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Technontologies, Complexity, and Hybrid Interfaces

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Abstract: *NBIC (nano-bio-info-cogno) applications enable hybrid cognitive interfaces between matter and mind. These hybrid interfaces between human and artificial intelligence are also found in cyberspace. These new developments, together with recent advances in quantum computational physics, challenge traditional philosophical ontology. The nature of being in relation to reality seems to be transformed. New ontologies, technologically based, appear. We call them technontologies. Pan-communicationalism is the most important technontology, evolving around the concepts of ubiquitous information, universal semiosis and a universal quantum computational matrix. Being seems to be, in this context, meaning in modulation.*

Keywords: NBIC convergence, complexity, technontology, universal semiotics, pan communicationalism, ontology

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1. Introduction

It is now possible, philosophically and scientifically, to understand matter in terms of information (Deutsch, 2003; Floridi, 2007; Wheeler, 1990). The informational nature of matter enables science to re-configure it through nanotechnology. Nanotechnology represents the promise of total integration between all material structures, be they biological or non-biological. NBIC (Nano-Bio-Info-Cogno) convergence (Bainbridge & Roco, 2006) is today the closest we have got to such total integration. Bio refers to biotechnology, Info refers to information technology, and Cogno refers to neurotechnology (cognitive science).

When applied to biology, nanotechnology makes the design of new organisms a reality; applied to information technology, it makes intelligent nano robots – nanobots – come to life; applied to cognitive science we have hybrid interfaces between mind and matter. Scientists are now using nanotechnology to build a common information system that integrates biology to robotics within cognitive applications, creating incredible new possibilities for redesigning and expanding our current human capabilities (Bainbridge & Roco, 2006).

The wildest possibilities are those related to nanorobotics and neurotechnology. An example of the kind of new hybrid interfaces that are emerging as a result of NBIC convergence is the research currently being done on *Biologically-Inspired Robotic Cellular Architectures* (Bernstein et al., 2006). Through the mapping of the neural circuits within the brain, nano artifacts are being designed that simulate the behavior of neurons, being able to interact with and be integrated to systems of cells. This is the new field of neurotechnology (Khushf, 2006).

By engineering and applying nanobots endowed with various degrees of Artificial Intelligence (AI), scientists get able to introduce intelligent agents into all types of material and molecular structures. When these nano intelligent artifacts enter within the neural networks of a brain, they become part of the conscious experience of that brain.

Many other nano applications are possible, all of them based on the decoding of natural patterns of information and on the coding of technological patterns of information which will interact with and sometimes surpass those of nature. The Cogno area of NBIC convergence entails intelligent digital interferences within neural informational processing networks, expanding the scope of human cognitive capacities. Nano enabled mind/matter cognitive interfaces are new forms of hybrid intelligence that are emerging as a product of NBIC convergence.

On a micro level, cognitive NBIC applications are material interfaces in which the merger between artificial and human intelligence takes place in the neural networks of a specific brain. Similarly, on a macro level, digital social networks are a collective product of the merger between artificial and human intelligence which is virtually embodied in cyberspace. There seems to be an ever closer technological relationship between material and cognitive; matter and mind. Converging technologies (Nordmann, 2004) bring together mind and matter at the edge of cognitive nano enabled interfaces, while pervasive digital information technologies enhance matter with properties that are comparable to those of mind. Such hybrid forms of intelligence represent the future promises of NBIC state of the art.

Hybrid cognitive interfaces are a product of the hybrid flow of information, information processing and the creation of common semiotic systems through quantum manipulation. The quantum level of matter is characterized by modulation, and modulation in itself is understood as a particular kind of intelligence-driven information flow by some quantum physicists (Deutsch, 2003; Lloyd, 2006). Quantum modulation (as information flow) is found in mostly every level of convergence, placing the entire debate on nano convergence within the realm of complexity studies.

Quantum complexity is not only at the underlying physical level uniting all material structures so vividly within NBIC convergence. It is also at the heart of intelligent processes of cognition, be they natural or artificially mediated. Non-linear dynamics are found to exist everywhere from biology to computing and back. In fact, non-linear principles of computation are being used to develop nano artifacts for hybrid cognitive interfaces (Bernstein et al., 2006). Therefore, complexity is at the core of converging technologies, especially when cognitive applications are at play. The realm of converging technologies, be they digital or nano, shares many important aspects with the realm of complexity. These are the scientific facts. Both represent scientific revolutions in their own ways. Complexity is about quantum properties; NBIC convergence is about quantum manipulation.

