replacement. Our thought process is partly *embedded* in and *scaffolded* by the material, and there is a *performative* element to the process.

The idea that cognition is embedded has gained a significant foothold in cognitive science (Chemero, 2009; Clark, 1997 Hutchins, 1995; Noë, 2004). The contention is that the world is not just the passive recipient of our ideas but an active part of, together with our brain and body in how our cognition and behavior are organized. Hutchins (1995) famously gives the example of a process of coordination and solving a problem on a hangar ship, which is distributed over many minds, instruments, and objects. In the case of analog computers, the idea is the same, only turned on its head. "The constraints of the represented world are...built into the physical structures of the device" (p. 98). Hutchins gives the example of the Astrolabe: "a manipulable model of the heavens – a simulator of the effects of time and latitude on the relationships of the heavens to the horizon" (p. 98). The Astrolabe emulates a phenomenon and has several functions such as calculation of the position of celestial objects and local time and latitude. Again, because of the invariant conversions that can take place, one can dispense with calculations and simply move parts of the instrument and read the results. These results can then be used in the real world. The tool converts a real world problem into a manipulable mechanical device that relies on physical constraints for its efficacy and accuracy. In a sense, it is using the qualities of one part of the world (constraints) to reveal something about a different part of the world.

> [Tools and props] function so as to either carry out or to facilitate computational operations important to various human projects. The slide rule *transforms* complex mathematical problems (ones that would baffle or tax the unaided subject) into simple tasks of perceptual recognition. The map provides geographical information in a format well-suited to aid complex planning and strategic military operations. The compass gathers and displays a kind of information that (most) unaided human subjects do not seem to command. (Clark, 2011, p. 21, my emphasis)

As per the quote, it is not simply a transfer of a calculation task; it is also a transformation. Latour (1986) speaks of a superimposition in the case of writing: "It is because all these inscriptions can be superimposed, reshuffled, recombined, and summarized, and that totally new phenomena emerge, hidden from the other people from whom all these inscriptions have been exacted" (p. 29). In the same way, devices allow the manipulation of phenomena or information that would not otherwise be separable from the situation. One could say that the movement of celestial objects are superimposed on the Astrolabe or that mathematical problems in the world are superimposed on the slide rule. As in the cases of writing and mathematical notation, "thinking is made visible," as Victor (2013) expresses it. At the same time, we are relieved of thinking of stars and positions (like the word version of a mathematical problem) and can think *about* the stars and their related positions. Bateson (1972, p. 407) calls this way of mapping a problem a "rigorous metaphor." The crucial part is that the relations in question remain constant under transformation (the "invariant conversions" mentioned above). November, Camacho-Hübner, and Latour (2010) give the example of a navigator working with a map on a ship. "For the navigator, the map is indeed like a 2D slide-rule that incorporates in a *precalculated* format huge masses of information about angles and distances and on which is overlaid in various fonts other types of information" (p. 585, emphasis in original). The authors' point is that the map is not simply mimetic, that is, seeking to create a correspondence between the map and a territory; it is the continuous effort to relate what is on the map with relevant cues in the process of navigation that is important. The process of navigation is transformed by the use of a map.

A large element in the utility of such devices is that problem-solving is off-loaded into the environment. The world *scaffolds* the task at hand, to use a Vygotskian (1986) term. An example of scaffolding such as training wheels on a bike comes to mind. In the above examples, it is the task of calculation that is scaffolded, only that the scaffolding also changes the task. No calculation, *per se*, is being done.

> We may call an action 'scaffolded' to the extent that it relies on some kind of external support. Such support could come from the use of tools, or the knowledge and skills of others; that is to say, scaffolding (as I shall use the term) denotes a broad class of physical, cognitive and social augmentations – augmentations which allow us to achieve some goal which would otherwise be beyond us. (Clark, 2011, p. 22)

The task of calculation is handed over to the invariant properties of the material. The devices exhibit a case of what Clark (1989) calls the "007 principle":

> In general, evolved creatures will neither store nor process information in costly ways when they can use the structure of the environment and their operations upon it as a convenient stand-in for the information-processing operations concerned. That is, know only as much as you need to know to get the job done." (p. 64)

Along these lines of reasoning, we can think of devices as overall *analogous* wherein representational devices are seen as a special case. Baird (2004) distinguishes between material models, devices, and measuring instruments:

> *Material models* are a material form of representational knowledge. *Devices* that produce phenomena are instances of working knowledge, a kind of pragmatic knowledge that is constituted by effective action, but effective action with a twist, for the locus of the action is the device itself, not a human being. *Measuring instruments* present a third kind of material epistemology. They encapsulate in their material form not only both model knowledge and working knowledge but also, in many cases, theoretical knowledge and functional substitutes for human skill. (p. 116, my emphasis)

What Baird refers to as model or representational knowledge is, for instance, the process of calculation that we engage in in order to say something about the world (we use the slide rule to say something about something to which the result is analogous). The working knowledge is the device's handling of the calculation process that replaces actual calculation. By manipulating the slide rule, we know how to work the device, but we also know how to do the calculation. This dual aspect of working a device cues in related efforts to understand cognition, and analog computers, as performative (Stewart, Gapenne, & Di Paolo, 2010; Varela, Thompson, & Rosch, 1991). Cognition is not the passive reception of information about the environment but an active participation and generation of meaning wherein the world is enacted. In this way of seeing cognition, what is being done (the working knowledge) is not communicative in a classical sense, nor can it simply be broken down as an interaction with a device. Although we do not engage in calculation, we still have to know that the process of calculation has been replaced by the measurements and manipulations of the device. As such, we cannot apply theories of communication or think of them as interactions with a representation (what Hutchins, Hollan, & Norman, 1985, p. 317, refer to as the conversation metaphor and model-world metaphor; see also Vallgårda & Sokoler, 2010). Instead, we have a literal form of "thinking with your hands." I employ the term "visuo-tactile" in order to denote the coming together of visual and tactile thinking. A visuo-tactile interface allows the manipulation of visual phenomena in a way that constrains a statespace, that is, in a way that creates information and knowledge.

The embedded, scaffolded, and performative take on our thought process in relation to analog thinking means that we have to abandon the idea that "[e]very computer...is a physical structure that manipulates physical entities" (Vallgårda & Sokoler, 2010, p. 3). We cannot infer the computer's properties and use by looking at the computer when it is turned off (i.e., attempt to glean a system from its material properties). Whenever we do so, we are forced to conclude that the "[c]omputer's properties and behaviors will always be indirect" (p. 2), that is, we would inevitably conclude that the computer will always be a medium whose only function is to represent its object (i.e., information). In contrast, the pay-off of using an analog computer is precisely that we see the problem we want to see *directly*, and we can handle the problem *without* rerouting through conscious thought. The breakthrough

we are seeking is an analog computer interface that will allow us to in fact harness 3D environments. The computer equipped with an analog interface would be able to handle the superimposition of all kinds of (real world) problems by emulating any set of invariant properties of existing materials. Crucially, however, it will also be able to transform *between* these invariants. A small-scale imagined example would be a slide rule that allowed for physically changing its scale to fit the calculation of square roots, exponentials, logarithms, and trigonometric functions.

It is crucial to understand that the analog interface is not a visualization of information. It is the means for tactile control coupled with visual constraints. In Bateson's (1972) terms, it is a mapping. Bateson gives the example of an algebraic proposition that can be mapped onto a system of geometric coordinates, and there, proven by geometric methods (p. 407). In this case, we map cognitive problems and solve them by manipulating visual structures. Just as the calculation on a slide rule is a transformation of a problem into the manipulations under the constraints given by the metal and scale, the analog computer interface will transform any problem into the constraints it emulates. How is this different from the physical world? It is not only much faster, more versatile, and flexible, the interface also effectively replaces atoms for photons, as it were. As a consequence, the computer is capable of creating impossible objects (with impossible constraints, e.g., the ones produced by the artist M. C. Escher). For instance, an infinite number of objects may occupy the same space regardless of their "size"; any object may be divided into an infinite number of subdivisions or types of subdivision without contradiction. We can design the constraints however we want to and dynamically change one constraint into another. The visuo-tactile phenomena produced by the computer have the possibility of changing into anything.

