

Grounding 4E Cognition in Mexico: introduction to special issue on spotlight on 4E Cognition research in Mexico

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Abstract

Embodied, embedded, extended and enactive (4EC) perspectives on cognition have gained epistemic legitimacy during the last 25 years in the international arena. They have encouraged new ways to understand the mind. Mexico has not been an exception; rather, it has the potential to provide a fertile ground for the development of 4EC perspectives, as shown by the variety of contributions in this special issue. In this editorial introduction, we discuss recent concerns about a lack of coherence in the inter-relations between these perspectives, and we propose that it is more appropriate to view 4EC as an emerging pluralistic research tradition that shares crucial commitments. Furthermore, we show that this pluralistic tradition has been gaining ground in the specific research context of Mexico, because of the country's distinctive historical, scientific and philosophical development. We finish by describing the promising research potential of the current heterogeneous explanations as evidenced by the papers in this issue.

Keywords

4E Cognition, pluralism, Mexico, research tradition, historical background

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1. Introduction

According to recent perspectives in cognitive science, cognition is embodied, enactive, embedded, and/or extended (4EC¹), which means that cognition depends on the characteristics of the agent's body and its interaction with the physical and social environment. In other words, the working hypothesis is that the corporeal, motor, and interactive aspects that go beyond the brain play a functional or even constitutive role in cognitive processes. The papers in this special issue, from various perspectives, examine the reasons why processes like perceiving, imagining or reasoning have turned out to be deeply rooted in the circular interactions of embodied agents with tools and culture from the environment. Moreover, all the papers build on the idea that cognition does not always require internal representations of the objective external world, and they, therefore, share a "4E Cognition" (4EC) perspective (Kiverstein & Clark, 2009; Menary, 2010; Newen, Gallagher, & de Bruin, 2018; Vörös, Froese, & Riegler, 2016).

In general terms, all the articles can be grouped together because they have the purpose of reconfiguring computational and representational cognitivism and inviting other explanatory elements to the cognitive party: (1) they drive new ways of understanding the mind, where the aim of cognitive system is to provide possibilities for embodied action interacting with the world, not represent it; (2) they reject the strong theses of traditional cognitivism, internalism, representationalism, and methodological individualism; and,

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following Menary (2010), (3) they similarly assert that simple and homogeneous explanations do not do justice to the complexity of cognitive phenomena.

Accordingly, in this editorial introduction, we will briefly describe the heterogeneity of the different lines of research within 4EC and how they relate to the contributions of this issue. We begin by introducing each of the mind's "Es" by presenting differences in their emphasis, applications, and empirically informed research to cognition:

1. *Embodied*. The bodily realization of cognitive abilities as constitutive for their achievement. As opposed to the representationalist perspective, the knowledge and meaning is not based on a mental mirroring of nature but on the embodied experience of the agent that emerges from a peculiar view of the world on which he actuates. In addition, the mind as embodied opens up a way of thinking of the body as inherently meaningful and action-based rather than as a mechanical or epiphenomenal process that executes pre-planned movements: meaning is entwined with the physiological level of motor knowledge of the agent (Overy & Molnar-Szakacs, 2009). Rodney Brooks (1990, 1991) designed artificial insects with an architecture designed to carry out basic motor skills. He corroborated that his robots, which have a body that actively interacts with the environment through intelligent behavior, do not need to manipulate internal representations.
2. *Embedded or situated*. The embodied mind, thus, cannot be conceived of in isolation from its environment; it is always already embedded in a context. This context offers affordances, as relational possibilities of action, for interactions that are directly perceived in a meaningful manner. The chair is directly perceived as being there for sitting. A recent theoretical development in this regard is the skilled intentionality framework (SIF), an embodied, ecological, and enactivist perspective that conceptualizes how skilled and embodied agents coupling with the regularities in the environment let their behavior be guided by the practices in their particular form of life (Van Dijk & Rietveld, 2017). Cognitive agents capitalize the distinct bearings of their environmental context in order to accomplish their abilities. Kirsh and Maglio (1994) described strategies in which cognitive work is solved more effectively with the benefit of external spatial keys. The most well-known example in this regard involves the computer game Tetris. Some authors suggest that embedded and extended concepts of cognition are similar since both refer to the way in which the cognitive system relies on the environment through cultural artifacts, including language and technological tools, in order to free limited cognitive abilities. For instance, in

