COGNITION AS A PROCESS IN DYNAMIC SYSTEMS. NEUROPHENOMENOLOGY, LEARNING AND EDUCATION*

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ABSTRACT: The purpose of this article is to show the importance of the neurophenomenological approach for education, specifically in the digital society, where, more than ever, learning requires the co-development of our observation and analysis skills in conjunction with our abilities to design and implement actions in our surroundings in order to reduce complexity and increase our capacity for action. To this end, the connections between neurophenomenology and related theories will be firstly addressed. These theories provide us with the hermeneutical framework to introduce then some of the most relevant cognitive approaches to learning, with emphasis on new literacies related to advances in information technologies. Finally, the most relevant conclusions of the study are summarized, stressing the importance of promoting pedagogical innovations in the age of digital technologies that can facilitate inclusive education and learning environments.

KEY WORDS: Neurophenomenology; Neuroplasticity; Embodied Cognition; Enactive Interfaces.

La cognición como proceso en sistemas dinámicos. Neurofenomenología, aprendizaje y educación

RESUMEN: El objetivo de este artículo es mostrar la importancia de la perspectiva neurofenomenológica para la educación, en particular en la sociedad digital, donde, más que nunca, el aprendizaje requiere el desarrollo de habilidades de observación y análisis, así como de habilidades para diseñar e implementar acciones en nuestro entorno con el fin de reducir la complejidad y aumentar nuestra capacidad de acción. Con este propósito, se abordarán en primer lugar las conexiones entre la neurofenomenología y otras teorías afines. Estas teorías nos proporcionan el marco hermenéutico para presentar algunos de los enfoques cognitivos de aprendizaje más relevantes, en especial las nuevas alfabetizaciones producidas por los avances en las tecnologías de la información. Finalmente se resumen las conclusiones más relevantes del estudio, destacando la importancia de promover innovaciones pedagógicas en la era de las tecnologías digitales que puedan facilitar una educación y unos entornos inclusivos para el aprendizaje.

PALABRAS CLAVE: neurofenomenología; neuroplasticidad; cognición corporizada; enacción.

1. From the theory of information to the enactive approach in cognitive science

In 1947 Claude E. Shannon coined the neologism the *bit* —a tiny, abstract, insubstantial, irreducible fundamental particle— as a unit for measuring *information*[1]. Around the same time, Norbert Wiener, who had taught Shannon at MIT, proposed a new discipline: *cybernetics*, the study of communication and

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[1] Shannon, C. E., «A mathematical theory of communication», in: *The Bell System Technical Journal*, 27 (1948), pp. 379-423, 623-656.

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control[2]. This explosive junction explains the transformation of life in all its dimensions and the emergence of an era that we have barely explored. Such an intense development of the concept of information has given rise to the *theory of information* that appears today as a determining factor in mathematics, electrical engineering, computer engineering, biology, genetics, and even physics[3].

The classic paradigm of cognitive science has considered the mind as a computational information processing system and the brain as the place where understanding begins, where information is born[4]. Neuroscience has contributed in the revision of this conception of the mind and the traditional concepts related to cognitive processes. In cognitive science other perspectives have gradually developed that view cognition within an environment, such as embodied, enactive, distributed, embedded, extended or positioned cognition[5]. Although there are differences between these perspectives, all of them reject the more traditional ideas of cognitive science based on the mental sphere as a private, rational, abstract, disembodied occurrence, governed by rigid computational mechanisms which equate living beings with machines and relegate the active role of organisms in the formation of their experience. Additionally, they share core characteristics in the understanding of the cognitive system, such as interaction and dynamism: dynamic interaction framed in a body and the simultaneous understanding of bodily, neural, emotional and environmental factors that interact[6]. The starting point for supporters of these perspectives is the fact that there are ways of being in the world that do not involve neutral representations with regard to action, employing scientific methodological principles to propose a conception of our mind which is more in line with our evolutionary history and our radical insertion in the material and social environment[7].

The theory of enactive cognition, originally proposed by Jerome S. Bruner in late 1960s, highlights that in addition to the importance of the body and action, for a cognitive activity to emerge it needs to have a physical medium with special organisational properties that emerge in organisms, which in terms of biological bodies —autonomous or *autopoietic*— are regulated and generate

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[2] Wiener, N., *Cybernetics; or control and communication in the animal and the machine* (Wiley, New York, 1948).

