The technological construction of reality

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Dedications

We dedicated our first book to our wives.

We dedicate this one to each other.

We dedicate the next to Artificial Intelligence, just in case.

CHAPTER 1

INTRODUCTION: TECHNOLOGY AND REALITY

The technological reshaping of the world

Since the dawn of a self-perceived intelligent humanity, we humans have developed several different artifacts to impose change on the world around us. The original spirit of these technological developments found humans constructing tools to adjust their immediate reality. For example, harnessing fire, a primal form of technological development, allowed humans to keep warm. While local temperatures can be raised naturally, such as in volcanoes, it would be impractical to live too close to an inferno just to keep warm. Early developments planted the seed for what was to become a broad field of technological innovation. With each seed planted, deeper roots grew, and technology came to have both an enabling and a transforming effect.

The emergence of the modern world has seen technologies that produce food, satisfy domestic needs, enable construction, transport and communications, and develop medicine, etc. A new technological order began rapidly expanding from around 1750 with the steam driven industrial revolution. Subsequently, the rise of the modern chemical industry, the internal combustion engine, electricity and nuclear power, were a few central pillars of a new age of innovation (Eichholz, 1961). This second wave of innovations resulted in a quickening of the tempo with which technology has come to play a pivotal role in the development of the world around us. However, within the past few decades, technology has also come to interfere with the very fabric of this world, and in far more fundamental ways. Consequently, the focus of technological innovation would inevitably shift from the periphery of our perceived reality to its very core.

Until very recently, technology was either very basic (but still innovative) and/or it took inspiration from nature. For example, the discovery of penicillin, produced naturally by the penicillium mould (Bédoyère, 2006), allowed a new technology (i.e., antibiotics) to control infections. In all such similar cases of marked technological development (however advanced and impressive their effects might appear), their construction within what can be called reality is a replication of something occurring naturally. Humans could now govern and steer their immediate reality in the sense of early cybernetic and systems theories (von Bertalanffy, 1950, 1969). Such technology allowed humans to carve out a course in the world around them, and in the case of biological innovations, also to steer the world within, thereby gaining an evolutionary advantage (e.g., survive a cold winter, or an attack by a virus).

Furthermore, it is important to reflect on the invention of technologies based on phenomena that are found nowhere in nature. For example, in materials engineering, the invention of synthetic plastics in 1907, which are chemically derived from gas, oil, coal, minerals, and plants (Birley, Haworth and Batchelor, 1992). It takes a combination of unnatural techniques to bring plastics into existence, unnatural in the sense that the net combinations used to produce an output cannot occur naturally in any way. Lasers are another example of such a genesis. Modern humans take these advances for granted, considering them to be a casual part of everyday life. But these are quite astonishing developments, particularly when viewed from a philosophical and particularly an ontological standpoint. We cannot overemphasise the fact that such developments can be framed as *bringing something into existence,* something that did not (and could not) exist previously by any natural means.

The development of synthetic plastics (and similar discoveries) in this context is astonishing because for most of human history, to shape and transform the world around us we have been constrained by both nature and the resources available. However, similar developments in artificial materials, have helped us gain the ability to create entirely new substances that have no direct analogue in nature, and no direct correspondence to how the natural world is materially expressed. This is a distinct transition in our ability both to shape and to transform the natural world in unprecedented ways. Sometimes such unnatural naturality is fundamentally at odds with the reality that accommodates it. Because of this contrast, artifacts like plastics take more than 1000 years to dissolve, and in fact, never dissolve fully, leaving us with an environment increasingly polluted with microplastics (Andrady, 2011).

The list of unnatural innovations is not only expanding, but also becoming more elaborate and complex within various fields of human endeavour. For example, the creation of microchips in microelectronics, an incredible feat of engineering in its own right, is seeing competition in spintronics (Moutafis, Komineas and Bland, 2009), a branch of physics/electronics/computing that elaborately controls the spin of electrons in solid state systems, which opens up unique pathways that can revolutionize electronics and computing by storing digital information on the spin of electrons.

Novel computational applications, relying on the abstract syntactic and digital symbol-processing systems of machines, have changed human reality beyond its ordinary physical activities. The world has come to be seen as information, which can be abstracted computationally, virtualized, bound logically, and operated upon algorithmically. This has given us the capacity to simulate, execute operations on large datasets, virtualise functions and resources across a series of domains, and use digital technologies across all industries and areas of application. It has also led to an increasing recognition that technology does not merely represent phenomena, but also produces them (Schultze, 2016).