this aspect, another related body of knowledge is niche construction models of evolution where environmental resources, as tools and other resources from material culture, are considered to enhance and amplify the adaptive fit between agents cognitive capacities and intelligent action with the world (Sterelny, 2010, 2013).

3. *Extended*. Cognition is *extended* beyond the boundaries, thus being inherently connected with the respective physical or socio-cultural environment. Clark (1998) argues that the use of tools, such as public language, is an external artifact that has reconfigured the computational forms of human biological brains. In Clark's (2013, 2017) latest extended functionalism papers, he has been working on a hierarchical predictive processing account.² He argues for brains as "prediction machines" whose core functional operation is to inferentially learn about the world by trying to predict their own patterns of sensory stimulation. He tries to avoid a brain-bound "neurocentric" vision of the mind, suggesting a new synthesis in which predictive brains act only as entry points for "extended minds," where bodies in action contribute constitutively to the larger cognitive circuit (Clark, 2017).
4. *Enacted*. Cognition and consciousness emerge only through the active embodied interaction, or structural coupling, of an autonomous living system with its environment. Enactive approaches to perception emphasize patterns of dynamical interaction and active embodied engagement, instead of internal representations. O'Regan and Noë (2001) show that the conscious visual experience is enacted by a series of saccades and anticipative movements of the active and selective visual exploration that is guided by the action of the body. Nowadays, distinctions have been made between various forms of enactivism, raising questions about their inter-relations (Vörös et al., 2016). *Sensorimotor enactivism* stresses the particular *quality* of perceptual consciousness as constituted by the exercise and engagement of sensorimotor capacities (Degenaar & O'Regan, 2017; O'Regan, 2011; O'Regan & Noë, 2001). *Autopoietic enactivism* appeals to a broader range of biological processes and makes use of the explanatory tool of dynamical systems theory. It claims that there is a *necessary and constitutive* relation between conscious experience and autopoietic processes, which leads to the life-mind continuity thesis (Di Paolo, Buhrmann, & Barandiaran, 2017; Froese & Di Paolo, 2011; Jonas & Jonas, 1966; Thompson, 2007; Varela, Thompson, & Rosch, 1991). *Radical enactivism* (REC) that is best understood as a program for consolidating the many different varieties of enactivism through a process of philosophical clarification (Hutto and Myin, 2013, 2017).

As a result of philosophically and empirically informed research, these perspectives have gained ground worldwide (Di Paolo et al., 2017; Froese, 2016; Newen et al., 2018; Vörös et al., 2016). Some contributors to these developments (Di Paolo et al., 2017; Dotov, 2016; Menary, 2010) have raised concerns about whether it is appropriate to place these approaches in an uncritical way within an amorphous set; since they can share some commitments, this does not guarantee that they have consistency, conceptual clarity, or coherence between them. We do not deny that it is possible that discussions of each perspective become organized according to either different conceptual descriptions or different substantive concerns within the perspective. In fact, they raise fundamental questions about the nature of theoretical progress and integration: how does cognitive science progress? How does one evaluate this progress in the development of theories and perspectives? Is diversity in perspectives an indication of lack of conceptual clarity and coherence? Is integration across perspectives possible and desirable?

In response to these questions, we believe that the mere existence of diversity in perspectives does not mean that the development of body of knowledge has not been achieved correctly (Low & Altman, 1992; Patterson & Williams, 2005). Specifically, we see a systematic coherence when dealing with the diversity in perspectives characterizing 4EC, and it may be the case that we require such a pluralistic epistemic view to fully understand the complexities of the mind.