Together, converging technologies and complexity raise many important ontological questions. How do these new possibilities change our *being-in-this-brave-new-world*? Are hybrid cognitive interfaces hybrid forms of *being*? And if they are, how do they stand in relation to philosophical ontology? In this article, we take a look at the new ontologies that seem to be emerging around converging technologies, trying to frame them in relation to complexity.

2. Technontologies

The challenges brought by converging technologies and complexity are philosophical *par excellence*. They range from ontology to epistemology, ethics, and go on to reach the realm of cultural and social studies. There are many examples of the new philosophical and cultural trends that are emerging in response to contemporary technology. Transhumanism, post-humanism, extropianism, etc; all of these movements respond to these new possibilities in terms of reassessing traditional philosophical values. Much has been said about the ethical implications of current advances in information technology (Bowyer, 2000; Brey, 1999) and nano convergence (Capurro, 2006, 2006b). Transhumanists call for a post-human ethics, claiming that there will be no further distinction between artificial and human intelligence in the near future, if reverse-engineering of the brain continues to progress at the same rate (Bostrom, 2000; Kurzweil, 2005).

The ever accelerating speed of technological evolution (Kurzweil, 2005), implied in converging technologies, raises social issues concerning, for example, rights of privacy within ubiquitous pervasive digital networks (Capurro, 2003), risk of environmental and health hazards caused by nanoparticles, and the appearance of a *nano divide* (Capurro, 2006) in the context of a global digital divide. These examples refer to cases in which there are ethical choices to be made regarding possible uses or applications of converging technologies. They do not point to any noticeable change in the concept of ethics itself.

However, hybrid cognitive interfaces within a human mind bring about the possibility that a form of hybrid (post?) human identity could emerge. Here, we move away from the epistemological ground of utility to enter the ontological ground of being. That is why, not withstanding the importance of such ethical claims, we consider in this article that the most significant philosophical challenge posed by converging technologies is rather ontological than epistemological. The re-ontologizing of the world (Floridi, 2008) is about the ontological consequences of the re-engineering of reality that happens through converging technologies.

Philosophical ontology is about the essence of being, or the essence of *being in relation to reality*. Our understanding of the essence of being, or the essence of being in relation to reality, seems to be undergoing a deep ontological renewal. Classical ontology is not sufficient to address the changes that are occurring in our perceptions of reality and the technological advances being made in the way being relates to reality or in the expansion of possible realities available to being. This ontological renewal has been, undoubtedly, triggered by new technologies and the brand new possibilities they pose to humankind. Not only do we have new perspectives about what is there to be known, but also we have glimpses of brand new systems that remain unknown; in such manner that new ontologies, technologically inspired, appear. We call them technontologies (Lemos, Franklin, Alves, & Kern, 2007).

Within the context of converging technologies, the essence of being in relation to reality seems to be all about information, communication, interpretation and meaning. Quantum physics has dematerialized the ontology of matter, which has gone from a newtonian perspective that was solid and concrete (atomic particles) to a quantum perspective that is fluid and modulates (quantum waves). According to quantum physics, matter has dynamics that are very similar to the dynamics of meaning: permanent movement and change, constant modulation in an all-encompassing realm of continuity. Cognitive nanotechnologies have, simultaneously, materialized the ontology of mind, which shifts from the idealistic perspective of mind as pure abstraction to the materialistic perspective of mind as an emergent property of complex neural quantum computation in the brain.

The cognitive interface between neuron and nano artifact enables hybrid ontologies in which idealism is linked to materialism against the background of Peircean pragmatism. What happens is that, through the pragmatic development of functional nano applications, new levels of semiosis come to light in the thresholds of mind and matter. Two levels of intelligence, human and artificial, touch each other through nano devices. Pragmatically, meaning in this context becomes a means to an end (the improvement of human capacities), but also an end in itself (nano enabled semiosis).

Hybrid interfaces are indeed hybrid, not only as systems, but most importantly as the triggering agents of new ontologies. There are hybrid ontologies emerging as a result, all of which consider information to be (on its pure form, dynamics or meaning) the key concept of a new ontological approach that would answer the philosophical challenges of converging technologies. Examples are the three *pan*-approaches, which are pan-informationalism (Floridi, 2007), pan-semioticism (Brier, 2006) and pan-computationalism (Deutsch, 2003; Dodig-Crnkovic, 2006; Lloyd, 2006).