The idea of the computer as an analog fits a longstanding vision and ambition to *reach out directly and touch information* as it was first elaborated in the seminal article, Direct Manipulation Interfaces (Hutchins et al., 1985). What has been done in the case of the slide rule? Handling the model becomes solving the problem. The slide rule has created problem-solving behavior that required fewer resources than before. As in the case of the transition from speaking into writing and mathematical notation, representation and control (or calculation) are rolled into a single system (Ullmer & Ishii, 2001; Zhang, 1997, p. 214). Hutchins et al. (1985) sought to close the gap between handling the model and solving the problem. They tried to make as short a distance as possible between the *what* and the *how*. Unfortunately, they coined their attempt in terminology that created an impasse between the thoughts and physical actions of the user as well as between the user and the system:

> A short distance means that the translation is simple and straightforward, that thoughts are readily translated into the physical actions required by the system and that the system output is in a form readily interpreted in terms of the goals of interest to the user. (p. 317)

No matter how fitting a metaphor is devised, the "what" and the "how" remain separate and never the twain shall meet. To make the "what" and the "how" coincide, an analog

computer has to be devised. This means giving up the idea that a computer is an input-output device. An analog computer does not make a distinction between input and output. Everything is a change of state. Ullmer and Ishii (2001) give the example of an abacus: "[T]he abacus beads, rods, and frame serve as manipulable physical representations of numerical values and operations. Simultaneously, these component artifacts also serve as physical controls for directly manipulating their underlying associations" (p. 579).[163]

What Hutchins et al. (1985) overlooked is that information either does not look like anything or it looks like everything. "The goal is to permit the user to act as if the representation is the thing itself" (p. 320). When we device an Astrolabe, we are not interested in making the user think that he is literally moving the heavens. That would mimic the folly in Borges (1975) oft-quoted story of the map makers who made a map of the kingdom on a 1:1 scale. What we are interested in is making the problem of observing, calculating, and predicting tangible. The Astrolabe could be made of cheese and shoestring as long as it served its purpose. We are interested in devising and controlling constraints that provide a shortcut for our cognitive workload. Hutchins et al. (1985) agree with this as their intuition of the direct manipulation approach is that "[a]t the root of our approach is the assumption that the feeling of directness results from the commitment of fewer cognitive resources" (p. 317). The well-known desktop metaphor is made under the assumption that emulating the physical devices of inscribing meaning (e.g., writing emulated in this word-processing software I am using) constitutes an interface for the computer. My contention would be that the desktop metaphor utilizes the computer interface to emulate the circumstances of writing. The digital version does have improvements over the bureaucratic desktop equipped with a typewriter, folder cabinets, and secretaries, but the most important part, the process of encoding information, remains the same. To realize the potential of the computer as a new medium, we have to design ways of devising and controlling constraints, as in analog computers, that *coincide* with how we manipulate and *change* between different (sets of) constraints. In the real world, this would be equivalent to the (magic) ability to change a material (and other constraints) into any other material at will.

Redundancy

How therefore do we go about designing this new interface? The example of analog computers points the way toward controlling constraints and thereby encoding information in manipulable structures. Couched in the language of problem spaces, this means specifying a language in terms of how a state of a system is established (nodes), as well as its operation (line between nodes). It also means specifications of how the system changes state. In the example of the slide rule, the different states of a system are not the different positions of the strips; they are the states of knowing or not knowing the result of a calculation. The operation is "moving the strip" while reading the results. There are of course many possible calculations that can be made. The distinction between state and operation is brought up to draw attention to an idea proposed by Bateson (1972) and

[163] Curiously, as mentioned above, Irwin (2009) points to the abacus as the "forefather" of the digital computer since it is manipulated with fingers (digits). In this sense, the scope of an analog computer engulfs that of a digital one.

cybernetic theory, that information consists not in building a particular pattern (like a sentence) from a series of elements (words); rather, information consists in the way a system, which can attain multiple states, provides information by reducing alternatives. Bateson uses words such as restraint, pattern, redundancy, information, and meaning synonymously:

> Any aggregate of events or objects (e.g., a sequence of phonemes, a painting, a frog, or a culture) shall be said to contain 'redundancy' or 'pattern' if the aggregate can be divided in any way by a 'slash mark,' such that an observer perceiving only what is on one side of the slash mark can guess, with better than random success what is on the other side of the slash mark. We may say that what is on one side of the slash contains information or has meaning about what is on the other side. Or, in engineer's language, the aggregate contains 'redundancy.' (Bateson, 1972, p. 130)

If we say that a slide rule or an Astrolabe is on one side of the slash mark, the phenomenon in question is on the other side. In Bateson's terminology, the slide rule *maps* the problem or the Astrolabe *maps* the phenomenon. Just as in the case of tic-tac-toe, the system (problem or phenomenon) has a problem space, that is, a number of states it can be in. The trick is that any given state is unique and therefore disallows all other states. In information terms, a given state does not speak of itself being in a certain state; it relays the information that it is *not* in any of the other possible states. One way of illustrating this is again with reference to Lego. The number of ways to combine six two-by-four studded Lego bricks of the same color is 915,103,765 (Eilers, 2005). If we combine these six bricks in a concrete pattern, this particular pattern would contain significant amounts of information or redundancy. It effectively tells us that 915,103,764 other possible combinations are not realized. In contrast, a coin holds little information or redundancy. Seeing a coin with "heads" up only gives us the information that "tails" is not up. The object of an effective encoding is to shear away alternatives in a systematically recognizable way. One system has already been touched upon in the example of positional notation. If we imagine a lottery with 1,000 lottery tickets (numbers from 000 to 999) and as many participants each with their unique ticket, then a drawing that starts out by picking the first number (the hundreds from 0 to 9) will immediately shear away 900 tickets. The next one will eliminate 90, and the last will eliminate 9. The example shows that there can be layers of redundancy built into a system wherein parts of a solution are reached in different tempi.[164]

The efficiency with which alternatives are eliminated tells us how informative the interface is in terms of redundancy, but we are nowhere nearer ideas on how the system would change into different states. What we need are images in our mind's eye. If we are to think in visuo-tactile terms, then the direction we are heading should be something seen and manipulated. To illustrate, I will employ a biological metaphor in what follows. Imagine, if you will, a zygote – the embryo of a mammal. In the early stages of mammal

[164] Bateson (1972, p. 4) speaks of levels of choice: "[I]f I can achieve this higher level choice on a negative base, it follows that, after making the higher level choice [...] I shall not be faced with the alternatives at a lower level." If for example a number could only be drawn once, then drawing number 9 first would not only eliminate 900 alternatives but also all of the remaining numbers containing 9 (19).

embryogenesis, the developmental stages are, for the untrained eye, largely indistinguishable (see Figure 2).

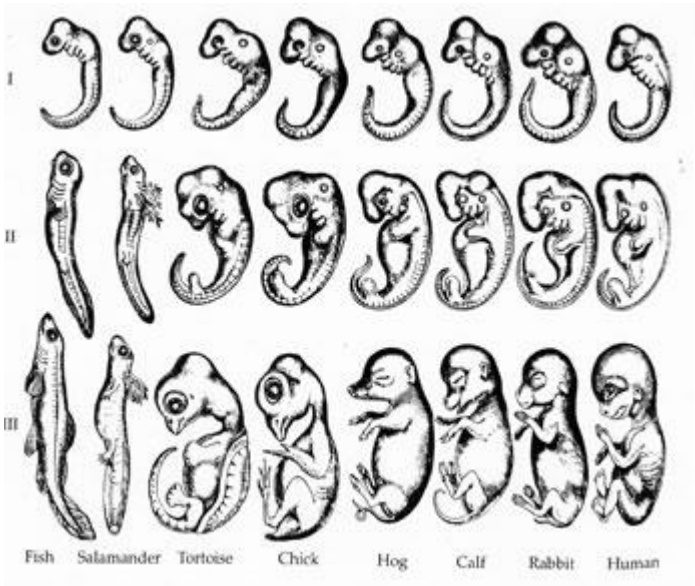

Figure 27 (2 in article). Embryology (Source: Gilbert & Raunio, 1997)

Each animal develops through stages where different "choices" are made or triggered. The end result are different mammals as we know them. For laymen, among which I count myself, the proof of their contiguous past can be seen in the fact that all mammals share the same basic body schema. Consider George Louis LeClerc de Buffon's comparison of horse and man:

> The horse, for example—what can at first sight seem more unlike mankind? Yet when we compare man and horse point by point and detail by detail, is not our wonder excited rather by the points of resemblance than of difference that are to be found between them? Take the skeleton of a man; bend forward the bones in the region of the pelvis, shorten the thigh bones, and those of the leg and arm, lengthen those of the feet and hands, run the joints together, lengthen the jaws, and shorten the frontal bone, finally, lengthen the spine, and the skeleton will now be that of a man no longer, but will have become that of a horse. (Buffon, as quoted by Butler, 2010, p. 88)

In other words, the skeleton of a man can be transformed into the skeleton of a horse or any other mammal for that sake (see also Figure 3 for an illustration). The finished individual (whether a man or a horse) consists, in information terms, of a series of choices. Each choice can be compared with the same choice made in a different constellation.