In this editorial introduction, we are more interested in this emergent and pluralist research tradition, where we can identify the same tendency as an explanatory alternative to cognitivism: the mind ceases to be identical with the brain, and is rather an embodied activity that extends into the environment, especially when using tools and when it is sustained by the scaffolding of a socio-cultural environment. We want to underline that 4EC provides a unique opportunity to build epistemic and methodological bridges between various disciplines and to create a common space for reflective dialog, integration, and exchange. The contributions of this special issue go in that sense, showing how each of these 4E perspectives has been gaining ground in the specific research context of Mexico.

In the next section, we introduce the historical trajectory of the 4EC perspectives in more detail, in the spirit of the development of scientific research traditions analyzed by the philosophy of science and then we revisit these ideas in particular with respect to relevant scientific developments in Mexico. In the subsequent section, we present the different contributions that make up this special issue. Finally, we offer a tentative outlook regarding the future of 4EC in Mexico as a conclusion.

2. 4EC: one research tradition or many?

In the last 25 years, the literature on 4EC has become extensive, the range of phenomena studied has grown, and the wide range of empirical and experimental evidence have conferred greater recognition (Colombetti, 2016; Di Paolo et al., 2017; Froese, Iizuka, & Ikegami, 2014). In the context of the development of scientific disciplines, we can identify 4EC as one of the main competing approaches to cognition, especially in contrast to computational or representational cognitivism. We are going to employ the concept of *research tradition* to refer to 4EC, as articulated by Larry Laudan (1977, 1996) following Thomas Kuhn's "paradigm" and Imre Lakatos' "research program" conceptualizations. However, unlike paradigms and research programs, Laudan's research traditions³ can coexist and compete for long periods of time, generating substantive claims that may even overlap with those produced in other traditions (Keble & Weaver, 1999). Research traditions show a process of convergence that incorporates multiple theories of different kinds that are focused on the same domain of interest (Keble & Weaver, 1999). Indeed, Laudan's research program may be considered near to the notion of "family resemblance" theories (Wittgenstein, 1953). Particularly, a research tradition is the place where normative philosophical commitments that guide research are established.

In our view, recent concerns about 4EC suggesting a lack of conceptual coherence and a lack of systematic inter-relations between these perspectives (Dotov, 2016; Menary, 2010; Van Dijk & Rietveld, 2017) result from viewing the 4EC perspectives as if it should constitute a single research program. Instead, we maintain that it is more appropriate to view 4EC as a heterogeneous domain of research, an emerging pluralistic research tradition that is informed by multiple research programs that share some, but not all, commitments (see also Kiverstein & Clark, 2009). Shared commitments are the criticism of the traditional view of informational processing in the head (Varela et al., 1991), the rejection of internal representations as the only vehicles of all cognition (Di Paolo et al., 2017), and the questioning of the cerebral hegemony as the center of cognitive operations (Thompson, 2007).

In this sense, we are advocating a specific normative position at an epistemic level, calling for researchers to adopt an epistemological pluralist perspective and a reflective dialog between each of the perspectives that make up 4EC. In order to achieve this objective, the researchers need to have an attitude of openness to, to be curious about every perspective commitments, and to recognize that the cognitive realm is still characterized by limited explanations and empirical evidence. This does not imply the collapse of critical thinking; it is important for researchers to maintain some

questioning—about nature of cognitive reality, processes of knowing or instrumental goals of every perspective, as well as having the disposition to create explanatory bridges. Such an understanding does not require achieving a dominion of all the perspectives but it does require an awareness of core distinctions and contributions from each approach (Patterson & Williams, 2005).

We envision an exchange where the aim is not supremacy of one research tradition or the reduction of the different perspectives into a univocal tradition, but clarification and enrichment through an increased understanding and appreciation for the nature, predictions, and limitations of every perspective (McGregor, 2017). Basically, this reflects the critical pluralist position defended by Patterson and Williams (2005) or Olivé (2009). In this respect, the aim is similar to radical enactivism's goal to strengthen and integrate the varieties of 4EC into a more coherent collective that can rival classical ways of thinking about mind and cognition (Hutto, 2017).