[3] Gleick, J., *The information. A history, a theory, a flood* (Pantheon, New York, 2011).

[4] Newell, A., Simon, H. A., «Computer science as empirical inquiry», in: *Communications of the ACM*, 19 (1976), pp. 113-126.

[5] Rumelhart, D. E., McClelland, J. L., PDP Research Group (eds.), *Parallel distributed processing* (MIT Press, Cambridge, 1986); Gelder, T. van, «What might cognition be, if not computation?», in: *Journal of Philosophy*, 91 (1995) pp. 345-381; Gelder, T. van, «The dynamical hypothesis in cognitive science», in: *Behavioral and Brain Sciences*, 21 (1998), pp. 615-628.

[6] Brooks, R. A., «Intelligence without representation», in: *Artificial Intelligence*, 47 (1991), pp. 139-159.

[7] Arenas-Dolz, F., «Cognición y retórica: bases biológicas del significado y la comprensión», in: *Pensamiento*, 72/273 (2016), pp. 997-1018.

sensory experiences[8]. Thus, knowledge cannot be reduced to the passive reception of information; rather, it is established during the development of organisms, which *enact* their significant worlds that are full of meaning. Knowing is not only a *living* phenomenon, but a *lived* phenomenon, as a knowledge experience is always based on first-person experience. Cognition will depend on the embodied nature of the sensory-motor skills, which in turn are immersed in a broader biological, psychological and cultural context. The world does not exist separately from the way in which the system makes it emerge through the actions within it[9].

Interesting analytical approaches have been developed which allow us to understand that cognition is not what happens when we stop to contemplate the world and try to understand it, but that we are always involved in our objects of interest and knowledge. The world is not entirely objective (a reality that we access through representations) or entirely subjective (a purely *ex nihilo* creation of a world of representations). The central pillar of human existence is thinking about relationships and the relationships between relationships, within the cognitive domain.

This is the idea that motivates *enactivism*, whereby cognition is a continuous practice, shaped by processes of active participation in the world and by experience, and deeply rooted in biological and cultural history. Living systems and cognitive systems form a continuum and influence each other. This perspective has significant practical consequences as it allows us to actively intervene in the design of organisational reality. Firstly, it leads us to recognise that organisation is whatever its communication is, as organisation itself is a communicational phenomenon: where there is no conversation there is no organisation. Secondly, organisation is not limited to the words expressed in it, as all physical elements communicate, and these can also be interpreted as the result of conversations held within organisation.

Cognition appears as an emerging phenomenon in self-organised, distributed networks, as a continuum of embodied, enacted actions: knowledge is action; it is the emergence of appropriate actions in defined, specific contexts. This approach opens up the possibility for reflection on the sentient or cognitive capacity, integrating the contributions of neurosciences —neurophysiology, neurochemistry, neuropsychology— and non-reductionist theories of the mind such as phenomenological and other philosophical perspectives. The senses, feelings, cognition and context are fundamental, essential ingredients in any experience. Phenomenological issues such as awareness and self-awareness, intentionality, perception, time, corporeality and the temporary nature of

[8] Varela, F. J., Thompson, E., Rosch, E., *The embodied mind. Cognitive science and human experience* (MIT Press, Cambridge, 1991).

[9] Maturana, H., *Erkennen: Die Organisation und Verkörperung von Wirklichkeit* (Friedrich Vieweg und Sohn, Braunschweig/Wiesbaden, 1982); Maturana, H., Varela, F. J., *The tree of knowledge. The biological roots of human understanding* (Shambala Publications, Boston, 1992).

experiences, as well as our understanding of ourselves and others, are particularly important in neurophenomenology. In these areas, there may be fruitful dialogue and mutual enrichment between cognitive sciences and phenomenology.

Briefly, based on concepts such as plasticity, enactive interfaces and emergence, with special attention to the link between the scientific study of consciousness and its analysis using first-person methodology, neurophenomenology has attempted to explain how cerebral phenomena which establish consciousness occur, seeking a solution to the opposition between the biological foundations of consciousness and the basic fact of having an irreducible experience[10]. Neurophenomenology has built bridges between the dynamic approaches of the mind and the phenomenological approaches of human subjectivity, highlighting the role of both intentionality and the living body: the subject is not a mere cognitive entity with intentionality whose mission is to represent reality for itself; the organism defines its own «point of view» of the world in the dynamics embodied by its operation, and not through static rules, so that subjectivity is intrinsically open to intersubjective validation.