While earlier technologies allowed for a change in the world around us, more modern forms are changing the world within. By within here, we mean not only our internal logical and biological reality, but also a re-entry into reality itself. This is a deeper, more esoteric turn; it is a unique self-referential structure (Bartlett and Suber, 1987; Geyer, 2002) which assimilates novel constructed realities and re-inserts them into the fabric of reality, thereby elevating the options for novel constructed realities. In a way, modern technology has become the enabling ingredient through which we can turn reality in on itself. In doing so, we find that there is a significant degree of malleability in what can be technologically constructed. The degree of reality-construction through technology is not marginal but profound. Technology is creating new and not just slightly different realities.

This signals a radical twist in our conceptions of technology and revitalises the need to reconsider its broader role. Indeed, over time, we have been developing yet more tools to inflict change upon ourselves. This far more foundational technology-driven interference opens a whole new chapter in our relationship between technology and what we perceive as reality; it repositions the relationship between technology and nature as well. For example, the creation of new biological forms in the field of synthetic biology, including developments in artificial life, creating embryos from stem cells, precision genetic editing with CRISPR, and emerging forms of biohacking, construct new biological realities, or edit pre-existing ones at the deepest possible ontological ground-level of biological reality. Another example, metamaterials, are now being developed that exhibit so called exotic properties found nowhere in nature, such as negative refraction, cloaking, superconductivity, and others, essentially constructing new physical phenomena and twisting the structure of nature (Huidobro *et al.*, 2018). We are prompted to recognise this as the *stabilisation of new forms within reality.*

This ontological malleability at the most basic level of reality signals a far more subtle situation. We are not just discovering the world around us; we are constructing it. This raises again a question that has preoccupied modern humanity and philosophy since time immemorial: what sort of reality are we in? What sort of reality allows itself to be manipulated at its very foundations? It is as if reality itself has given us permission to bring forth new forms of reality, equally fundamental in their being real, and equally astonishing in their potential. This birthing of new realities, this novel existential conjuring in the art of a *technologically-induced ontological genesis*, is not only a new chapter in the relationship between technology and nature, but also a seismic shift in our understanding of what it means to be human, of what it means to be real, and of what the new frontiers of technological interference can be.

Although far from being the most foundational, the potential of artificial intelligence (AI) has exploded onto the scene. Given this technology's deeper ontological interference, a much broader discussion is needed, to rethink of the deeper role of technology from an observer-relative perspective. In a somewhat parenthetic remark, we note AI is yet another disappointment for the objective realists, as if the more foundational discoveries in the theory of relativity, the wave-particle duality, the Heisenberg uncertainty principle, and other fundamental discoveries that challenge the view of a fixed background reality, were not enough (Angell and Demetis, 2010). The operative structures within which AI can impose decisions of its own making, particularly in the form of neural networks with machine learning and deep learning, further complicate notions of a determinable reality. At various levels, uncertainty, relativity, and observer-sensitive framings are now computationally expressed.

It is against this complex and dynamic ontological backdrop that digital technologies are starting to play both a critical part in the *construction of new realities,* while at the same time giving us the freedom to *edit reality itself.* This denotes a more creative paradigm, a more malleable understanding of what is ontologically possible, and a more varied frontier on which innovations become plausible. Consequently, the very foundation of reality becomes open to alterations and to new options. The implications are staggering, and the possibilities are, by and large, limited only by human imagination. The question, therefore, is not whether we can create new realities, but what kind of realities we want to create. The editability of reality, however, will come at a cost. Will there be an equivalent 'microplastics polluting effect' for artificial intelligence? How will the autonomous hijacking of human decision making create a lingering digital effect of unintended consequences? Naturally, the hazards associated with this new level of ontological tampering are significant. The dangers of the technological construction of reality are also clear: loss of trust in reality; creation of false narratives; increased potential for deception; manipulation of public opinion; amplification of echo-chambers; distortion of historical facts; erosion of privacy; surveillance and control; widening inequality gap; job loss and automation; elevated dependence on technology; cyberattacks and hacking; spread of misinformation; fragmentation of societies; weaponization of technology; loss of personal agency; ethical concerns and dilemmas; addiction and dependency; disruption of social norms and values; unintended consequences and unpredictable outcomes. These will be discussed throughout the different chapters, and a broader reflection will be given towards the end of the book.