We will show that this emerging pluralistic tradition around the globe has had a strong echo in Mexico because of the country's distinctive scientific history and social and philosophical development. By understanding the history of this research tradition, and its echoes in Mexico, we will more easily understand the normative philosophical commitments that guide its empirical and experimental development.

3. Historical background to 4EC perspectives in Mexico

The 4EC perspectives did not emerge spontaneously 25 years ago; rather, some of their theoretical achievements and early development come from the first decades of the 20th century, where philosophical ideas were appearing that questioned the dualisms—subject/object, human/world, and mind/body—and the internal Cartesian conception of the mind (Dotov, 2016; Menary, 2010; Vörös et al., 2016). In this section, we provide the reader with some general background on phenomenology and cybernetics, we continue with some historical criticisms that have been made regarding traditional conceptions of cognition, and we end with a very brief review of some emblematic works that propose the theoretical rupture that gives rise to the emergence of 4EC perspectives, particularly as they pertain to Mexico.

Perhaps, the first precedent to consider is the work of Martin Heidegger (1927), *Being and Time*, which holds that human existence is embedded in the world, which implies that to study the human mind, it could not be separated from the world (Wheeler, 2005). These ideas were developed in Mexico City by Emilio Uranga, a student of José Gaos (disciple of José Ortega y Gasset

who went into exile in Mexico after the Spanish Civil War and brought with him phenomenological thinking and translated the work of German phenomenologists), who appropriated Heidegger's ontological hermeneutics and employed his methods of existential analysis in an effort to expose the historico-existential structures and Mexican *modes of being* in the world according to a Mexican *form of life* as reflected in existential expressions of sentimentality and emotions (*Análisis del ser del mexicano*, 1952). In addition, he translated Merleau-Ponty's "Phenomenology of Perception (1945)" into Spanish.

Indeed, Merleau-Ponty's work, *The Structure of Behavior* (1942), had an important influence in Mexico. Arturo Rico Bovio (1990) of the Autonomous University of Chihuahua, reevaluating this basic precedent of philosophizing about the body, became the initiator of the "Latin American Theory of Philosophy of the Body," whose theoretical development is fundamentally found in the text "Las fronteras del cuerpo: Crítica a la corporeidad" (Dussel, Mendieta, & Bohórquez, 2009). Likewise, Mario Teodoro Ramírez (1994) from the Universidad Michoacana de San Nicolás de Hidalgo shows the good reception of the thought of the French philosopher Maurice Merleau-Ponty in Mexico; in his book "El chiasmo," he proposes the interbreeding between the lived body and the embodied consciousness, and how Merleau-Ponty's philosophy of corporality is gradually transformed into a philosophy of the sensible.

We must also mention Ricardo Guerra (1927–2007), who was a student of Merleau-Ponty and had the honor of being part of the Hyperion Group.⁴ He addressed phenomenological–existential issues in his book "Filosofía y fin de siglo" (Guerra, 1996). The impact of phenomenology continues, as demonstrated in Antonio Zirió Quijano's (2003) "La fenomenología en México," and also by the foundation of the "Latin American Phenomenology Circle" in 1999. This appreciation of Merleau-Ponty in Mexico is a basic precedent of philosophizing around the body and underlining the importance of including the body and subjective experience in the study of the mind.

The Cybernetics movement also set up a precedent. The robotic turtles of William Gray Walter (*Imitation of Life*, 1950), which exhibited cognitive and mobile behavior, and William Rosh Ashby's (1952) homeostat (*Design for a brain*), which presented a model of the brain that adapts to the environment and does not use representations, gave rise to a new avenue of systemic research where the interaction of the agents was paramount. In Mexico, the physiologist and physician Arturo Rosenblueth, working with the founder of cybernetics Norbert Wiener, set the bases for this new science. In *Behavior, Purpose and Teleology* (1943) and in *Mind and Brain: A Philosophy of Science* (1970) he

made seminal contributions to our understanding of the role of feedback in direct purposeful behavior.