Based on this approach, cognitive activity is not considered as simply the representation of a pre-configured reality that it merely reproduces; rather cognitive activity materialises through our actions, so that the world and those perceiving it define each other reciprocally. Knowledge is not possible without experiencing the situation that encompasses it, while the situation is shaped as and to the extent that it is known.

2. Cognitive processes and learning

Communication is a genuinely social operation, because it implies the concurrence of a large number of systems of consciousness, but precisely for this reason, taken as a unit, it cannot be attributed to any single consciousness. It is social because in no way can there be a collective common consciousness —that is, consensus cannot be reached in terms of a full agreement— yet nevertheless, communication works[11]. Social systems are formed through communication, understood as the exchange of codes that allow contact to be put into operation between individual consciences. Contrary to the classic perspective, communication is not the transfer of semantic content from one psychic system that already possesses such content to another system: «Humans cannot communicate; not even their brains can communicate; not even their conscious minds can communicate. Only communication can

[10] Varela, F. J., «Neurophenomenology. A methodological remedy for the hard problem», in: *Journal of Consciousness Studies*, 3, (1996), pp. 330-349.

[11] Luhmann, N., Schorr, K. E., *Problems of reflection in the system of education* (Waxmann, Münster, 2000).

communicate»[12]. In this way, all communication must be able to distinguish between information and the action of communicating.

Knowledge is an important factor in social change. The knowledge society requires the development of a human science able to read these changes and which allows us to acquire the skills necessary for processing information and creating meanings, unravelling the ambiguities and interpretations often hidden behind our concepts. Knowledge must be understood as the capacity for understanding, interpreting and using sources of information. Therefore, knowledge is not information, although admittedly these two words are often used interchangeably. Information is a static memory whereas knowledge is a dynamic memory; information involves an external medium but knowledge is nowhere else except in the head of an individual, as their collection of mental models. To transfer knowledge from one individual to another it must be explained, through information, which can be assimilated by others in their brain from their own mental representations or framework. Knowledge thus accumulated allows the observation of a phenomenon to be assimilated as a fact, and therefore, as new information which is integrated as a new element of knowledge.

Cognitive processes, which must be understood as positioned, embodied and oriented towards the achievement of specific objectives, are usually developed in real life situations in interactions with the material and social environment. While some mental states and experiences can be internally defined, there are many others in which processes of attributing meaning include components located outside the skull. Consequently, some cognitive processes cannot continue to be understood as constrained by the physical limits of the brain. Conversely, these processes emerge, develop and extend through interactive networks which integrate and functionally and strategically synchronise with the brain, the body and the physical and social world[13]. Cultural artefacts —including language— and technological advances can have a cognitive life, as they are converted into a literal extension of the human mind[14]. Cerebral plasticity modifies and updates the mental framework of the user's body, playing a central role in the full process of their cognitive incorporation. Additionally, technological devices go beyond their basic functionality as tools which merely increase human capabilities[15].

However, a number of authors maintain that external resources such as the body and the social and material environment can only form part of cognitive

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[12] Luhmann, N., *Theories of distinction. Redescribing the descriptions of modernity* (Stanford University Press, Stanford, 2002), p. 169.

[13] Clark, A., Chalmers, D., «The extended mind», in: *Analysis*, 58 (1998), pp. 7-19.

[14] Clark, A., *Supersizing the mind. Embodiment, action and cognition extension* (Oxford University Press, Oxford, 2008).

[15] Arenas-Dolz, F., «Neurofilosofía, naturalismo y juicio moral», in: Carbonell, C., Flamarique, L. (eds.), *De simios,* cyborgs *y dioses: La naturalización del hombre a debate* (Biblioteca Nueva, Madrid, 2016), pp. 207-223.

systems that play a causally active role in them if they are directly connected to the brain[16]. The social and material contexts form part of the external environment, which has a powerful effect on the activation and development of mental processes, but without forming part of the cognitive systems[17]. Traditionally, the various branches of cognitive science have considered the mind to be a processor of abstract information, whose connections with the outside world were of little importance. Currently, interactions with the outside world have significantly increased in importance[18].