Of course, there is another reading to reality-construction, one that is more esoteric to humans and perhaps more phenomenological in that regard (Husserl and Hardy, 1999; Sartre, 2003). Initially, as Heinz von Foerster would have put it, we humans always bring forth a reality. It is what we do. We create a reality through an elaborate cognitive and interpretive reconstruction of perception data, or else, we see the shaping and construction of our experienced reality as an in-mind phenomenon that is dynamically engaging the reality that it experiences, instead of simply passively observing some pre-existing objective reality (von Foerster, 1981). As von Foerster's insights rest on the classic constructivist pillars in which the role of perception, language, and culture partake in the shaping of human experience, and in the understanding of the world around us, there is another, deeper level of *radical constructivism*, which asserts that knowledge is *not discovered* from an objective reality but created/constructed by the observer. We will come back to technologically-inspired implications for radical constructivism, particularly in situations where novel constructed realities test the boundaries of knowledge construction and re-construction, such as in the interplay between our intelligence and artificial intelligence.

While new technological innovations reset and expand the range of experiences available to any given observer across various human-machine interactions, they also enhance reflexivity and self-reference, and severely challenge traditional notions of reality. They also raise new kinds of questions. For example, if machines simulate cognition and bring out their own (logical, even if not emotional) experiences, can they be considered as observing systems? Do we need to consider a phenomenology for machines? If machines construct new realms of reality in a novel biological reality where we design DNA, 3d- or 4d-print it, and create (artificial) life, will this change our perspectives by considering evolution by un-natural selection in a non-Darwinian paradigm?

Whatever the fabric of the technological construction of reality, the relationship between humans and machines is on track to a truly profound and revolutionary shift. The more fundamental relationship between technology and reality will be tested to the extreme. Ironically, in a recursive mode of interference, these constructed realities also come to influence descriptions of the perceived reality of the old positivist order.

We admit at this point that nowadays post-positivism has mostly taken hold after the invention of quantum mechanics, even in the realm of what some would call the hard sciences. In such a post-positivist world, the observer must come first. It is the observer that constructs the world. In fact, two different observers are even entitled to their own facts as latest scientific advances demonstrate through experimental testing of local observer independence (Proietti *et al.,* 2019). In a fascinating experimental set up at Heriot-Watt University in Edinburgh, researchers succeeded in showing that quantum mechanics is effectively incompatible with the assumption of objective facts and that in the quantum level, "there may not be an objective story to tell" (Proietti *et al.,* 2019, p.1). In fact, the 2022 Nobel prize in Physics has settled the decades-long debate, giving empirical validation to the idea that the *universe is intrinsically indeterministic* and hence Einstein was wrong when he said that 'God does not play dice with the universe' (Sinha, 2023). Perhaps it is in the seeds of that indeterminism that the option of ontological malleability has taken hold, and it is within these possibilities that the emergence of a new world order becomes possible: one wherein technology constructs physics itself by creating new 'unreal' realities.

Accepting indeterminism in the context of the technological construction of reality is accepting the following triplet: 1) *freedom* to make choices in the sociotechnical shaping of reality, 2) *creativity* where there is more room for *ontological innovation* and novel reality-construction, 3) *responsibility* to assimilate the technological construction of reality within a broader second-order society that emerges from a deeper appropriation of technology. This latter part, where a digital meta-society is constructed, requires careful consideration of the risks associated with it, and the dangers that emerge.

This notion of second order is extremely important and will recur many times in various contexts throughout this book. The term involves a thing being perceived by an observer, rather than the thing in itself. For example, with Artificial Intelligence, first order intelligence is the machine's behaviour being intelligent on its own terms, whereas second order intelligence is the observer interpreting that behaviour as intelligent, usually in relation to human intelligence. In AI, most references to intelligence are second order. And the authors commenting on the observer looking at AI is a third order observation!

For the reasons mentioned above, and the theoretical demands that these place on reflection, the authors subscribe to Systems Theory, and will use a handful of its theoretical constructs to allow them to reflect on the technological construction of human and possibly other realities. They subscribe to the second-order cybernetics branch of constructivism as proposed by Niklas Luhmann (Luhmann, 1995). More specifically, they take the view that the world is not discovered, rather constructed by *observing systems* when interacting with their – more complex – environments. This position does not deny the existence of a real world, but it argues that systems are entities either perceived in or inferred from observation, or conceptual systems such as logic, mathematics or music, which are symbolic constructs. Therefore, a system is not something presented to the observer, but recognized by the observer. This means that the construction of a system depends on the observer, on his knowledge, interest, ability, etc. While it is always the case that the syntax is not sufficient for the semantics (Searle *et al.*, 1992; Searle, 1995), digital technologies can be conceived of as observing systems, imposing their own computational rationale, based on the possibilities for computational realities that they embody.