Another relevant aspect of this contextualization is provided by the ecological psychology of JJ Gibson (1979) in his research of perceptual systems. In *The Ecological Approach to Visual Perception*, he proposed that vision did not begin with the representation of the world in a passive retina, but rather that the organism moved actively to interact with the invariants that it perceived depending on its interests and its bodily possibilities. He coined the notion of *affordances* as the possibilities of action, which overcame the object/subject distinction by its relational nature with environment. He was one of the pathfinders in proposing an embodied approach to vision.

In Mexico, research that has taken into account ecological psychology⁵ and especially the concept of affordances as an explanatory construct for cognition has taken two main philosophical aspects, first, within the framework of a UNAM research project: “Cognition and Reasoning,” resulting in articles such as Estany and Martínez (2014) “Scaffolding and affordance as integrative concepts in the cognitive sciences.” And, second in the seminar series of “Semiotica musical” founded in 1995 by Susana González and Ruben Lopez Cano, which has led to many research lines among which are López-Cano’s (2006) *What kind of affordances are musical affordances? A semiotic approach*.

Nevertheless, despite these precedents, 4EC perspectives did not take off until the last couple of decades. This is because the second half of the 20th century came to become dominated by the computational metaphor of mind, which came to be formalized as cognitivism. It was only in the 1990s that the winds of change could no longer be ignored by the mainstream. Allow us to mention four exemplary contributions.

First, probably the contribution that has caused the greatest impact in this regard, the work *The embodied mind* (1991) written by the Chilean biologist Francisco Varela, the philosopher Evan Thompson, and the psychologist Eleanor Rosch, where it is argued that the body and the environment to which it is anchored are central components of cognition and consciousness. This work is crucial given that it poses a break with the cognitivist currents of cognitive sciences, assuming that the starting point to study the experience cannot be solely psychological or computational, but it is necessary to rescue the biological and phenomenological aspects. Specifically, it proposes the enactive approach, as an explanatory alternative to cognitivism, especially with respect to scientific attempts to explain consciousness.

It is important to mention that the multidimensional theme of consciousness was advanced in Mexico, in a naturalized epistemological way, in a symposium (“La conciencia: el problema mente-cerebro”) organized by Augusto Fernández-Guardiola (1979) at the National

Institute of Neurology and Neurosurgery in 1976, in which he brought together philosophers, psychologists, psychoanalysts, and neurobiologists, such as Dionisio Nieto and Margarita Valdéz, to try to understand conscious experience. As a result, he published a book “*La Conciencia: el problema mente-cerebro*,” in which attention was drawn to the importance of the mind and body integration for the emergence of cognition. Furthermore, this conference foreshadowed the interdisciplinary approach that in the anglo-saxon context had its first important expression in the first meeting of the conference series *Toward a science of consciousness* in Tucson (Hameroff, Kaszniak, & Scott, 1996).

Second, in the field of artificial intelligence, Rodney Brooks (1990) with his article “Elephants do not play chess” criticized representationalism in the task of emulating intelligence and robotic models, by stating that “the world is its own best model” (p. 3). And in a later article “Intelligence without representation” (Brooks, 1991), he proposes that beyond building robots with algorithms and representations, interaction with the world is needed. We will see a continuation of this tradition in Mexican robotics is one of the contributions to this special issue.

Third, in 1995, the anthropologist Hutchins publishes *Cognition in the Wild*, where he suggests that for the resolution of certain cognitive tasks, the interaction between agents, environment, and artifacts is crucial. This work helped to give rise to what later would be called distributed cognition, by some, and situated cognition, by others.