The theory of embodied cognition proposes that certain aspects of our bodies determine our mind. All aspects of cognition are shaped by aspects of the body. These include the perception system, intuitions that underlie the ability to move, activities and interactions with our surroundings, and the simple knowledge of the world installed in our bodies and brains[19]. The theory of embodied cognition focuses on aspects that the classic cognitivist approach did not consider: the temporality of cognitive processes, the cognitive component of emotions, the interest in interaction between the brain, the body and the means by which mental skills are configured during development, etc. Instead of conceiving cognition as a symbolic information process, it is conceived as the way in which the organism adapts to its environment, by developing expectations and controlling it, because of the brain's capacity to reorganise itself interactively. Of course, there is no unanimity or established alternative, but it is a promising way to avoid the obstacles that hampered cognitivism. The modern version of embodied cognition is based on visions provided by recent research into linguistics and cognitive science[20], artificial intelligence and robotics[21] and neurobiology[22].

The theory of distributed cognition affects the social aspects of cognition[23]. From this framework, cognition is understood as the information process arising from interaction with symbols in the world. Human knowledge and

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[16] Fodor, J., «Where is my mind?», in: *London Review of Books*, 31/3 (2009), pp. 13-15.

[17] Rupert, R., *Cognitive systems and the extended mind* (Oxford University Press, Oxford, 2010).

[18] Glenberg, A., Vega, M. de, Graesser, A., *Symbols and embodiment. Debates on meaning and cognition* (Oxford University Press, Oxford, 2008).

[19] Calvo, P., Gomila, A., *Handbook of cognitive science. An embodied approach* (Elsevier, Amsterdam, 2008).

[20] Lakoff, G., Johnson, M., *Metaphors we live by* (University of Chicago Press, Chicago, 1980).

[21] Brooks, R. A., *Flesh and machines. How robots will change us* (Pantheon Books, New York, 2002); Moravec, H., *Mind children. The future of robot and human intelligence* (Harvard University Press, Cambridge, 1988); Pfeifer, R., Scheier, C., *Understanding intelligence* (MIT Press, Cambridge, 1999).

[22] Edelman, G. M., *Second nature. Brain science and human knowledge* (Yale University Press, New Haven, 2006); Damasio, A., *Descartes' error. Emotion, reason, and the human brain* (Quill, New York, 1994); Damasio, A., *Looking for Spinoza. Joy, sorrow, and the feeling brain* (Mariner Books, New York, 2003).

[23] Hutchins, E., *Cognition in the wild* (MIT Press, Cambridge, 1995).

cognition are not just confined to the individual, but also to distributed memory spaces, facts or the knowledge of objects in our surroundings. Distributed cognition may serve to lead to a theory of learning in which the development of knowledge is the result of a system formed by the relationship existing between human agents and the objects with which they interact. As human knowledge and cognition are not limited solely to people, for the study of the internet of things, this source of knowledge is important to clarify «communication» between artefacts and their context.

From this perspective, education is understood as a phenomenon where all human dimensions are integrated so that body and spirit are involved in every manifestation of life; the opposite would mean the loss of social and individual sense[24]. Thus, learning is conceived as an integral process where the body inevitably intervenes, so that what is learned is not only known, but also configures the being.

The body that we become is enriched by the intervention of significant others and by the interrelation with the environment. The importance of embodiment for cognition is therefore widely recognized[25] and encompasses a holistic psycho-corporeal vision[26], already highlighted by philosophy[27]. However, the school minimizes the body, putting more emphasis on learning abstract concepts than learning from experience.

Reductionist ideas about the mind-body problem raise very serious ethical issues[28]. In his critique of the dominant paradigm in cognitive neurosciences and his interest in highlighting the new paradigm of the embodied mind, Thomas Fuchs explains that traditional cognitive neurosciences understand the brain as a constructive entity, and focus on questions related to how neural machinery produces the experiences of the world and the experiencing subject of these experiences[29]. From this perspective, consciousness is the internal representation of the world within the head of a living being. In this sense, the brain is considered as a system in itself, as opposed to the rest of the body and the surrounding world, while the body is understood as a physiological support mechanism for the brain that apparently can generate consciousness, as if the brain was cut off from the body. According to Fuchs, this approach neglects the interactions and the circular processes in which the brain is involved.

