Current Alternatives on Perceptual Learning: Introduction to Special Issue on Post-cognitivist Approaches to Perceptual Learning

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Abstract

This special issue is focused on how perceptual learning is understood from a post-cognitivist approach to cognition. The process of perceptual learning is key in our cognitive life and development: we can learn to discriminate environmental aspects and hence adapt ourselves to it, using our resources intelligently. Perceptual learning, according to the classic cognitivist view, is based on the enrichment of passively–received stimuli, a linear operation on sensations that results in a representation of the original information. This representation can be useful for other processes that generates an output, like a motor command, for example. On the contrary, alternative approaches to perceptual learning, different from the one depicted in the classic cognitivist theory, share the ideas that perception and action are intrinsically tied and that cognitive processes rely on embodiment and situatedness. These approaches usually claim that mental representations are not useful concepts, at least when portraying a process of perceptual learning. Approaches within post-cognitivism are not a unified theory, but a diversity of perspectives that need to establish a dialogue among their different methodologies. In particular, this special issue is focused on ecological psychology and enactivism as key traditions within the post-cognitivist constellation.

Keywords: Post-cognitivism, ecological psychology, enactivism, perceptual learning, embodied cognition

Introduction

This special issue is focused on perceptual learning from a post-cognitivist approach. Perceptual learning is a key process in every psychological theory, for it allows us to discriminate key environmental elements and to adapt our actions to achieve our goals skillfully on the basis of that previous discrimination.

The traditional view on perceptual learning is based on the cognitivist approach, which is the mainstream view in the Cognitive Sciences. This view implies that cognition is a process of its own kind, different from perception and action, which consists on information-processing so as to form representations of the outer world. Perception is understood as the passive reception of environmental stimuli that causes certain sensations, which are stored and enriched to form the already-mentioned representations. These representations are used to trigger behavioral outputs in the form of motor programs that serve as responses to those stimuli. Traditionally, in this view, perceptual learning refers to the process of enrichment in the manipulation of symbolic information that allows a generalization across stimuli properties or, in the case of vision, retinal locations (Eckstein, Yu, Sagi, Carrasco, & Lu, 2018). In this sense, the contrast between specificity and generalization (also known as transfer) is a classic topic in the field perceptual improvement (see also the editorial of Herzog, Cretenoud, & Grzeczkowski, 2017)

Nevertheless, the cognitivist view has been recently challenged due to the rising of the so-called post-cognitivist[1] of 4E approaches to cognition (the 'E's stand for embodied, embedded, enacted and extended). According to the post-cognitivist view, cognition is not information-processing, but adaptive behavior: the multiple ways in which organisms navigate their environment making use of certain abilities that are not based on representations or motor programs, but on

[1] The label 'post-cognitivism' must be handled with care, for it is not a historical definition. As a matter of fact, cognitivism, enactivism and ecological psychology (the two latter as part of what has been called post-cognitivism) were developed mostly in parallel, specifically during the second half of the 20th Century. Since the cognitivist framework imposed itself as the mainstream view on the mind, the ideas of non-cognitivist approaches were quite unknown until recently. A proof of this is that Gibson's book on visual perception and ecological psychology was published in 1979, three years before David Marr's influential book on vision. In the last years, we have been witnessing how current approaches re-discover theories and views (such as ecological psychology) that challenge the well-accepted cognitivist views. For that reason, '*post*-cognitivist' is used as a label for explaining that some views are a reaction to the influence of cognitivism, not a mark to reveal a historical development of both approaches.

dispositions and habits that are enacted thanks to environmental elements. This way of understanding the mind does not separate perception, cognition, and action: rather, they are different aspects of the same continuous, spatio-temporally extended process. It is worth mentioning that this post-cognitivist approach is not a unified or single theory, but a plethora of approaches with different methodologies, and also different epistemic and ontological commitments (Gonzalez-Grandón & Froese, 2018).