In Mexico, there is an important anthropological tradition probably because of the diversity of cultural groups and variety among material cultural practices. Although the discussions in anthropology do not tend to start with the aim of providing explanations of human cognition, researchers also consider embodiment as a crucial paradigm in the field. In fact, the anthropological problematizations in Mexico—with a big influence of the anthropologist Victor Turner and the phenomenologist Merleau-Ponty—resulted in fruitful research groups in the anthropology of the body and of performance (Muñiz & List, 2007). Indeed, in Mexico, there is a trajectory of reflection on the body in relation with subjectivity in anthropology and the social sciences since the late 1980s. We think a good reference to see the evolution of this trajectory and authors of this line of thought are the memories of the international Congress “El cuerpo descifrado” (“The deciphered body”) as “Cuerpo, significaciones e imaginarios” (Carrizosa, 1999) or “El aura del cuerpo” (Dallal, 1990).

And finally, fourth, in philosophy the incipient paradigm shift also took shape. In 1998, Andy Clark published *Being There: Putting Brain, Body and World together Again*, where he argues that cognition is embodied and grounded in the interaction with the world. In

this work, we find the prolegomena to the thesis of the extended mind. And it is in 1998 when the journal *Analysis* publishes an article by the philosophers Clark and Chalmers (1998): *The extended Mind*, where they defend that cognition and some mental states extend to the world, and therefore, some elements external to the subject are also constitutive of the mind. It is hard to overstate the impact of the hypothesis of extended cognition. Authors, such as Theiner (2011), have gone as far as affirming that the revolution of the extended mind is similar to that made by Darwin or Newton. With this, a new externalist ontological thesis emerges.

In Mexico, the anthropologist Roger Bartra (2014; *Anthropology of the Brain. Consciousness, Culture and Free will*) proposed similar intuitions. His bold proposal is that self-consciousness is not a function restricted to the brain, but extended in a broad symbolic network of a material and cultural nature. In his work, such an external prosthesis would not work only as an appendage to the brain but would come to constitute part of consciousness in its own right: an exobrain.

Through this brief historical and contextual overview, we wish to emphasize that 4EC is emerging as a coherent research tradition that proposes genuine alternatives compared to its cognitivist rivals. Moreover, increasing numbers of researchers in Mexico and worldwide are drawn to the perspectives it offers, so it may be passing the test of the tenability of its hypothesis about the complex nature of cognition with a better rating. Now that the theoretical foundations of these new perspectives have been established, future work should try to make more targeted experimental comparisons with competing theories in order to assess their relative empirical adequacy and so as to generate new proposals that provide the best explanation. We are on the path to giving greater rigor and coherence to this domain of research, and the research community in Mexico is poised to contribute to this development.

4. Current research themes as illustrated by contributors to this issue

We begin the special issue with *Miguel Angel Sebastian's* (2018) article, in which he argues for a view of phenomenal experience as constitutively, and not merely causally, depending upon bodily activity beyond the brain. The author presents an attractive position that helps resolve certain conundrums in the philosophy of perception and is tailored to fit certain widely agreed-upon features of phenomenal consciousness (in particular, its for-me-ness and cases of shifted spectra). He deploys a representational framework from analytic philosophy of mind (following Shoemaker, 2008; Egan, 2006) in an interesting effort to reconcile the representationalist view to human cognition with 4EC perspectives that are less inclined to representations. Sebastian

argues that in order to solve the problem derived from the shifted spectrum, representationalists should endorse the view that experiences concern its subject where the content of experience is *de se*, explaining the subjective character of the experience. He also argues that entertaining this kind of representation is embodied: consciousness constitutively depends on bodily activity.