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[24] Maturana, H., Nisis de Rezepka, S., *Formación humana y capacitación* (Dolmen, Santiago de Chile, 1997).

[25] Gallagher, S., *How the body shapes the mind* (Oxford University Press, Oxford, 2005).

[26] Atkins, K., *Narrative identity and moral identity. A practical perspective* (Routledge, London, 2008).

[27] Nietzsche, F., *On the genealogy of morality* (Cambridge University Press, Cambridge, 1994); Merleau-Ponty, M., *Phenomenology of perception* (Routledge & Kegan Paul, London, 1962).

[28] Fuchs, T., «Ethical issues in neuroscience», in: *Current Opinion in Psychiatry*, 19 (2006), p. 605.

[29] Fuchs, T., *Ecology of the brain. The phenomenology and biology of the embodied mind* (Oxford University Press, Oxford, 2018).

Fuchs connects the memory of the body with the concepts of explicit and implicit knowledge. Explicit knowing is related to «knowing what», while implicit knowing is related to «knowing how»[30]. In addition, the body memory which is part of our implicit memory, appears in different forms, which are classified as procedural, situational, intercorporeal, incorporative, pain and traumatic memory. The six types of body memory are briefly described as follows: «Body learning means forgetting what we have learned or done explicitly, and letting it sink into implicit, unconscious knowing»[31].

Education should enhance the cognitive abilities of students. Thus, according to Maturana, cognitive education considers that humans are «culturally and genetically endowed and inclined to be learners, as well as transformers and generators of information, therefore having the potential to be active participants in and beneficiaries of the information age»[32].

3. Tools of the mind

Today the digital revolution is arguably increasing the availability of information to a greater extent than effective knowledge for our societies. However, to associate this trend towards endless information (*big data*) with knowledge requires individual and organisational learning. In this context, the importance of computers lies in their facilitating this coordination work rather than simply processing data[33]. To learn, we need to exchange ideas, stimulate each other, reason, receive feedback and enjoy constructing new ideas and meanings. The transformation of information into a deeper knowledge requires monitoring and tutored mediation. Guiding us through obstacles, the tutor strengthens sustained motivation. Applied to learning, technology may carry out an important function as a tool for constructing knowledge, that is, a tool of the mind[34].

Technology has a transformative effect on educational practice and leads to the constant challenge to redefine teaching initiatives. By *mediating* the relationship, it is transformed, adding new possibilities and limitations for learning. Technology is not merely gadgets, but true *structures of action*, models for reconfiguring the *thought framework* of the subject, operating as a *tool for mediation* and promoting an internal modification of the subject's thought and learning structures.

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[30] Fuchs, T., «The tacit dimension», in: *Philosophy, Psychiatry, & Psychology*, 8 (2001), p. 324.

[31] Fuchs, T., «The phenomenology of body memory», in Koch, S., Fuchs, T., Summa, M., Müller, C. (eds.), *Body memory, metaphor and movement* (John Benjamins, Amsterdam, 2012), p. 13.

[32] Maturana, H., *Transformación en la convivencia* (Dolmen, Santiago de Chile, 1999), p. 41.

[33] Winograd, T., Flores, F., *Understanding computers and cognition. A new foundation for design* (Ablex, Norwood, 1986).

[34] Jonassen, D. H., «The mediation of experience and educational technology. A philosophical analysis», in: *Educational Communication and Technology*, 32/3 (1984), pp. 153-167.

What are the effects of technology on subjects' *frameworks of thought*? Cognition does not operate solely as a biological reaction, but is a property mediated through external resources such as the measurement tools that culture and society offer us, which provide the subject with a new way of transforming reality. In learning, there may be two types of mediating effects of technologies: some refer to the use of technology (what can be learned *with* technology), and others affect more or less sustained cognitive transformations, as a result of interaction with the structure of technology itself (what is learned *from* technology).