According to these approaches, reality might be understood in terms of informational structures and the flow of information (pan-informationalism); a quantum computation universal matrix (Deutsch, 2003) – ubiquitous quantum level information processing (pan-computationalism); and the semiotic systems formed by continuous semiosis amongst them (pan-semioticism). When NBIC convergence is the issue at hand, these approaches seem to be very accurate. Together, they represent the emerging hybrid ontology of *pan-communicationalism*; which has communication processes, based on the continuous interplay of matter and mind, at its core.

3. Pan-communication

Pan-informationalism postulates that "reality is a pattern of information, a pattern in fact space" (Rucker, 1987, p. 31). Information pervades us and our environment. The way in which information is structured determines what characteristics each object or organism will have, including its condition as living or non-living. We are used to thinking about information as an abstraction, something that exists only in relation to our minds. It can be hard to think of a chair (or a stone, or anything solid and inanimate for that matter) as information. However, information can be concrete and abstract at the same time. Information as the underlying organizing principle of reality could possibly be compared to energy in its material dimension.

Information depends on energy in order to be conceived, distributed, received and interpreted, while energy follows rules that are configured according to previous patterns of information. Information and energy are inseparable (Macdonald, 1994) in the continuous flow of the universe. We are experiencing a shift from understanding reality in terms of the relations between objects and beings to understanding reality in terms of the flow of information/energy and meaning.

On the level of social communication, pervasive digital technologies and immersive virtual environments in cyberspace are external platforms for semiotic continuity between digital artifacts (matter) and intelligence (mind); or between artificial and organic bodies. On the level of nano communication, hybrid cognitive interfaces are inner-body platforms for semiotic continuity between matter and mind. Be it internal or external, continuous semiosis from matter to mind is communication that goes from the quantum essence of matter to the abstract dimension of cognitive experience, and vice-versa. Information is at the heart of both.

Such an expansion of the possibilities and reach of the human mind is not new as a feature of technological developments. Cyberspace has done exactly that, through virtual networks of collective intelligence (Lévy, 1996). Pervasive information technologies such as RFID (radio frequency identification tags) and virtual immersive environments in cyberspace are interfaces where the interplay between artificial and human intelligence is a condition *sine qua non*. Pervasive information technologies could, just like nano applications, be applied to mostly every level of material structures, expanding the reach of intelligent communication across beings and objects/artifacts (Floridi, 2008). Virtual landscapes that promote the emergence of collective expressions of human consciousness are also technologically mediated platforms of cognitive expansion and convergence (Ascott and Shanken, 2003).

These collective digital platforms are addressed by philosophy of information (Floridi, 2007), a new area of research which interprets converging technologies as elements of an information-based, all-encompassing environment: the Infosphere. All beings and things acquire an informational "ITentity". Philosophy of information also interprets the ontological impact of Artificial Intelligence (AI) and the *intelligentification* of external reality (Floridi, 2007). Advances in RFID technologies allow any physical object to acquire an informational identity, called "ITentity" by Floridi (2008). These very small RFID tags are microchips that can be incorporated to living and non living beings and objects, and provide Wi-Fi access to the internet. This type of technology makes possible a new expanded hybrid network of digital and biological informational entities, one that is not restricted to any computational platform, but expands into the surrounding environment, configuring an Infosphere.

In this Infospheric network, human intelligence relates and interacts with AI, forming new hybrid networks of collective intelligence. This combination between human intelligence and AI is expressed by the concept of *inforg*, informational organism (Floridi, 2008). Assuming that by applying RFID technologies to objects it is then possible to confer to each object an "ITentity" (and that this digital *inforg* possesses a certain degree of AI being able to communicate and interact over the Net), then a true *intelligentification* of things occurs.

Beings acquire properties of electronic devices (digital expansion of human cognition) and electronic devices acquire properties of living creatures (intelligence and communication). Converging technologies are making the boundaries between on-line and off-line, digital and non digital, to become less and less clear. Be it digital or genetic, everything is code, everything is information - and if everything is information, everything communicates, and could possibly converge.