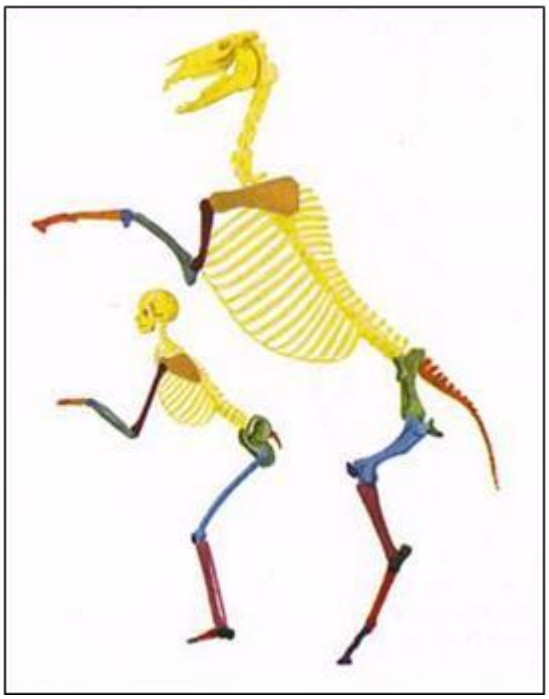

Figure 28 (3 in article). Man and horse skeleton comparison (source: http://www.quia.com/pages/3107anatomy3.html)

So the hips or shoulder blades can be found and compared in humans and horses. The two exhibit 2.order isomorphisms (Edelman, 1998), that is, if you found a bone from a mouse and compared it to a bone from a hump whale, you would not necessarily see any likeness. Their likeness rests in their relative position being the same in the body scheme. Interestingly, the same isomorphisms can be found in the human body itself. Bateson (1979) gives the example of the upper arm corresponding to the thigh (see also Figure 4):

> And in your own body, of course, the same sort of thing is true. Humerus in the upper arm corresponds to femur in the thigh, and radius-ulna corresponds to tibia-fibula; the carpals in the wrist correspond to tarsals in the foot; fingers correspond to toes. (p. 18)

This suggests that the series of "choices" of which a human or other mammal is made uses the same type of information or system (or interface) over and over again on different levels. The incalculable number of choices made in a human body are, again in information terms, all the result of a genetic alphabet of only four letters (A, G, T, and C). This is an extremely efficient encoding. The crucial thing to understand about the series of choices is that no information is *added*. Information is created by what is *lost*. DeLanda (2002) uses the very complex mathematical example of differentiated geometric spaces that are produced by cascades of symmetry-breaking phase-transitions. In layman's terms, this can be interpreted, as far as I can tell, analogously with the zygote. Geometric objects should, like the zygote, be thought of as initially "the same" (think of a perfect symmetrical sphere). When choices are made, the object assumes a specific shape. By choosing one shape, the object has forfeited all other shapes it could have potentially assumed (the symmetry is broken). Unlike the Lego blocks that can be easily reconfigured, potentials are lost when biological choices

are made.[165] However, like Lego blocks, each actual configuration (set of choices) has enormous informational value or redundancy. If we want to copy such a system, we should not try to have the computer medium present a likeness or representation of the information or phenomena we are trying to create. We should instead find a system for decomposing each phenomenon or piece of information we need to work with into the same basic structure. Like Lego blocks, each phenomenon that we are capable of building should be able to be built with the building blocks (choices) at hand.[166] What is interesting about a phenomenon is less what it is and more what it is *not*.

The potential of the metaphor is the accuracy with which we are able to discern different types of animals and infer different properties. Imagine a codification for knowledge work that treats every project, every case, every client in the same way. Instead of standardizing each record into a form, an icon or a name, each project is considered a new zygote (a fertilized embryo) that, throughout the lifetime of the case, develops through a series of choices and accordingly changes appearance in *a systematic way*. Decisions are made whereby some development paths are explored while other paths are deselected. Each object would be a system unto itself that requires a series of comparable decisions to be made (regardless of whether the field is project management, drawing up legal contracts, shaping business propositions, filling out medical records, etc.), displaying when these choices have been made. Drucker (2013) speaks of a performative materiality that "suggests an approach to design in which use registers in the substrate and structure so that the content model and its expressions evolve" (par. 36). Objects would be comparable (like skeletons of mammals) in terms of their stage of maturity and the choices and compromises made and would hold financial, temporal, historical, mechanical, etc., information in the same "object." At the same time, each project would also be distinctly recognizable in its developmental path as detailed knowledge of the choices made in the case can be accessed on a micro level while, at the same, affecting the overall appearance and behavior of the case on a macro level. Each decision would likely follow in its progressive unfolding from inception to termination. One would be able to overview a portfolio of cases and recognize all sorts of behavior, signals, and actionable properties based on their appearance (or rather affordance). Each case would provide information not only based on the information present (this project has gone over budget), but also in the information absent (e.g., "I can tell from its shape that this project is thinly funded"), and would provide the basis for comparison on all common parameters. Contrast this with your average folder of documents. Except for very specific metaphor-related ways, entities (icons) cannot be divided, merged, grouped, brought into taxonomic relations, brought into relations (juxtaposed, compared, etc.), built into larger assemblages, or (re-)organized. An icon provides no information on how long the file has existed, whether it has 10 lines or 10,000 lines of information, who has worked with it, what

[165] Bateson (1972) has devoted an article, A Re-examination of "Bateson's Rule," to the explanatory principle of loss of information in his groundbreaking work *Steps to an Ecology of Mind* (1972).

[166] It is like the mathematical puzzle of finding polygons that can "tile the plane," that is, a shape that is multiplied and aligned side by side with itself can cover a flat surface without gaps or overlaps. Decomposing phenomena into the same basic structure is a way of inverting the process of designing an interface. It is like starting with the game controller and finding out how to decompose as many different moves into the same basic set of available button presses or stick movements.

its relation to other objects are, etc. Further evidence that current computer interfaces are informationally underwhelming is the fact that no icon or similar object can be associated with another (e.g., clustered into a larger icon) or provide any meta-information. The file-folder system can be adapted to function as such, but it still does not provide any (or very little meta-information). Seen through this lens, both the visual and tactile languages of existing computer interfaces are crippled and unable to impart information.

The task of creating a novel interface lies not in finding an appropriate metaphor, in refining the use of tabbed browsing, or designing a new symbolic system. The task lies in finding a visuo-tactile *data structure* that allows us to manipulate data into recognizable phenomena.[167] An example is the game Foldit[168] in which amino acids are folded into proteins. The unique part of the game is that the rules of behavior for amino acids (constraints) are embedded into the interface. Acids that will not join in real life cannot be connected in the game, and chains of acid will behave in predictable, rule-based ways. Choices made in the game have rule bound consequences that are directly discernible, can be recognized as patterns, and can be brought to bear in future problem-solving situations. The point of the game is that human pattern recognition and problem-solving skills make them better investigators of undiscovered patterns than computers, thereby making it possible, through playing, to find proteins that solve problems in real life. Like an analog computer, the data structure is not strictly visual (it is not symbolic), but only understandable as we learn to manipulate the acids and get acquainted with their behavior. In a completely analogous way, we should find problem areas where the constraints of the system can be identified and embedded in an interface that allows control and manipulation. We will have created an analogous computer interface for a digital computer. A computer interface wherein we manipulate knowledge and information would require a thorough understanding of the particular type of knowledge work that we are trying to accomplish. It would also require a complete reimagining of how the job can be done and what it "looks like" relative to new media possibilities. Any simple "digitization" of a system ignores that the information the current system is composed of is constrained by a linguistic mode of composition and manipulation (i.e., writing and reading).

Conclusion

The idea of an analog computer interface holds promise for the HCI design community because the computer is capable of realizing impossible constraints. The computer allows for infinite subdivision, infinite integration and association of objects and parts of objects, and many different modalities at work at the same time. As is painfully clear from this article, the direction has only been suggested here; and as stated earlier, what is needed is not more words on the matter but actual functioning interfaces that experiment with the

[167] Simon (1973), in a different context, states that "there is merit to the claim that much problem solving effort is directed at structuring problems, and only a fraction of it at solving problems once they are structured" (p. 187).