The post-cognitivist framework: Ecological psychology and enactivism

Among the different views within post-cognitivism, two approaches are highlighted: ecological psychology and enactivism. Ecological psychology is an approach to perception and action that was pioneered by James J. Gibson, Eleanor J. Gibson and colleagues from the mid-1950s onwards. This approach claims that perception and action are two sides of the same continuous process, that the minimum unit of analysis for the study of perception-action processes is the organism-environment system, that ecological information is key for understanding how organisms and their environments are engaged so as to form a coalition or system (hence rejecting the cognitivist idea of the poverty of the stimulus), and that representations are not needed for making sense of perception-action processes. As it can be argued, the ecological approach is an antecedent of the embodied and situated approaches to the mind. This ecological approach to perception and action is based on different theoretical and methodological sources, such as Jamesian functionalism, Holtian behaviorism, Merlau-Pontyan phenomenology and Gestalt psychology (Heft, 2001; Lobo, Heras-Escribano, & Travieso, 2018). One of the advantages of ecological psychology is that this approach developed its own scientific methodological framework for obtaining empirical data from in vivo experimental setups, making it a highly suitable theory for the study of perception and action from a post-cognitivist approach. Ecological psychologists developed a scientific methodology for the study of perception and action based on key ecological principles. For example, regarding vision, James J. Gibson (1961) pioneered ecological optics, a scientific framework for studying the environmental aspects that shape our visual process and our way to detect visual information for action (J. J. Gibson, 1979). The same framework has been applied to touch and haptics, inaugurating dynamic touch, an

ecological approach to touch (see, for example, Carello, 2004; Carello & Turvey, 2000; Turvey, 1996). The key methodological aspects for an ecological study of perception and action are the following: first of all, an ecological scale that includes the behavior of the agent and the information of the environment as the main unit of analysis; second, a description of the informational variables of the environment as higher-order variables; third, the use of mathematical resources (such as dynamical systems) for explaining the interaction between the exploration of an organism and the informational variables that can be accessed through that exploration of the environment.

According to James J. Gibson, he and Eleanor J. Gibson decided to split tasks for developing the ecological approach around the ending of the 1960s: he would be focused on perception and she would be focused on perceptual learning (J. J. Gibson, 1966). This division of efforts lead to different landmarks in this approach: he authored *The senses considered as perceptual systems* (1966) and *The ecological approach to visual perception* (1979), the latter published a few months before his death. She authored *Principles of perceptual learning and development* (1969), *The psychology of reading* co-authored with Harry Levin (1975), *An odyssey in learning and perception* (1991), and with Anne Pick she co-*authored An ecological approach to perceptual learning and development* (2000) before her death in 2002.

A seminal paper[2] on perceptual learning co-authored by J. J. Gibson and E. J. Gibson (1955, further commented in this issue, see Szokolszky, Read, Palatinus, & Palatinus, 2019) already posed a key question regarding perceptual learning: Is learning a process in which our perception improves by diminishing the importance of the environment? That is, if learning amounts to the enrichment of percepts instead of to the specification of information, one of the consequences is that a process of learning should show that the role of the environment diminishes its importance with time, because the perceptual learning process per se would be based on the enrichment process that takes place between perception and action. It is important to say that, decades later, this idea was refined and widely accepted when Chomsky (1986) elaborated the hypothesis of the 'poverty of the stimulus' to

[2] Cited more than 1350 times according to a Google Scholar search performed on 15th July 2019.

claim that environmental stimuli are not sufficient to account for cognitive processes. Born in the field of linguistics, the hypothesis of the poverty of the stimulus was applied to several processes and fields, including perceptual learning processes. Thus, the enrichment hypothesis was re-shaped in a more meticulous way thanks to the developments of cognitivism.