Ascott and Shanken (2003) present their idea of an all encompassing technological convergence through the concept of Moist Reality: an inorganic, digital, *Dry* Reality vs. an organic, biological, *Wet* Reality. Cyberception (Ascott, 1994) is the technologically expanded capacity of human perception, triggered by the hyperconnectivity of cyberspace, which informs the concept of Moist Reality (Ascott and Shanken, 2003). The latter (formed by the coupling of the wet dimension of biology to the dry dimension of digital technologies) is very close to the concept of Infosphere (Floridi, 2008).

Ascott also identifies forms of artificial consciousness emerging from the new hybrid interfaces between man and machine. It is becoming more and more difficult to distinguish, in the universe as a whole, man from non man. Ascott's idea of unity within a mind-body-world (Ascott and Shanken, 2003), is equivalent to Floridi's concept of informational unity in the Infosphere (Floridi, 2007); also equivalent to these concepts is the concept of unity of matter in NBIC (Bainbridge & Roco, 2006), a concept firmly established in the ground of complexity. Similar patterns of complexity are being found in many levels of technological convergence, such as the merger of human and artificial intelligence and the recognition of common systems of communication and exchange.

4. Complexity

The complexity we find in quantum levels of reality is also present in hybrid cognitive interfaces and pervasive digital computer networks. Non-linear dynamics operate on biological, computational, cybernetic and cognitive levels of reality. Uncertainty, auto-poiesis, emergence, self-replication: all these characteristics are found to be ubiquitous in the realm of converging technologies.

Nevertheless, what exactly *is* complexity itself? Complexity can be defined as "the property that makes difficult the predicting of the general behavior of a system, even when the information about its functioning and the interrelation between its components seems to be complete" (Edmonds, 1999). This concept originated from a series of advances in the history of science, which demonstrated the coexistence of complex properties shared by all areas of human knowledge. The properties of non linearity, non determinism, self-organization and emergence, constitute a general framework to the study of all complex phenomena (Pavard, 2001). Complexity seems to be, indeed, a group of properties, in which the property of uncertainty has the highest status.

Uncertainty, as a challenge to modern science, does not originate entirely in quantum physics. Originally, uncertainty was relative to the mechanics of celestial bodies. Everything started in the macro level of celestial mechanics, with Poincaré's "problem of n-bodies" (basically about determining the subsequent trajectory of n celestial bodies, given their mass, weight, speed and initial position), which was the first mathematical demonstration of the chaotic and unexpected behavior of a complex system: the universe. A century later, this problem remains unanswered (until today it is not possible to completely foresee the trajectory of celestial bodies due to singularities, antimatter spaces that inhabit the interior of black-holes).

Only later would complex properties also be found in micro levels of material reality, in the work of Heisenberg, Bohr and Prigogine. The limits of formal logic as an all-powerful knowledge method had been enunciated previously to Heisenberg's Quantum Principle of Uncertainty. Quantum theory, however, was responsible for bringing uncertainty to the limelight of science. Although there have been other instances of instability and randomness in science, such as Chaos Theory (which added the concept of hiper-connectivity to the emerging theory of complexity), quantum theory remains the master home of complexity.

After physics demonstrated that material reality (on a micro level) is one single self-organizing mass composed of waves and particles of unexpected behavior, the greatest scientific challenge of our times seems to be to understand exactly how these micro, subtle, and essentially unstable manifestations of quantum energy self-organize in so many distinct physical forms ranging from a living cell to a quantum computer. The physical dimension of everything around us, including ourselves, is made of the same subtle substance in the quantum level. Quantum level systemic organization is responsible for producing the effect of the multiplicity of material, organic and non organic, compositions.

Inherent to the apparent stability of material organizations is its micro physical quantum instability. This characteristic is implicit to the phenomenon of emergence, and common to all complex systems, be they physical, biological or social. From the quantum instability on the underlying level, various degrees of apparent stability emerge on the higher levels; both in social organizations, biological organisms and dry forms of matter. This statement applies to all scientific, technological and social areas, and therefore to all systems we find complex. Emergence can be observed in the functioning of all complex systems: organic, inorganic, digital or analogue. Either in organic or inorganic levels of organization, non linearity in the underlying level of a specific phenomenon gives rise to gradations of predictability in the higher level.

Contemporary science has shown that complex properties are interchangeable, simultaneous and co-exist in all knowledge areas. Complexity is transdisciplinary, since it is related to the entire body of science; for the science of complexity brings about the complexity of science (Fuchs, 2004). The necessity of elaborating new intellectual parameters for the interpretation of complexity propels science and philosophy to re-interpret themselves. Technontologies are calling for technoepistemologies as well.