[168] An explanatory video can be found here: http://aeon.co/video/science/the-contenders-a-short-film-about-crowdsourced-science/

possibilities. Words cannot capture the visuo-tactile understanding that develops once a detectable pattern is embedded in an interface. One example is the prize-winning 4D experimental game Miegakure.[169] In this game, the designer makes an impressive attempt to explain the philosophical implications of how a 4D being would think of us poor creatures trapped in a 3D world. He provides the example from Edwin Abbott's science fiction novel *Flatland* (1884) where the reader is taken to a two-dimensional world occupied by geometric figures. By analogy, we understand that there could be creatures moving and acting in higher dimensions than we do. The game provides the ability to shift between different dimensions, each of which are 3D worlds occupying the same space.[170]

Introducing constraints and analog computers into interface design is a way of providing "the user with a higher-level language, one that directly expresses frequently encountered structures of problem decomposition" (Hutchins et al., 1985, p. 324) – though not as metaphors, but by moving in the opposite direction. Creating an interface based on decomposing problems into a data structure that is both visual and tactile is a way of making impossible Lego bricks. As such, we potentially move information work in the direction of "greater merging," as Latour (1986, p. 16) puts it. The dream of the internet was to connect all information in one gigantic hypertext. Creating visuo-tactile structures that follow different rules opens up one possibility that text cannot provide: the integration of information. The Library of Congress in Washington, D.C., has a collection that stretches about 1,199 kilometers, with 130 million items and 29 million books.[171] Written information is integrated by creating more books; researchers synthesize information by creating more information.[172] Being able to synthesize information without necessarily relying on consensus (e.g., Wikipedia) would bring the dreams of encyclopedists to a complete new level of fruition.[173] This has to be done by creating a systematic interface capable of decomposition, not a mechanical monster to supplement the wasteland of icons, windows, and buttons. As Drucker (2011, p. 3) puts it: "Ultimately, a new language of description and analysis [of interfaces] will take into account the spatialization of meaning and the meaning

[169] Videos and explanations can be found at http://miegakure.com/

[170] The ingenious shift between dimensions takes a while to visually decipher, but once it has been decoded, one can easily see what is "going on." There are several maps superimposed on top of each other. At any time, the player is situated at a particular set of coordinates. Depending on the map, this position will have different options (and consequences) available.

[171] Shaffer and Clinton (2006, p. 7) accurately state that: "Theoretic culture depends on large-scale storage of information as a database for analytic thinking, and on a set of external tools that help us control the flow of this information to our biological processors—that is, to our brains—which evaluate and transform that information. In a theoretic culture, what matters is not what the unaided mind can accomplish, but rather, as Clark (2003, p. 69) suggests, "how information is poised for retrieval and for immediate use as and when required."

[172] This applies doubly for any scholarly environment that seeks to develop the possibilities of the computer for its own field. In the words of Drucker (2011, p. 2): "The authoring and reading environments for interpretative scholarly work are only just beginning to be designed in such a way that the linear, finite, conventions of print media can be changed for the constellationary, distributed, multi-faceted modes of digital media."

[173] For instance, the version control system GIT (https://en.wikipedia.org/wiki/Git_(software)) supports non-linear workflows, and each directory is a complete history with version tracking capability. Interestingly, GIT has a visualization tool called Gource. Although Gource is mainly a visualization tool, it clearly embodies a simple encoding whereby historical information (version control, that is, choices made) is read directly from the visual structure.

producing features of spatialization" – to which we can add, not just description and analysis, but production itself has to take spatialization into account.

When we accept Victor's claim that "representations are how we understand [a] system and what we understand about it" (2013), we are primed to investigate, and take into consideration, how current representational formats affect our concepts and understanding. Such an awareness makes it possible to recognize when ideas stem not from the problem at hand but from the format with which it is being gauged. Rethinking how we think about systems requires thoughts that hail from a different world than pen and paper.

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Videos

Alan Kay: https://www.youtube.com/watch?v=0oonXT-gYjU; http://vimeo.com/23291347

Victor, B. (2013) http://worrydream.com/#!/MediaForThinkingTheUnthinkable

Appendix 4 - Operational meaning

- Or how signals become systemic.

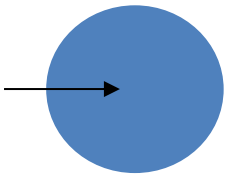

Figure 1 A difference

Figure 1 illustrates a difference in the world. It is what Spencer-Brown (1972) calls a 'crossing.' The image can be interpreted from two perspectives. One perspective is the well-known first-person perspective. Another perspective is the equally well-known third-person perspective. The first-person perspective is the view you and I presumably observe as we look out onto our respective worlds. From the first-person perspective, a difference is extended in the world. A *thing* (the blue circle) *embodies* a difference, if you like. The blue circle is a clearly demarcated entity severed from the *rest of the world*. The third-person perspective, on the other hand, takes something as a proxy of itself. This perspective allows you to put yourself in the place of someone or something else or imagine yourself in the process of doing something. We can imagine ourselves performing the *crossing* for the movement in Figure 1, as represented by the black arrow crossing from white into blue. The movement itself from white to blue must be imagined, as paper does not lend itself to representing this movement. We could *perform* the movement, as our gaze sweeps from the arrow's butt to its tip. Alternatively, we could imagine the arrow as a point starting on the left and gradually extending itself from white into blue; in the process transgressing the boundary between the two. For clarity's sake, however, we use yet another proxy, a robot turtle, to represent the third-person perspective (Figure 2 below).

Imagine the robot turtle meandering on a plane (figure 2 below).[174] The turtle scans the color on the plane directly underneath it. If the turtle detects a change in color, for example, by crossing into a blue circle, its internal state is inverted, changing between internal states 0 and 1. It does not matter whether the turtle crosses the

[174] I owe this example entirely to a now-defunct webpage. A cached version can be found by googling 'spencer brown turtle' and entering http://www.lawsocietyblog.com/archives/349.

boundary or the boundary is moved underneath the turtle. Note, for the turtle, it makes no difference whether we are talking about its state or place. The turtle simply changes state whenever it crosses the boundary. We, the observers, are the ones who are able to discriminate between the turtle's *place* (i.e., the plane – white/blue) and the turtle's *state* (i.e., the turtle in state 0/1).

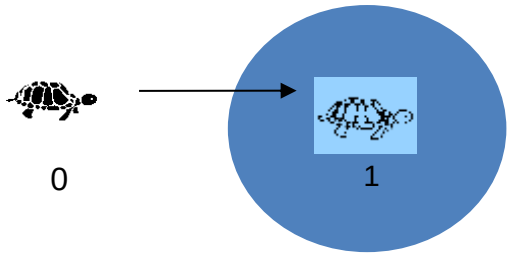

Figure 1

'Place' is the (ontological or physical) extension of the difference crossed (from a first person perspective). 'State,' on the other hand, is the (epistemological) proxy of the turtle's state, that is, its perception (from a third person perspective. We can say the turtle's world has *operational meaning*. State and place must follow one another. Which would lead us to conclude that we can equate the white part of the plane with state 0 and the blue part of the plane with state 1 as seen in figure 2.

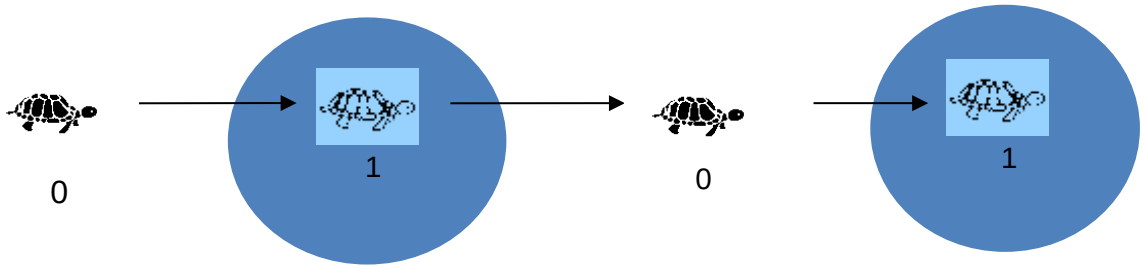

Figure 2

Spencer-Brown refers to this as the 'law of calling'. We count two circles in Figure 2, but from a logical point of view, the result of the crossings is the same as crossing into one circle. The turtle's basic response does not change, regardless of how many nonoverlapping circles exist on the plane. The turtle therefore has no way of distinguishing between state and place.). For the turtle, the crossing (a difference) is not the perception of a thing (yet). The turtle is bound by the world. The turtle changes state in perfect tandem with its change of place. Being bound

by the world in this manner, a turtle's perception is in a sense boundless. Regardless of which state you find it in, it will know of nothing but its particular state. It has no conception of being *inside* the blue circle, as opposed to *outside* it. Its states have no borders or horizon. It simply *is* its world, like Uexküll's tick.[175]

In other words the turtle cannot be said to 'read' the blue circle as a mark, unless we by 'read' mean something to the effect of shifting into a certain state. If the turtle could be made to shift into a state (1) without having crossed into a blue circle, its state would be indistinguishable from a shift of state induced by a crossing.