However, the Gibsons reacted against the enrichment hypothesis and claimed that the environment was an essential, constitutive element of perceptual learning processes, so its influence does not diminish with time. Instead of postulating inner information-processing or computing mechanisms for enriching stimulus information, the Gibsons claimed that perceptual learning must be considered as the *education of attention*, a process in which organisms navigate the environment, innovating their ways for focusing the attention in the relevant information for exploring, guiding their action and performing their tasks more efficiently. Consequently, no homuncular process guiding the improvement is postulated: the environment keeps contributing to the cognitive development of the agent and the agent keeps relying on environmental stimulus information for guiding its actions. This does not mean that ecological perceptual learning is all about the environment: the contribution of the organism is essential, and there is refinement and attunement to new informational aspects as well, but the organismal side of the process is not reduced to the postulation of inner mechanisms (symbolic or not) for enriching percepts. This only means that behavior is not detached from the environment, and this claim is valid independently of the level of expertise of the agent who is performing the task.

As we can see, a pioneering branch of perceptual learning within the ecological approach was inaugurated by Eleanor J. Gibson and was based on a rejection of the cognitivist-inspired enrichment views of the stimuli. This approach focused on collecting empirical data that supported the idea of the education of attention for explaining perceptual learning. In particular, E. J. Gibson worked on the visual cliff experiment (Gibson & Walk, 1960; Walk & Gibson, 1961) including empirical data not only from infants, but also from other animals, and she also worked with some variants of this experiment to study affordance perception for displacement in infants (see, for example, Adolph,

Eppler, & Gibson, 1993). This research area has been very influential in Developmental Psychology, especially for the behavior of crawling and locomotion from the perspective of motor development (e.g., Adolph et al., 2012; Adolph, Vereijken, & Denny, 2008) . Years after the initial formulation of the education of attention (J. J Gibson, 1979), Jacobs and Michaels (2007) proposed the direct learning framework for explaining perceptual learning processes including a operationalization of this concept. It is worth mentioning that the connection between both approaches is not historical, but conceptual: whereas the direct learning framework emphasized the idea of the education of attention, the authors developed their own methodological framework for analyzing the process (although, of course, in line with the ecological scientific framework summarized above). According to Jacobs and Michaels, it is possible to represent the available informational variables within an information-calibration space in which experimenters can observe the learning process as a movement in this space toward the specification of information (see a summary of this theory with examples in Higueras-Herbada, de Paz, Jacobs, Travieso, & Ibáñez-Gijón, 2019, this issue). As the authors noted, the difference between a novice and an expert in the learning process depends on the informational variable that the performers detect for guiding them in the performance of the task. In conclusion, novice participants become experts when they educate their attention to look for the most specific variable in the informational space. When participants rely on this kind of information, their performance increase their efficiency.

Enactivism or the enactive approach is another post-cognitivist approach within this view. It is also based on the rejection of the main cognitivist principles[3], and it is inspired in two main theories: the autopoietic view of living organisms developed by Humberto Maturana and Francisco Varela and the phenomenological post-Husserlian tradition in philosophy. The work that properly inaugurated the enactive approach was *The embodied mind* (Varela, Thompson, & Rosch, 1991) and in that work

[3] [3]Considering that the foundational works of enactivism started in the 1990s and the foundational works of ecological psychology were published from the 1960s to the 1980s, in my opinion, enactivism is clearly indebted to the advances made by ecological psychology in order to pursue a non-representational, situated and embodied approach to cognition.

they define the main claims of such view. Specifically, those that affect the topic of perceptual learning would be that cognition is perceptually-guided action and that organisms are active explorers that enact different sensorimotor contingencies. These contingencies are needed in order to develop the skills that will allow them to deal with their surroundings. The idea of sensorimotor contingencies is key in this approach and it is based on the claim by which a particular movement leads to a particular sensation, establishing a lawful relation between movement and sensation. The mastery of sensorimotor contingencies is at the basis of the skillful behavior of agents.