5. Multiple Levels of Reality

Technontologies have scientific (quantum), philosophical (pan-communication) and technological (converging technologies) aspects. Based on all three, we observe that a new ontological ground of understanding starts to emerge around the concept of multiple levels of reality (Nicolescu, 2007). Multiple levels of reality connect visible to invisible, into more or less accessible environments of information networks available to perception.

If the concept of multiple levels of reality is new to the hard sciences, it is very old when it comes to philosophy. In classical philosophic ontology, the notion of multiple levels of reality exists ever since the Greeks. Ontology is in itself based on this multiplicity. Some philosophical theories of multiple levels of reality distinguish four great levels: that of natural, physical, phenomenological and intuitive realities; also distinguishing levels of material reality from formal reality (Poli, 1998). The significance of the idea of multiple levels of reality is so great in philosophy that it acts as a pillar for phenomenology and also for metaphysics. A philosopher in his own right, Heisenberg had also pointed in the direction of the concept of multiple levels of reality (Nicolescu, 2000). In fact, it was only after quantum physics that the notion of multiple levels of reality acquired a scientific connotation.

Simultaneously, Information and Communication Technologies (ICTs) and their digital convergence are also creating multiple levels of reality in a direct relation with complexity. Technology's interplay to complexity brought new ontological perceptions on what exists and is there to be known, implicit in the new alternative environments that are digitally available to our cognition. If multiple levels of reality start to be perceived in the micro and macro physical realms, they also start to be conceived and explored through digital technologies.

Virtual reality establishes itself as a technological level of reality created and mediated within digital convergence. When establishing the Virtual in contra position to the Real, other layers of reality are unfolded from digital technology (Lévy, 1996). The very possibility of immersion in virtual reality generates new questionings about the nature of reality itself. These new philosophical ponderings brought forth by ICTs continue to evolve at the same pace new technologies evolve and expand the levels of reality available to human cognition. Multiple levels of reality within cyberspace are being configured and explored through the digital cognitive expansion made possible via digital technologies.

The perceptual dematerialization of reality is not only quantum, but also digital. The fluidity of digital environments, where information configures multiple realities through one same binary code, happens as a powerful metaphor to the quantum fluidity of the real world, where continuous modulation between wave and particle configures multiple spaces and environments.

6. Conclusion

All forms of mind are converging; all forms of matter are converging. Not only are they converging, but they are being transformed by convergence itself. Matter begins to show fundamental properties that are similar to those from mind, and vice-versa, as quantum physics informs us of its quantum computational nature (Deutsch, 2003; Lloyd, 2006). Unity of matter in NBIC applications is about quantum enabled nano continuity from natural to artificial systems of intelligence, integrating living to non living systems. From a pan-communicationalist perspective, matter would account for the flow of energy/information; while mind would account for the flow of meaning. There can be no separation of the two.

Peirce's universal semiotics and Deutsch's (2003) universal matrix are both conceptual bridges connecting matter to mind. Quantum physics joins semiotics in stating that continuity is to be found in all levels of hybrid interfaces, be they micro (nano) or macro (cyber), individual or social. Matter itself, according to Peirce, is permeated with semiosis, and therefore, mind. If we parallel Peirce's idea of universal semiotic continuity to Deutsch's idea of continuity within a quantum computation universal matrix, we shall observe that for the first, convergence between matter and mind happens through semiosis, while for the second it happens through quantum computation. According to Deutsch (2003), matter in its quantum essence is universal intelligence in permanent modulation. According to Peirce, matter is *effete mind*, and the law of mind can be found in all levels of reality (Santaella, 2001, 2004).

Quantum physics could prove scientifically what Peirce meant philosophically about continuity in the physical universe, while converging technologies are proving Peirce to be right in relation to the universal character of semiosis and the continuity of mind and matter. Converging technologies bring about a pragmatic instance of quantum semiotic continuity at mind-matter interfaces, being in accord with every nuance of Peircean semiotics, and being physically established within systems of quantum complex interactions.

Technontologies such as pan-communicationalism are, therefore, a product of a mix between the universal computational perspective in quantum physics, information based approaches such as Floridi's philosophy of information and the semiotics of Charles Sanders Peirce. What these technologically based ontologies are telling us about the essence of our being in relation to reality is that being seems to be, more than ever, a form of living communication, an uncertain and continuous flow of meaning, across permanent quantum modulation.

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