Sebastian's article can be somewhat controversial within this special issue because not everyone associated with 4EC perspectives is anti-representationalist, representationalism is by no means a dominant position, and at best controversial in a 4E context. Several prominent 4EC thinkers, mainly from enactivism, for instance, are highly critical of representation as a useful concept, arguing that there is no need at all for mental representations in cognitive models (Chemero, 2011) or that they will have a very limited role (Hutto, 2008). But some extended mind theorists, such as Clark (2008) or Sutton (2006), are quite happy to endorse that representations are sometimes involved in process of cognition. Anyway, the author has made an intriguing bridge between representationalism and 4EC perspectives. Even though he assumes a strong representationalist starting point, he shows compellingly that one still ends up with the conclusions that embodiment is constitutive. At times, his proposal seems similar to extended functionalism (Clark, 2008, 2017; Wheeler, 2010), where bodies in action contribute constitutively to the predictive brain cognitive circuit (Clark, 2017).

José Luis Díaz-Gómez (2018) contribution gives an integrative, neurocognitive, and dynamic system account of self-consciousness. He argues that eight psychosomatic and extended cognitive functions can work as an interactive whole to constitute the self. These integrative self-consciousness states and subsystems may work independently but they may be connected. Furthermore, the integrated self, conceived as an organized conglomerate interacting according to the demands of the task, does not reside in particular brain sites or neural networks but depends on top-down and bottom-up mechanisms coupled with incoming and outgoing sensory-motor loops in a dynamic interaction with the environment. Although it might seem like the discussion is mainly posited in neurocognitive terms, where the physical and social environment, affordances, and the body are epiphenomenal, rather than constitutive, the author posits that this integrative and dynamic model of self-consciousness is fundamentally compatible with the 4EC perspectives, in the sense that the concurring systems proposed require several of the embodied, enactive, extended, and/or embedded features of cognitive processes. In fact, he adds two further dimensions of Es as utterly necessary of self-consciousness, namely, Encephalic and Evolutionary factors, resulting in a 6E perspective.

Bruno Lara and colleagues (2018) offer a richly detailed review of their empirical work on Embodied Cognitive Robotics in their Laboratory at the Autonomous University of the State of Morelos (UAEM). They focus on the design of artificial agents that are capable of performing cognitive tasks autonomously and learning through interaction with their environment. Their work can serve as further empirical support for embodied cognition in one of the foundational research areas of 4EC, embodied robotics. They also engage with the shortcomings of classical artificial intelligence, arguing that such approaches are only concerned with separated high-level tasks and behaviors.

The main claim of the article is that learned sensorimotor schemes coded by internal models are the basis of cognition, in other words affordances, which the agents are acquiring thanks to a learning capability when interacting with the environment, are coded using sensorimotor schemes. These can be applied by a cognitive agent, online or offline, to make predictions about the sensory consequences of motor commands. They summarized the research carried out in their laboratory that follows the assumptions of embodied cognition, where instead of imitating high-level cognitive tasks in order to understand the mind, they turned to study low-level sensorimotor processes, and how these scale up during learning. This work is a pioneering effort in Mexico.

Valverde-Pérez and Negrete-Yankelevich (2018) propose an innovative bridge between the concepts of individuality and agency from autopoietic enactivism and Gilbert Simondon's notions of autonomy, integration, and amplification in the context of computational creativity. In their research, a new understanding of natural and artificial creativity based on a notion of relational creativity was developed, which encompasses both human and nonhuman creativity. In the strongest sense of 4EC, the authors argue that we should shift our focus from propositional knowledge of language that is internally represented to forms of knowing-how to interpret and communicate with others. Trying to avoid an anthropocentric approach to creativity, they use proposals from philosophy of technology and philosophy of organisms to discuss an imaginary scenario based on the interaction between a creative machine and a locked-in syndrome patient. The use of the example of locked-in syndrome is daring, as it provides a clear explanation of a non-reductive process of creativity relationally between a human and a machine.

We think that this article will provide a valuable contribution to enactive and embedded accounts of cognition, as well as to the emerging field of work utilizing Simondon's philosophy that encompass a wide reflection on the nature of the differences and continuities between animals and humans and how machines are part of evolution. We believe that this article provides a very noteworthy theoretical contribution to the

understanding of creativity, agency, individuation, and relationality with regard to humans and computers and will make a very good contribution to the existing literature in relation to process-relational understandings of human-machine interaction and in realizing that creativity is a heterogeneous and widespread activity.