From the turtle's point of view, it does not matter whether we conceive of the difference as represented by the blue circle, the arrow, the turtle, the 0/1 distinction, or the border between the blue circle and the white paper. The significance of a difference lies in the *change* of state or movement. There are, however, differences between the choice of proxy. The arrow and the border share the assumption of actually encompassing the movement in its entirety (from beginning to end). The turtle, the blue/white distinction, and the 0/1 distinction only allow us to infer movement from part of it, that is, the initial state or the end state, for example, the sense in which the mark embodies a difference from a third-person perspective lies in this inference of movement. Instead of seeing a thing (a difference embodied from the first-person perspective), we infer movement by metonymic reasoning (pars pro toto). It does not matter if we infer the movement from its initial or final state or from an arrow drawing the path of the movement. This is evident in Figure 2. We can *see* two turtles; but in reading the image movement was implied, and so one turtle was implicitly substituted for the other. In this sense, we only *saw* one turtle. We could just as easily have used one or both of the two figures (Figure 3) below as illustration. Taken separately, each figure implies the *other* turtle. Taken together, movement is implied by the juxtapositioning of before and after images.

[175] 'A being capable of sense-experience (*sentir*) – in a sense of coinciding absolutely with an impression or quality – could have no other mode of knowing' (Merleau-Ponty, 2008, p. 15).

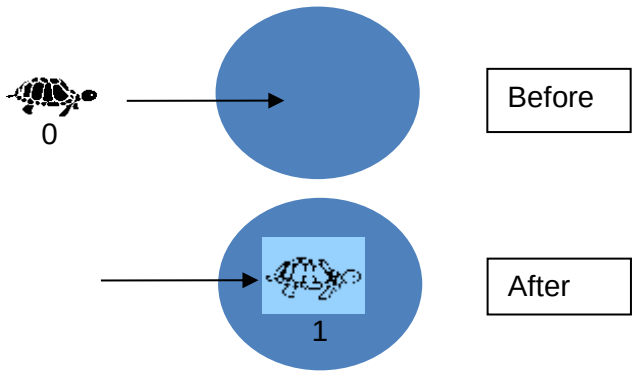

Figure 3

If the conceptual separation between state and place is to make sense, we must assume, despite the perfect correspondence between them (i.e., operational meaning, white = 0 and blue = 1), that *state* (or mark) signifies something different from *place*, (or thing). Since we have only specified that the turtle changes state when it detects color *change*, we could suggest that *1* marks a state of *difference*. This either entails that all changes become marked *1*, for example, crossing out from the blue circle into the white is also a change (see Figure 4), or it entails that the *other state* represents *the same*, that is, that 0 is a baseline or *neutral* state. But this violates the premise from the outset that we did not know which side to mark?

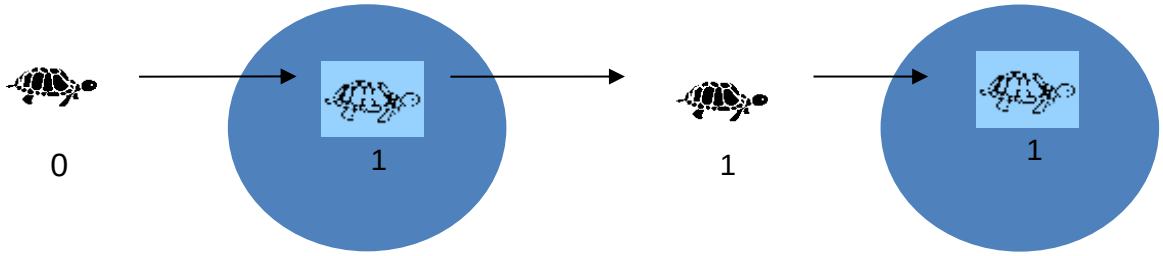

Figure 4

Consider another turtle starting in the opposite state mirroring the first turtle's states (Figure 5). We, as observers of both state and place, are able to see that the two turtles have inverted states for the same places in the world, or the same states for inverse places in the world. The two turtles will have no way of comparing notes, because they are bound by operational meaning. They have no *memory* or perspective telling them one state is different from another. They may, in a rudimentary sense, *agree*, because they de facto change states by crossing the difference. We can observe symmetry in their change of state, but they cannot observe themselves and are therefore unable to know their states are inverted in relation to each other.

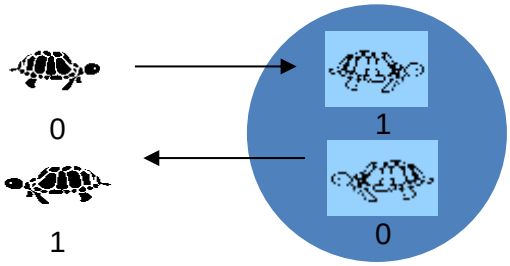

Figure 5

Since we have shown the turtles states to perfectly mirror each other, we can conclude that unless both turtles have full knowledge of their respective states in absolute terms, their *disagreement* will remain forever hidden. They will cross and recross in tandem not knowing that their states are inverted. To suspect a difference, they need to be able to differentiate states (1/0) in the same way they have differentiated between places (white/blue). It will not help either of them to attempt to observe the other. Such a feat requires the assumption that the seeing of another turtle (or itself, if that were possible) has anything to do with its internal states (the third-person perspective). For now, each turtle must remain in its first-person perspective bubble.

Un-mark - No-thing (2nd mark)

Thus does the question change to: 'How do you differentiate a state?' If *state* were the marking of *plane*, then a *secondary state* marks the first *state*. In other words, you mark the first mark with a second mark. Consider the following example. You have a blue pen and paper, and you have already made the first mark. Now … try to mark the mark?

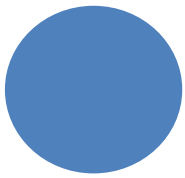

Figure 6

Since we are only equipped with a blue pen, regardless of which mark you make within the mark, it will not show up. What do you do in order to mark the mark? Our only option is to amend our primary mark.

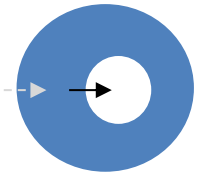

Figure 7

The solution is to *un*-mark the mark (white mark on blue mark). It is of outmost importance to note that what we *see* by the white un-mark is not a thing. It is the *inverse* of the blue mark, that is, it marks every-thing *by proxy* of (un-marking) the blue mark. If the blue mark marks everything, then marking the blue mark marks everything by proxy. In our turtle example, the same result is obtained by placing a circle within a circle (Figure 7).

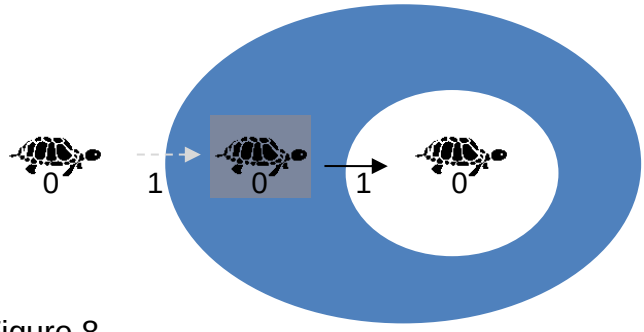

Figure 8

Crossing into the blue circle and then into the white circle makes the turtle's state inside the second circle equivalent to the turtle's initial state outside the blue circle. In other words, since our turtle has no memory, the two crossings might just as well never have happened. Only this time, the second crossing takes place within the boundary of the first crossing. Spencer-Brown (1972) dubs this the 'law of crossing'. Crossing from the un-marked to the marked state and back again (*recrossing*) annuls both crossings. How shall we understand the second mark, that is, the (white) *un-marking*?

If we assume operational meaning for the second mark as well, we can say the two crossings should be treated not sequentially but rather simultaneously (we must assume the third-person perspective). Crossing an all-encompassing mark within a mark is equivalent to crossing out of the first mark. From a first-person perspective, the second white circle should not be *inside* the blue circle. Rather, the white circle should completely eclipse the blue circle. Try to imagine the *inner* white circle as it

grows to eclipse the blue circle. We can illustrate this by gradually thinning the blue circle (Figure 9); we can see that the blue circle is completely covered by the white.