With technology, more specifically digital technology that encapsulates symbolic systems, we have the mediation of the dynamic between observing systems and their environments. Technologies (digital or otherwise) come both to deconstruct and reconstruct the reality with which observing systems interact. Furthermore, as symbolic systems advance in complexity (e.g., novel computations like deep learning, which bring forth new computable realities), the deconstruction and reconstruction of reality they enable become increasingly opaque. For example, we will see in the chapter on the construction of financial reality that algorithmic activities can escape economic rationale altogether.

This deep reliance on technology, coupled with the new realities that it constructs, give rise to a fundamentally different outlook in how technology constructs the reality arounds us. No domain remains untouched. And while most analyses seem to focus on linear paths of reality-construction, where science constructs technology, in this book we are more interested in exploring the recursive, self-referential constructions of reality.

As we will see, we are constructing reality through both physical and digital technologies, and through complex sociotechnical constellations of interactions. These bring forth new realities into existence (Foerster, 2002). Some of these new realities quite literally occur within the existence of humanity itself. For example, through latest technologies like CRISPR, we can now edit our own biology, and even create new life forms that did not exist previously in any form. As in just one example described later, advances in the field of *synthetic biology* use a combination of physical artifacts and digitalisation processes to digitalise the genetic code. We already have the tools with which computer code is translated and synthesised into new DNA strands. A digitalisation process, a high-precision chemical copy-pasting technique, and a 3d-printer that prints DNA are the essential components of this novel development. The technological construction of biological reality is pushing the boundaries of what is ontologically possible, which will even interfere with our own base (biological) reality. Technology has become a constructivist's pipedream, a hybrid observing system that mediates the construction of reality. Technology 'acts' as both an observed system and an observing system. Such systems of interference will imply that objectivity and causality are delusions (Angell and Demetis, 2010), which will be expanded on in Chapter 3. But where does that leave human observers?

With the development of computer-based technologies and algorithms, this latter form of ontological malleability opens up new avenues that interfere with reality, not only of physical reality, but also of social reality. The economic system, the political system and the social system at large are subjected to unprecedented degrees of technological interference. What then is the systemic role of technology in this context?

We are at the cusp of a new era of technological interference with reality: an era where reality becomes invisibly constructed through algorithmic decisions. With the capability of new types of Artificial Intelligence, such as in deep learning, where the probabilistic emergence of categories carries its own epistemic assumptions, a new type of a cloaked algorithmic reality emerges. This too interferes with what we perceive to be our own reality. Digital technologies act as observing systems that re-observe their own outputs in a self-referential process that develops over time. This virtualisation of reality through technology and its algorithmic execution, raises a series of concerns that need to be explored.

It is this set of developments that inspires and prompts us to take a deeper look at how the technological construction of reality occurs, and how our use of (and deployment of) technology has evolved to a point that it brings forth new realities. These new realities interfere with biological, economic, political, social reality at a more profound level. This interference occurs in both a self-referential and a systemic manner (e.g., technology reacts to technological decisions that are created through networks of algorithmic decisions without any human intervention). Coupled with the malleability of reality-construction through technology, we explore ways in which technology interferes with the world around us and how we, as human observers, can reflect on the form of this interference.

Consequently, this book will explore a fundamental question: *how* does technology *construct* reality and bring forth new realities? As the title of the book implies, the authors will be considering the critical role that technology is playing in the construction of the various realities perceived by humanity today: physical, biological, economic, political, and social.

Technology, reality, and the human condition

Naturally, this book's text must confront the very thorny questions of what exactly is meant by both the words technology and reality, as well as how we humans act in (and thus alter) that reality, hence all three issues must be dealt with. That is why this book will start by asking what to many might seem a very surprising question: why do we humans use technology?

First, technology has always been there throughout the history of humanity, and of its progenitors (Eichholz, 1961). Apparently, technology began when pre-humans first picked up what was at hand (bones, sticks and stones) with their fingers and opposable thumbs, and then used these tools for a variety of practical purposes; just as chimpanzees can be seen to do today, albeit without human dexterity.

This apparently innocuous observation conceals a series of subtle issues related to both the way things exist in the world, and the way we come both to know about them and to make claims about them; namely issues of ontology (the nature of being, of reality) and epistemology (*how* we know what we know about reality).