Martínez and Villanueva (2018) give an enactive perspective to explain how patterns of perception and interactions with the world evolve into the capacities for social coordination and social understanding distinctive of human beings. Taking as an example the origin and development of musicality, as human capacities for being musical, and focusing on the role of intentionality associated with the use of symbolic language, they propose that intentionality is not a monolithic phenomenon.

In this sense, their major contribution is that bottom-up intentionality—in contrast with classical top-down intentionality—is embodied in material culture and has played a crucial role in allowing for the complexity of human social cognition. Overcoming the duality between materiality and mind, as well as individual and collective agency, they claim that music is material culture and show that embodied actions associated with different manifestations of musicality involve the deployment of intentionality embodied in artifacts—a kind of intentionality critical in order to understand processes of skilled social cognition and to communicate with others through musicality. It is an important contribution that accounts for explanatory bridges in the evolution of cognitive abilities between enactivism, ecological, and embedded cognition.

The final contribution in this issue is an opinion piece by *Melina Gastelum* (2018). She gives us a brief treatment of time perception from a 4EC approach and how we might think of this phenomenon as part of a framework that takes into consideration conceptual resources from different approaches: affordances, sensorimotor contingency theory, and skilled intentionality framework. She argues that we need to re-think the temporal experience of embodied agents in terms of the fact that affordances themselves are dynamic, enacted, and have an intrinsic temporality. This opinion piece overcomes classical cognitivism and internalist approaches and sketches an outline of how time experience is constituted by the subject's interactions with the sociomaterial environment.

5. Conclusion

Research in 4EC in Mexico has been growing consistently and surprisingly fast in recent years. The once homogeneous framework of classical cognitivism is being replaced by an emerging domain of research informed by multidimensional tools of analysis that

incorporate brains, bodies, and environments in the same explanatory tradition. In this special issue, we wanted to show a little about what has been done in Mexico, and at the same time, we wanted to stimulate the Mexican researchers' engagement with these approaches.

We believe that Mexico, with its historical involvement in cybernetics, its appropriation of the phenomenological tradition of consciousness research in science and philosophy, and its adoption of an embodied paradigm in an anthropological tradition that has long been enriched by a diverse and multiethnic population, is ideally positioned to develop the 4EC perspectives in new exciting directions.

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Notes

1. Rowlands (2010: 29) attributes this acronym to a mention of Shaun Gallagher, during a conversation that took place during a lunch in Cardiff about a workshop on situated cognition. Subsequently, Gallagher organized a conference at the University of Central Florida in October 2007 titled: "4e: The mind embodied, embedded, enacted, extended."
2. Inspired in Helmholtz's (1860) key idea that sensory systems infer sensory causes from their bodily effects. In this account, to successfully represent the world in perception, neural representations encode probability density distributions and the flow of Bayesian inference against new sensory evidence. Perception thus involves matching sensory signal with a cascade of predictions (Clark, 2013, 2017).
3. Laudan emphasizes the significance of foundational commitments related to the evaluation of normal scientific research. These include
 - (1) a set of beliefs about what sorts of entities and processes make up the domain of inquiry; and (2) a set of epistemic and methodological norms about how the domain is to be investigated, how theories are to be tested, how data are to be collected, and the like. (Laudan, 1996: 83)
4. Hyperion Group was an academic group in the UNAM which included Luis Villoro, Leopoldo Zea, Joaquín Sánchez MacGregor, Emilio Uranga, and Ricardo Guerra, which provided valuable contributions to the study of the philosophy of the Mexican way of life from phenomenology and existentialism and represented an

important cultural vanguard in the middle of the last century (Dussel et al., 2009).

5. Currently, some theorists, such as Menary (2010) Dotov (2016), or have argued that the "E" of ecological is missing in the 4EC tradition. We also believe that the 4EC research tradition offers a large arena capable of housing a multifarious family of perspectives, including ecological psychology.

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