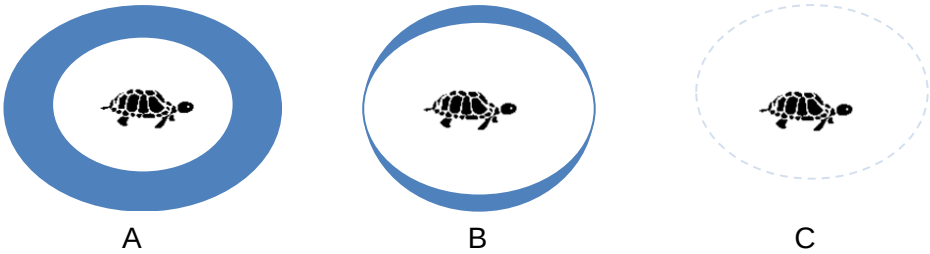

Figure 9

This is impractical on paper. We cannot change the color of a circle once it is on paper. We would have to be able to turn the color on and off like flashing a flashlight and even if we could, turning of the blue color would only leave us with:

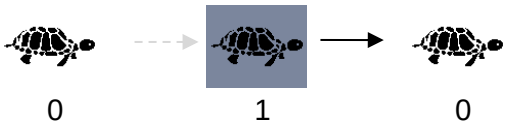

Figure 10

From a third-person perspective, we might ignore the circles in favor of focusing on the arrows. You will notice the first arrow moves from (0-1) while the second arrow moves from (1-0). If we call the first arrow an *entry* and the second arrow an *exit*, then, taken together, the two mark a simultaneous entry and exit. This too is impractical, as superimposing the arrows on top of each other would point them in the same direction, not properly indicating their inverse relationship:

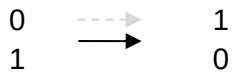

Figure 11

Cancellation

Instead, there are two simple ways of simulating an inversion of colors. We create a before and after image of the color inversion:

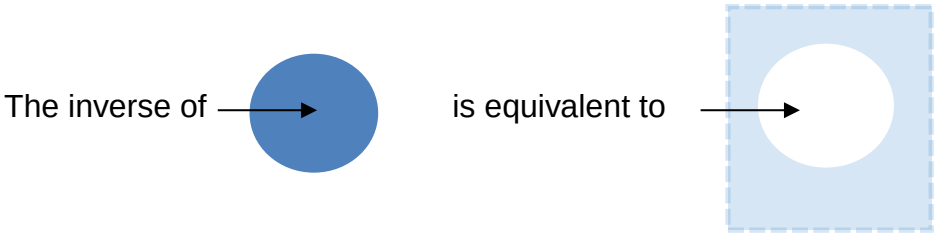

Figure 12

Inverting the colors (note how the entire page ought to turn blue by the inversion on the right in figure 12). Or we reverse the direction of an arrow. You can verify the change of color by thinking of the arrow as an entry into one color and an exit from the other color.

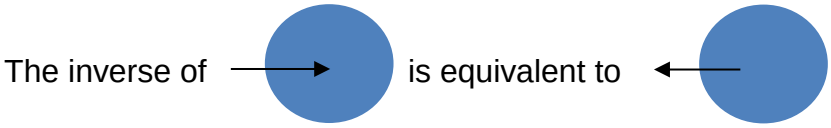

Figure 13 Reversing an arrow

Since in our example, an entry either goes from 1-0 or 0-1 and an exit does the opposite, reversing the direction of the arrow is equivalent to changing the color (assumption of operational meaning).

Reversing the arrows *and* inverting the colors simultaneously cancel each other out. Which means when we take a *before* image and perform both operations on it, the resulting *after* image does not give you the inverse, but its logical equivalent.

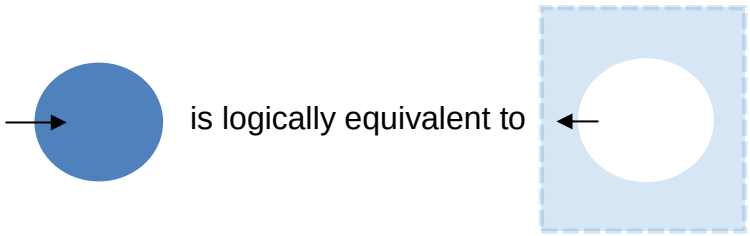

Figure 14

The figure illustrates Spencer-Brown's law of crossing: Two instances of the form are equivalent to no instance of the form, if one of the forms is the argument of the other form. A crossing starting from the marked state returns to the un-marked state. Hence recrossing annuls crossing. The figure shows that crossing into the third mark is logically equivalent to crossing into the first mark, since the first two crossings have cancelled out each other.

The truly mental *mind twister* I am trying to conjure appears when we combine the left and right side in Figure 14. Taken together, blue on white cancels out white on

blue, while the entry-arrow cancels out the exit-arrow. In other words, there ought not to be anything *at all*, not even the white paper, to truly illustrate the cancellation. When we first look at the blue on white, we see a blue thing side-by-side with a white background *or* we see a blue mark that covers up (substitutes) a white mark and the fact that it is *not the other side*. The second mark changes this image. We do not see a white thing on blue background, nor do we see a white mark that covers up a blue mark. We ought to see nothing.[176]

Once again, the print medium lets us down. Figure 14 provides the *before* image on the left of and what appears to be the *after* image on the right, but we cannot combine the two to provide the actual result. The only option paper allows us is to return to a *state* before the beginning, that is, before Figure 14, which is the plain white paper. White paper signifies nothing or everything, so once again, we must use a proxy:

Figure 15

The first figure given in a ghostly version – the dotted line in figure 30 – gives the impression of a cancellation and manages to reproduce the problem of beginning with which we started. If the first mark marks everything and the second mark cancels (un-marks) everything, then the ghostly line is an image of the nothing that apparently is prior to the Big Bang. Rather than starting over, we are now in a position to see that the second mark marks the crossing or movement instead of being the result of the crossing (i.e., *this* side as opposed to *that* side). It attempts to mark the arrow or the change between images.

Translating this into turtles, the problem is that 1 and 0 are not names of states corresponding with places. When we started marking the turtle's state in Figure 1, it

[176] Louis Kauffman expresses it thus: 'How can we get something from nothing? The answer in the Laws of Form is subtle. It is an answer that destroys itself. The answer is any given "thing" is identical with that it is not. Thus markedness is identical to un-markedness. Light is identical to darkness. Everything is equivalent to nothing. Comprehension is identical to incomprehension. Any duality is identical to its confusion into union' (Kauffman, 2001).

did not matter which label (1 or 0) we chose as one or the other. This caused problems in Figure 5, when we assumed that we could label the states *reversely* for the second turtle.

	Turtle I	Turtle II
Blue	Entry (0-1) Exit (1-0)	Entry (1-0) Exit (0-1)
White	Entry (1-0) Exit (0-1)	Entry (0-1) Exit (1-0)

Figure 16

But for there to be a contradiction, *1* and *0* have to respectively signify specific states independent of *blue* and *white*. Because we have assumed operational meaning, and the first and second marks are considered simultaneous, *1* and *0* binds to *white* and *blue*, respectively, signifying that white is *this* side and not *that* (blue) side and vice versa for blue. Figure 16 shows that an *entry into blue* is equivalent to an *exit from white*, while an *exit from blue* is equivalent to an *entry into white*. But notice that this goes for both turtles, regardless of the *names* of their states being inverse.

The figures 1 and 0 are mutually exclusive states. Assigning one or the other to a side merely serves to say: this is the *other* side. This barely makes sense to us, as this makes the meaning of both sides relative. 1 and 0 both signify *the other side*. You would be quite puzzled, if a man asked you to show him the other side of a coin and then, as you flip the coin over, replied: 'No, I didn't want to see *this side*. I asked you to show me the *other side*'. However the logic in the second mark is simply two mutually exclusive states. We could have imagined the second turtle juxtaposing the states A and B, a *donkey* and an *elephant*, or even random symbols, as long as the turtle *knew* that the two were mutually exclusive and in reciprocal presupposition. Just as it makes no sense to try and conjure a disagreement between a turtle differentiating between A/B and one differentiating between 1/0, there is no disagreement between the two mirrored turtles in Figure 5.[177]

[177] If their *perceptions* of the plane are identical, their states are identical, regardless of what label we assign the states. We might say there is logical equivalence between the two turtles' operations. It does not matter if the 2.order differentiations are inverted, as long as their 1.order differentiations

What does the second mark in fact mark? Observing that something is exclusive of something else does not at first glance appear to be saying much. But we can draw valuable insights from the un-mark. The second mark shows the connection between the primary and the secondary mark is not one of correspondence but rather a way of establishing the *unity that allows comparison*, to use a phrase by Bateson. Connecting two different phenomena requires an assumption of comparability. Up until this moment, we have assumed that *blue mark on white paper* was a reasonable representation of a first difference. Our juxtaposition of the two turtles rested on the difference between the plane white/blue and the state 1/0. But our initial doubts ought to have led us to ask: Can we assume that *blue mark* and *white paper* have anything to do with each other? Counter to our intuition, there is no reason to infer any relation between the two, unless *blue mark* is the *other* of *white paper* and vice versa. Before reaching the second mark, strictly speaking, we were not yet capable of juxtaposing a blue mark from white paper or a marked state from an un-marked.