The problem behind this is also reflected quite clearly in the double-ambiguity problem in the philosophy of technology as posed by philosopher Don Ihde: by placing technology within a cultural context, we have a double ambiguity - (a) first an ambiguity that arises when any technological artifact is placed in multiple use-contexts (so the same technology opens up a whole host of repurposing by different users in different contexts), (b) second, we have an ambiguity of selection as any technological intention can be fulfilled by a range of possible technologies (Ihde, 1990). The need to select one technology instead of another eliminates possibilities, contingencies and introduces unique path-dependencies and unique risks. The two aspects together, in a cultural, socio-economic, and organisational context, introduce a degree of indeterminacy to all human-technological interactions.

This injects ambiguity, and it is the key set of influences that dilute the causality embedded within technological operations. Ultimately, we are left with the complexity that surrounds them. Nevertheless, the end result is quite profound. Technology constructs reality-folds around itself, and these not only shape our reality through ambiguity but, in some cases, technology will construct a new reality altogether (i.e., establish a new ontology that – once placed in the world around us – will affect its environment).

Such realities are based on the way humanity categorises the world around us. We are predisposed to a linear form of atomism in which we create cognitively convincing categories. To do this we separate things from other things; entities are separated by a void, designated, distinguished and hence differentiated. This is the fiction underpinning the edifice of classification, which itself drives the thinking of man, the rational being who places his behaviour under the control of abstractions (Nietzsche and Breazeale, 1999).

Is technology just another cognitively convincing category? How is technology constructing new cognitively convincing categories, thereby separating things from other things, resting on the notion of *distinction* as the basic premise of all operations? All technology is very much in the eye of the beholder; it has a subjective, observer-relative mode of existence that does not preclude us from making epistemically objective claims about it and its components, or even epistemically subjective claims (although for reasons that underscore its significance, this book will concentrate mostly on the latter, the observer-relative).

These distinctions do not exist 'in reality'. Instead, they are drawn out by observing systems (technology included), in order to make the world observable, and thereby construct reality. In the words of Niklas Luhmann:

> "Whatever is observed is observed by an observer, who cuts up reality in a certain way in order to make it observable. Whatever distinction is selected, others remain possible. Each cut highlights certain aspects of reality and obscures others. Reality as such, the unity of the observing system and its environment, the paradoxical sameness of difference, of inside and outside, remains inaccessible; it is what "one does not perceive when one perceives it," the "blind spot" that enables the system to observe but escapes observation. An outside observer can make this blind spot visible by distinguishing the observed system's distinction as a form that contains both of its sides, but in doing so, any such second order observation must rely on its won blind spot and is bound to reproduce the paradox of observation at the operational level of its own distinction. Difference is both irreducible and paradoxical: without distinctions there would be no observable reality, yet reality itself knows no distinction" (Luhmann, 1995, p. xxxiv).

What Luhmann is saying is that observation carries a fallacy of linear interpretation. Instead, observation is conditional, but those conditions are necessarily unobservable, unappreciable; hidden in paradox, beyond observation, beyond cognition, beyond logic; these conditions are actually necessary preconditions of observation, cognition, memory and logic, but they must be denied for observation to operate.

> "If one tries to observe both sides of the distinction one uses at the same time, one sees a paradox – that is to say, an entity without connective value. The different is the same, the same is different. So what? First of all, this means that all knowledge and all action have to be founded on paradoxes and not on principles; on the self-referential unity of the positive and the negative – that is, on an ontologically unqualifiable world. And if one splits the world into two parts, marked and unmarked, to be able to observe something, the unity becomes unobservable. The paradox is the visible indicator of invisibility. And since it represents the unity of the distinction required for the operation called observation, the operation itself remains invisible". (Luhmann, 1995, p. xxxiv).

Here Luhmann uncovers a most powerful ontological delusion, a drive to qualify the ontologically unqualifiable world: the notion of the system and its complement, the thing being observed separated from everything else. Observation requires that we, as observing/cognitive beings, must distinguish and categorize the distinctions informed by memory; we indulge in the fallacy that we can separate each thing from its everything else, and treat that complement as a residual category. It is with this separation and categorization that we build up the memories that feed back into observation and cognition. So observation is, by its very nature, non-holistic, artificial, unnatural. Or in Luhmann's words, "the world is observable because it is unobservable" and "the condition of its possibility is its impossibility."

Cognition requires both the observation of each categorical thing, and at the same time the non-observation of the unbroken links that remain between it and its residual category. Meaning is based on the error/absurdity of compounding separation upon separation, a mountain of things categorized and distinguished from their residual categories and stored in memory. In the observed world, each thing and its complement can only exist as complements; they are otherwise non-referential. All reference between them is cut, as the distinctions needed by observation (cognition and memory) must separate utterly, with all connections severed.