Human cognition has been conceived as something «possessed» and residing «in the head» of individuals, and its study has not generally considered the social, physical and artificial environments where it is produced. In response to this conception, some authors have proposed a treatment based on the idea of cognition «distributed» among individuals and knowledge constructed socially through cooperative efforts aimed at achieving common objectives undertaken in cultural environments, where information is subject to processing, which takes place between individuals and the tools and artefacts that provide culture[35]. The cultivation of mental skills, the acquisition of knowledge and the role of social interaction and intelligent tools in the learning process is central to this theory[36].

The changes demanded by the digital era require education to promote the online cultivation of the mind. A new epistemology adapted to current challenges should be developed, capable of integrating the multiplicity of forms of knowledge, new literacies and contributions of technologies[37]. In the digital era, knowledge is a skill for operating/coping with practices of different spaces[38].

In summary, the need for multiliteracy teaching suited to our time, where diversity, the notion of design as a meaningful active creation, the importance of multimodality and the need for a more holistic approach to education are key[39]. A series of teaching actions —including «situated practice», «open instruction», the «critical framework» and «transformed practice»— needs to

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[35] Salomon, G., *Interaction of media, cognition, and learning* (Jossey-Bass, San Francisco, 1979); Salomon, G., *Communication and education. Social and psychological interactions* (Sage, Beverly Hills, 1981); Salomon, G. (ed.), *Distributed cognitions. Psychological and educational considerations* (Cambridge University Press, Cambridge, 1993).

[36] Salomon, G., Perkins, D. N., *Learning in wonderland. What computers really offer education*, in Kerr, S. (ed.), *Technology and the future of education* (University of Chicago Press, Chicago, 1996), pp. 111-130.

[37] Lankshear, C., Snyder, I., *Teachers and technoliteracy. Managing literacy, technology and learning in schools* (Allen & Unwin, St. Leonards, NSW, Australia, 2000), p. 39.

[38] Lankshear, C., Knobel, M., *New literacies. Everyday practices and classroom learning* (Open University Press, Berkshire, 2006); Knobel, M., Lankshear, C., (eds.), *DIY media. Creating, sharing and learning with new technologies* (Peter Lang, New York, 2010).

[39] Gallagher, S., *Hermeneutics and education* (State University of New York Press, New York, 1992); Arenas-Dolz, F., «Neuro-retórica. ¿Vino viejo en odres nuevos?», in: Cortina, A. (ed.), *Guía Comares de Neurofilosofía Práctica* (Comares, Granada, 2012), pp. 125-145; F. Arenas-Dolz, «¿Qué es la neurorretórica?», in: *Daímon. Revista Internacional de Filosofía*, 58 (2013), pp. 69-80.

be initiated in order to establish more productive, relevant, innovative, creative and even emancipatory teaching, aimed at creating a type of person, an active and meaningful designer, who is open to change and innovation.

Conclusions

Learning has traditionally been configured as a process through which the pupil comes into contact with and absorbs knowledge or skills from an authorised source. This definition is no longer sufficient to describe the intersection of knowledge conditions in the information society. Learners do not passively absorb personally meaningful knowledge, but instead actively create it from their experience in the world. Knowledge is fluid and available; it is not merchandise to be possessed and stored, but something which is accessed.

By using technology to make sense of the world around us, our knowledge becomes public information available in the public sphere. Some of the characteristics of this technology are the deep connection between what is real and what is virtual, the availability of information at any time, from any place and with a variety of devices that alter the way of accessing information and knowledge. We cannot underestimate the implications of these profound transformations in learning. Education in the knowledge society features mobility, interactivity and ubiquity, and offers continuous learning in space and time. It is not only a practical possibility, but a social imperative.

One of the challenges of our time is to confront complexity. Methods must be taught that allow learning of the mutual relationships and reciprocal influences between the parts and the whole in a complex world. So much information is available to us that we often get lost in the ocean of data and do not give ourselves time to think and make decisions. The new reality — that society today is addled by the avalanche of the technological revolution and the advance of neuroscience— requires the development of programmes which allow mankind and society to evolve, adopt and adapt to the new culture arising by virtue of the knowledge society.

Specifically, neurophenomenology teaches us that much of human coordination occurs in *conversations for action*, through promises and fulfilment of commitments between people. Knowledge no longer refers to a «reality» which is limited to «reproducing», but is present to the extent that it appears or emerges at the heart of the situation experienced, enacting with it, favouring the uniqueness of each and every one of the situations experienced.

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