Any mutually exclusive states comprise a unity in the same way we think of choices made. If you have a sack holding a white and a blue ball, then drawing a white ball from the sack tells you a blue ball is left. When you encounter a blue mark, you know that it replaced the option of no-mark.

As stated in discussing operational meaning, a rudimentary differentiating system (our turtle) does not *see* both sides when it differentiates, as it would be located on one or the other side. But the second mark will allow it to infer *the other side*, given the side it is located on, regardless of which side that is. The second mark establishes the blue mark and the white paper as mutually exclusive. We could call this a rudimentary memory, a before and an after the crossing. We can always infer upon entering one color, that we have just exited the *other* color and vice versa.

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are aligned. The differences they negotiate are the same. If their 2.order states were divulged, say, either by their body somehow revealing their state or by communicative means (and given that these means were identical), then a real disagreement on which plane elicits which state apparently takes place. Take, for example, the congenital condition *situs inversus*, where the internal organs of a person are mirrored from their normal position (transposed through the sagittal plane). Most individuals with this condition are phenotypically unimpaired, that is, they lead normal, healthy lives (see http://en.wikipedia.org/wiki/Situs_inversus). However, as we argued, the relative nature of the second mark is at odds with fixed markers. Both the *normal* person and the *mirrored* perform the same relative differentiation from mirrored origin points.

This is significant. It means when we see a thing we see not only that thing, but also, in a sense, we see everything-it-is-not, that is, the *other* side.

Thing - Some-thing (3rd mark)

We have established there are two places (blue/white) and that they are recognized as in reciprocal presupposition via two mutually exclusive states (1/0). What is missing is the answer to which side we in fact are looking at given the difference. Something has to break the symmetry introduced by the cancellation and indicate *this side* rather than *the other side*.

For the turtles, the reason the second mark differentiated states and not the plane was that the second mark marked the mark and not the plane. This was brought out by focusing on the arrows in Figure 8. This allowed the second mark to be a mark of the crossing (states) rather than the result of the crossing (planes). Just as the states characterized the movement (entry/exit) rather than the result (blue/white), we can characterize the movement of the second mark by placing a third mark. In Figure 8 above, the rightmost turtle marked the difference between states with a white mark on the blue. Similarly, we mark the white mark with a third mark, as follows:

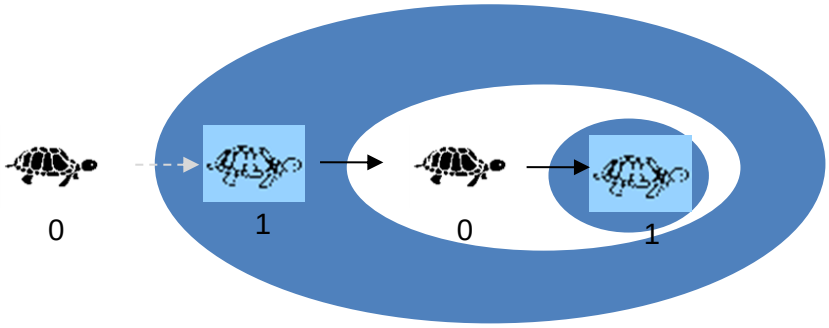

Figure 17

Marking an un-mark is the inverse (but logically identical) differentiation of un-marking a mark; however, since it marks the movement of the second mark, we must ask what movement is that? The first mark simply moved (crossed) to mark the plane. The second mark moved (recrossed) to mark the crossing that marked the plane. The third mark moves to mark the crossing that marks the crossing (that marked the plane).

How are we to understand *the crossing that marks the crossing*? Attempting to explain this verbally will, aside from producing a typical self-referential paradox, obscure a rather simple point. I will therefore resort to a visual solution that simplifies the matter before giving the verbal explanation.

As with the second mark, we assume operational meaning for the third mark. Therefore, the three crossings are treated as occurring simultaneously. As before, paper denies us a dynamic visualization. For lack of better options, Figure 18 shows three logically equivalent versions of the three crossings side-by-side. Each time we perform a crossing, the colors (blue/white) are inverted. Ghosting the circles allows us to remember the cancelled crossings.

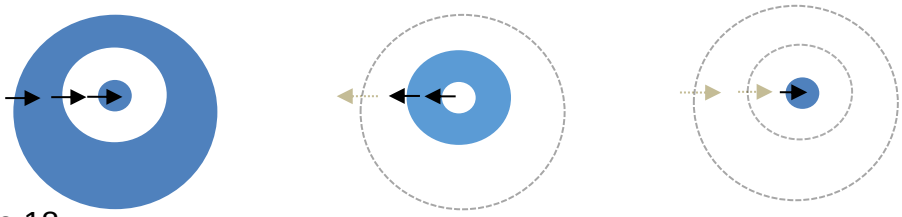

Figure 18

The third mark is therefore equivalent to the first mark, but not unqualified so. As the third mark, it affirms one side (blue) over the other (white). But this image does not properly line up the crossings (the arrows), and even if it did, it would not properly represent their reversal. At the same time, just as we could not see the cancelled color without the ghostly circle, the third arrow would cover up the two prior arrows.

Folding

To focus on the arrows, I will introduce yet a third way of visualizing the principle at work in the cancellation (the double movement of reversing the arrow and inverting the colors) called a *folding* (I borrow this term from Deleuze.[178] We could also refer

[178] The fold is a Deleuzian idea with far-reaching consequences requiring a propaedeutic of its own. It is a trope that in its various uses is intimately tied into its subject (primarily in the works *Foucault* (Deleuze, 1999) and *The fold* (Deleuze, 2003) on Leibniz). Deleuze literally thinks of *folds* or *pleats* as those found in fabric, flowers, skin, fluids, and origami, but instead of applying the concept to a phenomenon, he lets it loose on the world with the same ambition of reorienting our entire ontology, as Leibniz did in introducing his theory of monads as elementary particles. Avoiding implications of idealism, the world is conceived of as in continuous variation of matter and development of form. Folding is movement (the endless implication, explication, and replication) that continuously changes into infinity. The single sheet of paper in origami, divided into infinite folds, resonates well with the image of a closed autopoietic system that gradually complexifies through a process of differentiation. Similarly, folding is taken very literally here as explained above, and at the same time, it gives us a ghostly proxy for a phenomenon that is strange in every context we can imagine: how something can change and yet stay the same. Folding is traveling without moving. Fixating each moment of these

to this as the logic of Inversion Ingold discusses, only applied recursively on itself multiple times. The folding gives us the opportunity to highlight an aspect of the three crossings: the arrows. We have mentioned three differences (dubbed A/B, I/II, and X/Y below). We still operate within operational meaning. The arrows (1, 2, and 3) are shown in the top row of Figure 9, and not the colored squares. In the second row, A/B is folded into I/II. In the third row I/II is then folded into X/Y, but note that A/B and I/II have been compounded into a double arrow. A/B (which was folded into I/II) automatically follows this second folding. As emphasized, the double arrow represents a cancellation and should therefore not be there at all. It is retained in order to be able to connect X/Y with the two earlier crossings, giving the final result in fourth row where the final crossing is shown as a triple crossing. Since this too is not possible on paper, it is represented by three arrows instead of a single.

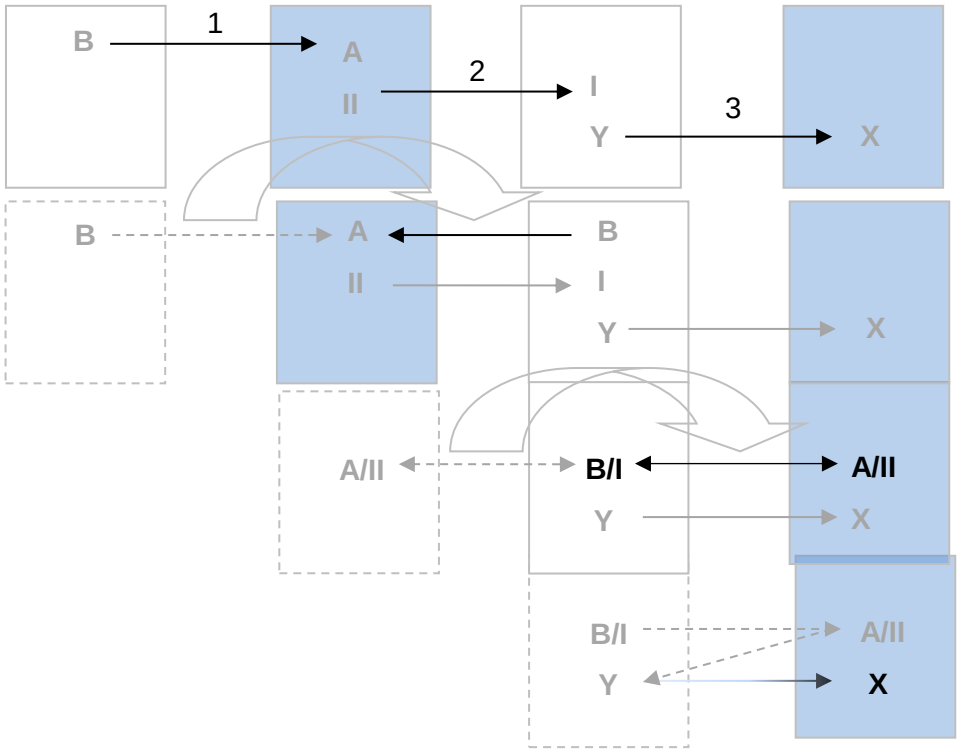

Figure 19

Folding aligns the arrows while reversing the arrows and inverting the colors correctly to ensure logically equivalent results.

crossings as separate stretches out an articulation normally infolded, giving the appearance there are three articulations instead of one.