A necessary precondition for the survival of each individual human system is the ability to profile its environment, and to position itself within that environment in order to create beneficial connections for itself. An appreciation of the premises of observation is therefore crucial because being able to observe is critical, not only for sustaining human life (and our individual survival within each of our respective environments), but also (and of particular interest to the authors as students of information systems) for the development of artificial constructs (non-human actors) like computerized algorithms that become equipped with an observational capacity infused by the will of humans.

From such humble beginnings of primordial observational faculties, the human species has evolved to having created a series of products of advanced engineering: from nuclear power, spacecraft, the Hubble telescope, to supercomputers and artificial intelligence, to the Large Hadron Collider, to the CRISPR editor that allows us to edit the genome of living organisms. The development of technology to a degree where we can literally *edit existence,* and thus, *edit the ontological state* of DNA, or synthesize new forms of existence in the field of synthetic biology where a living thing is replicated from digitalised and manipulated DNA, creates thinner boundaries between ontologically objective and subjective modes of existence that play conceptually at the boundary between the two. While many technological developments give the appearance that we develop artifacts in the world out there, some of which are sophisticated tools that can be used by humans, the evolution of (digital) technology has led to a level of interference of what we casually perceive to be reality at a much more fundamental level. How has that process unfolded?

Early thinking from seminal works sees technology as something that is constructed by us humans. According to Herbert Simon (1996), technology is something that is *external to us*, and which we have placed out there in the physical world. Therefore, in his view, it is artificial: a technology of artifacts. According to Simon's treatise (1996, p. 5), these are portrayed as follows:

1) Artificial things ["artifacts"] are synthesized (though not always or usually with full forethought) by human beings.
2) Artificial things may imitate appearances in natural things while lacking, in one or many respects, the reality of the latter.
3) Artificial things can be characterized in terms of functions, goals, adaptation.
4) Artificial things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptives.

In addition, Simon (1996) clearly conceives of the computer as an artifact:

> "The computer is a member of an important family of artifacts called symbol systems, or more explicitly, physical symbol systems . . . symbol systems are almost the quintessential artifacts, for adaptivity to an environment is their whole *raison d'être*. They are goal-seeking information processing systems, usually enlisted in the service of the larger systems in which they are incorporated." (p. 21–22)

Of course, despite the existence of some systemic characteristics in Simon's work in the context of the quotation above (e.g., system/environment), it was generally understood that computers as artifacts adapted to a very particular type of "environment" — one both created and guided by human decisions. Such artifacts are "human-created artifacts that have value insofar as they address this task" (March & Smith, 1995, p. 258). But as Demetis & Lee (2018) argue in their discussion, this conditioning has progressively been eroded and substituted by IT artifacts that are developing into *systems* that largely *create the environment* to which they themselves react. This human/machine role-reversal changes the landscape and puts machine reality at the forefront. Reality-construction through computational means can then be seen as a process of re-entry in which the constructed reality is co-created through recursive processes (Luhmann, 2002).

The complexity of how technology interferes with the relationship between observer/observed is elevated by all these different forms of recursivity and the computational encapsulation and rendition of reality. The entire process creates not one but many co-constructed realities that interfere with each other. Untangling these observer-relative reality-folds at a meta-level, as well as reflecting on their interaction, are considerable challenges. This is because, the moment a technology is created, it affects a much broader nexus of interactions, at the levels of both ontology and epistemology.

First, at a simple level, the very act of constructing an artifact implies its simultaneous deposition into an existing referent reality; this prompts a change at the ontological level since new artificial items (i.e., new technologies and artifacts) now exist within that reality.

Second, use of such technologies, shapes the way in which we interact with our observer-relative realities, and this affects the interaction itself; technology does that by co-creating a boundary of mediation alongside humans. The interaction between humans and technology then allows human observers to interpret the world around them in a novel way. In many ways, we bring forth a reality. The very act of speaking (the *logos* in *epistemo-logy*) about how we know what we know (epistemology) necessitates an interplay on these boundary conditions that are a negotiation between humans and technology.

There is however another internal and systemic technology that is part of a reality-within. This refers to human *cognition*, a faculty that self-constructs its (own) reality; a capability that all humans are born with, and one that rests upon a form that has existed even before pre-humans picked up the first stick or stone. This unique internal technology of ideas is an ideas-creator and a constructor of possibilities.

Each individual human is a biological holder of cognitive abstractions, which has the ability to construct *abstractions out of abstractions*. This unique self-referentiality can become both encapsulated and instantiated into what we casually call technology. In a way, our internal technology (i.e., our cognition) gives rise to, and enables, the construction of external/artificial technologies. Then feedback from the latter affects the way our internal technology is reshaped in order to reconstruct further external/artificial technologies … and so on. This dynamic is important, as it alters the course of our perception of reality. As we will see, it is also fundamental to the multiplicity of realities that emerge from the interaction between internal and external technologies.

Even the artifacts that humans place in the world must start out in this internal technology, as ideas in somebody's head. In fact, the entire edifice of design is an exercise of externalisation. Whether consideration is restricted to the external and artificial technology of artifacts a la Herbert Simon, or extended to the natural internal technology of ideas, clearly everything starts with an idea.

Such ideas are emergent phenomena that demarcate a spontaneous semi-autonomous development of connections between previously-observed but seemingly unconnected elements, which sparks a new level of organisation recognised as distinct. Human cognition has the ability to construct schemas (we call this *pattern-making*) that it maps onto a complex collection of the elements that it has observed (we call this *pattern-matching*) in order to simplify the cognitive representation of those elements, and from which it formulates decisions and initiates actions.

Even though a list of steps always tends to simplify any domain of exploration, particularly since there are always non-linear aspects involved, interactions and feedback-loops between such steps, the authors still find it useful to include such a list in order to break down some of the key milestones in the transition from the *existence of a mere passive observer* (awareness) to processes of pattern-making and pattern-matching. Doing so can help us appreciate and explore the ways in which technology then is being used both to externalise cognition, or in the case of artificial intelligence, to develop ways in which cognitive emergence and spontaneity can occur.

Step 1: Accepting at an ontological level the existence of a cognitive observer.
Our starting point is the axiomatic ontological acceptance of cognitive observers. This has two aspects that are significant. The first is influenced by 'the *cogito*' and Descartes' insight that even in the face of doubt we still have the reality of one's own mind, in the sense that there must be a 'thinking entity' (i.e., the self) in order for there to be a thought. The second is that

this cognitive entity is also an observer, or more generally, an observing system. Admittedly, there can be different modes of observation, and these affect cognition in a dynamic way. But it is largely the cohabitation of *observing* and *cognizing* that constitutes, constructs, and evolves the apparatus through which we perceive reality.

Step 2: Part of cognition is the 'operating *system*' that is structurally coupled with observation. Once we accept that cognitive observers exist, then the functions of cognition and observation are seen as intertwined and structurally coupled. Both work synergistically, and their symbiosis is what allows the cognitive observer to evolve. Thus, reality is constructed from within; more specifically, it is constructed from within the structural coupling of cognition and observation (with of course the inclusion of memory).

Step 3: A function of cognition is to generate distinctions that steer observation.
Precisely because of the coupling of cognition and observation, it is difficult to untangle the dynamic between them, yet this book has to start somewhere. This is taken to be where cognition generates the distinctions that steer observation. As was noted above, we humans can only observe through making distinctions. However, we also acknowledge that the function of observation is to generate new elements that will allow cognition to become further differentiated. This condition bestows cognition with the capability of increasing its variability in distinction-making, ultimately allowing the cognitive observer to steer observation further. The generation of distinctions, upon which a cognitive observer's constructed reality emerges, is fundamental, and is the basis for engaging with the world around us.

Since this book is about technology, and because computers are often portrayed as far superior to humans when it comes to computation, it is only right that we recognise that a human's categorisation of what is relevant in his surroundings far outpaces a computer's ability to do so. No matter how fast computers are, at present, they cannot compete with the interpretative subtlety and the contextual intuition with which the human brain scans its environment – almost instantaneously recognizing whatever is in its field of view.

Step 4: Generated distinctions reduce world-complexity and precipitate the progressive simplification of reality, by enabling the focusing of observation.
Once we accept the existence of a cognitive observer and the coupling between cognition and observation, then the question arises of how the observer manages to observe in a meaningful

way, rather than being overwhelmed by the totality of reality. The answer is that the function of the observer (through cognition) is to generate distinctions through which the world can be observed. As Luhmann (1995) frames this issue: the world is observable *because* it is unobservable and the condition of its possibility is its impossibility. To paraphrase what the authors wrote in *Science's First Mistake*: These two apparently nonsensical sentences actually make perfect sense. What Luhmann is saying is that observation is not, cannot be, what we think it is. Observation of a part is only possible because the whole is unobservable. Not that the whole in this respect can be defined, for then that whole would need to be distinguished from everything but the whole itself: namely, distinguished from nothingness. Such separation is intrinsically problematic, starting with the impossibility of defining *nothing*, as noted by Luhmann. The *whole* therefore takes on two different meanings in itself, introducing yet another distinction: i) the whole defined by an observation that separates that whole into what is being observed, and what is not; and ii) the whole as the external reality that cannot be investigated without the operation of observation.