What have we marked with the third mark? In the third row, the two first marks (B/A and I/II) are collapsed into a single line of distinction (since they cancel out, nonetheless). This is possible, because the two prior crossings are each other's inverse. Together, they are represented by a double arrow. Since this is the cancellation, nothing ought to be there. The cancellation is retained as a double arrow to see how it prepares the way for the third arrow. It is this cancellation we have attempted to mark by placing the third mark *on top of* the un-mark. The third crossing breaks the symmetry established by the two first marks. Thus we are provided with a solution to the odd problem of which side we are marking. It is the marked side, since the mark (third crossing) is what breaks the symmetry. Since we called the first arrow an *entry* and the second arrow an *exit*, then the third mark could be called a re-entry.[179] Together, the three crossings form the reason we see both sides of a line of distinction. Marking one side makes the inverse side the *other* side by default. The choice of a direction means what has not been marked is in reciprocal presupposition to that which has been marked. This reciprocal presupposition is exemplified in the Roman custom of symbolizing an agreement with a *tesserae hospitalis*. 'A token was divided, one half being retained by each party, to symbolize the agreement' (Lomas, 2004, p. 45).

Figure 36

Imagine breaking a coin or a stone in two. The fracture line gives the two sides unique complementary profiles. It is a natural code or key, since each side assumes or presupposes the unity of the two halves (or *the other*). In other words, the two

[179] I will return to the re-entry later. Readers of Luhmann will note *re-entry* is a concept taken from Spencer-Brown, that is, the operation of distinguishing between system and environment within the system. The great difference between this account and Luhmann's and/or Spencer-Brown's, which has already been hinted at, is for Luhmann, the re-entry is denied extension, making it paradoxically *in between* its progenitors: '[The re-entry] is another way of saying that a part of an entity may have higher reflexive capacities than the entity itself ... A reentry is a paradoxical operation. The distinction "before" and "after" the re-entry is the same and not the same. This shows that time (that is the temporal distinction of an observer) is used to dissolve the paradox' (Luhmann, 2002, p. 104). I do not claim Luhmann's quote suggests we are dealing with entities within entities. I am merely pointing out this is the only way the re-entry can become paradoxical.

halves are natural and mirrored synecdoches, where a part of something is used to refer to the whole thing (*pars pro toto*). They articulate the same difference and are almost perfectly coded by the profile of the fracture. Together, the reciprocal presupposition also comprises a unity, but unlike the unity involved in mutual exclusion, the two can co-exist. In fact they must. If one side is lost, then the other side is no longer *half* of anything. The *thing* is one half. The *rest* is the other half. The third crossing repeats the first crossing and implies the second crossing (by mutual exclusion). The triple crossing in the fourth row thus simultaneously indicates the inside (figure or the *same* side), the outside (ground or the *other* side) and the crossing from one to the other that privileges one side over the other. The *crossing that marks the crossing* is to be understood as indicating the movement of movement. The end result summarizes how the three crossings in a sense are different *aspects* compounded in the same crossing. Each crossing has an inside, an outside, and an indication of which is which by the line of distinction, but they each draw out a different property of the triple crossing.[180] Strictly speaking, we should not even talk of *simultaneity* and *compounding* as if the crossings were separate prior to and left intact by the folding. All three differences are the same difference accomplished by the same crossing.[181]

What is *the crossing that marks the crossing?* The act of pointing to the simultaneous first and second mark (marking/un-marking or crossing/recrossing) as well as the third mark itself is the attempt to capture the movement of the third crossing itself. The attempt was to see the *act* of marking. Since we have assumed operational meaning throughout, the third mark cannot mark the first and second mark without itself performing a crossing. Insofar as it marks marking as such, it

[180] The crossing that settles what is inside and what is outside is part and parcel of drawing the distinction. Luhmann and Spencer-Brown attempt to settle the question by invoking an 'operative unity of distinction and indication' (Luhmann, 1998, p. 13), but this necessitates two differences at work that together form a unity. In differential terms, differences can fold into each other, but they cannot fuse into one and the same difference. In other words, there is *no* separate indication, unless we take the distinction to be equivalent to the double-cross and the indication to be equivalent to the third crossing. This again would beg such questions as, what is the difference between distinction and indication, and how can an indication indicate when a distinction cannot?

[181] The three arrows combine to explain the asymmetry of change (i.e., time). A crossing signifies a before and an after, or a temporal gestalt. It is true any crossing is arbitrary, insofar as the opposite, or any other, crossing could have taken its place. However, once the crossing has taken place, it is no longer arbitrary. The crossing chooses the figure, and all that the figure is not (ground) becomes the wide open (endless) totality of the paths not chosen. The asymmetry of the gestalt arises from the redundancy created by the dissolution of the white un-marking, since this is indistinguishable from the 3.order blue marking Y→X when the mark is shifted. In other words, the blue mark gains primacy over the white un-mark, moving from a symmetrical to an asymmetrical relation and giving our arrow a direction. Redundancy is treated below.

therefore marks itself qua performing the crossing. It turns out that the act we attempt to fixate is as a *change* of state. It is the exact moment when the colors flip, that a state changes to *other* and (what would otherwise be) a symmetrical stalemate is broken.

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The development of novel interfaces is one of the most important current design challenges for the intellectual, cultural and cognitive evolution of human imagination and knowledge work. Unfortunately, the thinking surrounding this design challenge is heavily mired in conceptions that harbor ontological biases and epistemological assumptions which, to a great extent, delimit what can be thought about interfaces and shorten the imaginative horizon.

The objective of this thesis is to break the hegemony of a particular type of understanding of the world and interfaces, and to make new approaches available. It consists of philosophical considerations on matters of relevance for the design of interfaces. It takes the position that the graphical user interfaces of computers (the Desktop Metaphor or Windows, Icons, Menus, Pointers ['WIMP']) that ordinarily come to mind for most people are cognates of much older interfaces that are discussed in philosophy and cognition theory under headlines such as 'perception,' 'cognition' and 'representation.'

The conception that is disputed is that the primary way of making sense of the world is to deal with things. In the course of the dissertation this conception is identified as "the Format of Things." The format is embedded in our everyday thinking. In relation to design,it is found in the name taken by the design community, that is human-computer interaction (HCI), and it is mirrored in the desktop metaphor, wherein information is conceived of as the manipulation of objects by a user. This conception of the world is not claimed to be wrong, but in the course of the dissertation it is revealed as accommodating a way of engaging in the world that is expressible with pen and paper. Approaching the world in terms of "things" creates the optimal conditions for speaking, thinking and describing the world in words. In contrast, I claim that the computer is capable of creating dynamic phenomena in relation to which words are superfluous. Furthermore, I explore the possibility that such phenomena can be designed to support knowledge work in a way that matches or surpasses speech and writing. The well from which we draw our design ideas for novel interfaces is therefore needlessly restricted by a format that has outlived its purpose. The objective of the thesis is to dismantle the format of things as well as to sketch out novel paths of inquiry for new interfaces.

The dissertation is based on ideas found in philosophy, Human-Computer Interaction, Cognition theory (enacted, embodied, embedded, extended, situated and distributed), cybernetics, ecological theory, and sociology. The intention is not to take credit for the insight that the world has to be considered in dynamic terms. This is already suggested or explicitly defended in the works of several of the writers taken into consideration in the dissertation. Rather, I explain why, despite available theories to seek alternatives, interfaces continue to be conceptualized in terms of things and point to ways in which this tendency can be subverted.

The goal of the dissertation is to rouse the design community to approach the problem of creating future interfaces from a perspective that is less certain and more exploratory of how meaning is created. On the cusp of virtual reality gear reaching the broad consumer market, the question of how meaning creation turns 3D (or from atoms to photons) is ever more relevant.

ISBN: 978-87-7684-688-6

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