By necessity, the act of observation actively involves the observer in the world so that he has choices and is not at the mercy of inertia and inactivity. It becomes evident that in observing, the observed part is distinguished, separated. That very act implies that the separation between what can be observed and what must be left unobserved is more of a necessity than a mere compromise. However, such a necessity comes with problems and paradoxes. What is observed is not the thing itself, but an internalized representation of that thing, which has to fit into categories constructed for it by observation, cognition and pattern making/matching.

The cognitive sampling and categorization of things observed in the world is both the result of observation, and the means whereby observation is possible. We do not observe categories, rather through categories. The very act of categorization remains an obscure selection process that is guided by the success or otherwise of previously chosen categories. Each observation categorises things in the world via the imposition of linear distinctions. These things are separated within the observed scene, but they still remain structurally coupled to the rest of the world. These couplings are lost to the particular observer, but they remain part of a non-referential system created by the self-reference imposed by original observation (as the unobservable part of the distinction). However, they may appear as other-referential systems within the self-reference of other observers.

Thus, the observer generates distinctions that carve reality into *observable/unobservable* spaces. This operation occurs many times, enabling a reduction of world-complexity and the progressive simplification of reality. It is this sequence that allows an observer to conduct more focused observing.

Step 5: Through focused observing, the selected elements are internalised by the observer and codified into the observer-specific cognitive reality.

Thus far we have accepted the existence of a cognitive observer, the coupling between cognition and observation, and the primacy of distinction-making as the mechanism through which world complexity is being reduced (and consequently, the progressive simplification of reality becomes manifest). Clearly, the outcome of this process affects the observer as it generates new elements that can only be realised relationally; that is, these new elements (we can think of these as some sort of *cognitive quanta*), once created, find themselves within a pre-existing nexus of other elements (in memory). The assimilation of new elements within the stratum of cognition is also a cognitive process, in fact a creative one where new connections are enabled and realised dynamically from within the full spectrum of cognitive possibilities; this is delimited only by what memory can recall and how consciousness within a cognitive observer affects the observer's state of being, as well as the observer's capacity for synthesis. But overall, it is safe to say that we do not know how the brain does it and how it gives rise to the one conscious experience through which cognition and observation are realised (Chalmers, 2010).

Step 6: The spontaneous semi-autonomous development of connections between seemingly unconnected, previously-observed elements, gives rise to ideas.

Once the observer is accepted as an entity that relies on a dynamic relationship between observation and cognition, and as we saw in steps 4 and 5, when observation essentially functions through the creation of distinctions that carves reality into observable/unobservable spaces, thereby allowing for a progressive simplification of reality, we are ultimately left with how new ideas are generated. As the creation of new ideas is an emergent phenomenon, it is impossible to describe the mechanism of how the generation occurs with any precision. Nevertheless, there are some aspects that can be thought of as attributes at a meta-level of the mechanism itself. First, we can acknowledge that it is a semi-autonomous mechanism, in the sense that it can be guided from within the cognitive capacity of the observer based on an intent (e.g., create an architectural model of a new building, or develop an equation to describe the movement of ants, or build a rocket), but it is also unguided in how the brain progressively develops connections between seemingly unconnected and previously-observed elements. Realization of not enough connections can prompt the observer into a further dynamic of cognition and observation of the world around him, however, this takes us back to step 5 and the internalisation of new cognitive elements. At this stage, most of the processing takes places within the cognition of the observer in a self-referential manner. Cognitive quanta are recalled, synthesized, re-networked and unconnected elements give rise to new ideas.

Step 7: New ideas can be depicted into notational schemas, symbolic systems and machines
The culmination of these seven steps means that human cognition makes sense of the world it observes, and we are convinced by our interpretation of that world. We have fabricated reason and its reasonableness (Heidegger 1999) while we can also depict new ideas into notational schemas, symbolic systems and machines. Cognitive quanta, once assembled self-referentially by cognition, can now be externalised and taken forward into various forms.

References of Chapter 1

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