The enactive approach is divided into different strands or branches: the traditional enactive framework, that includes a theory of biological agency as a self-organized and operationally-closed system and a cognitive agency based on sensorimotor systems (Barandiaran, Di Paolo, & Rohde, 2009; Di Paolo, 2005; Varela et al., 1991); the sensorimotor enactive approach that is solely based on the idea of sensorimotor contingencies and does not necessarily accepts the self-organized biological agency (O'Regan & Noë, 2001); and radical enactivism, a more methodologically-oriented approach to enaction whose aim is to sanitize or debug current post-cognitivist approaches from cognitivist remainders (Hutto & Myin, 2013, 2017). Enactivists supported their claims with scientific evidence mostly from computational modelling simulations and some in vivo experiments, mainly in the fields of visual processes (O'Regan, 1984; Philipona & O'Regan, 2006; Rensink, O'Regan, & Clark, 1997) and sensory substitution (Bermejo, Di Paolo, Hüg, & Arias, 2015; Froese, McGann, Bigge, Spiers, & Seth, 2012). Thus, enactivists (in this sense indistinguishable from sensorimotor theorists, see Taraborelli & Mossio, 2008) are also committed to the idea of the organism-environment relation as the basis of cognition, as well as with the idea that cognition is a dynamic process that does not need to rely on representations to explain it.

The issue of perceptual learning has also been addressed by the enactive approach. The most recent proposal has been that of Di Paolo, Buhrmann, and Barandiaran (2017). As Higueras-Herbada et al. (2019) claim in their contribution to this special issue, the main highlights of their approach to perceptual learning are the following: (1) it is an embodied, embedded and enacted framework, which

means that it does not rely on representations for explaining how we learn to perceive and act; (2) learning processes are meant to transform perception rather that constructing it, which means that perceptual learning is a process that starts from a perceptual process, so it cannot construct perception, it just modifies the previous states so as to develop it into new forms; (3) perceptual learning should be action-based and world-involving: 'action-based' means that perceptual learning requires personal effort, and 'world-involving' means that perceptual learning "involves a relation to the dynamics of the world beyond the mere supply of sensory input" (Di Paolo et al. 2017, p.80); (4) perceptual learning also requires adaptive mechanisms that imply some normative evaluation through a particular feedback that allows the agent to evaluate the appropriateness of the state the agent is engaging in, which means that the agent is capable of learning from failures thanks to this evaluation of the available feedback; (5) finally, the claim that learning never ends is key, since it is an open-ended process in which the agent is constantly adapting itself to the perturbations of the environment and trying innovative ways to deal with unexpected situations.

As we can see, there are similarities and also differences between an enactive approach and an ecological approach to perceptual learning. The similarities should be clear at this point: both approaches are committed to embodiment and situatedness; this is, to the idea of the primacy of the agential level of description and also to the essential contribution of the environment for offering a complete picture of the perceptual learning process. Nevertheless, there are also differences: there are different methodological and experimental frameworks on both sides, and the vocabularies they use are also different, which does not make it clear enough if they are discussing the same phenomena (notions like 'sense-making' or 'affordance' are exclusive of each approach, but it is not clear if similar words like that of 'meaning' mean the same for each approach). This is one of the main reasons for making this special issue: it is important to reconcile both approaches so as to offer a unified picture of the post-cognitivist approach. Hence the importance of perceptual learning, because it emphasizes the commitments to embodiment and situatedness of both approaches and, at the same time, it points to what have been considered as problematic processes because the imply certain

degree of detachment from the environment according to the cognitivist approach, such as learning. However, as we can see, this is not necessary according to post-cognitivist approaches.

Alternative approaches to perceptual learning illustrated in this special issue

This special issue includes a series of papers that aim to offer a contribution to the field of perceptual learning that can be useful for researchers involved in both enactive and ecological approaches to cognition. Together, they propose an encouraging view of the process of perceptual learning that goes from lower levels of analysis to higher levels while keeping enough flexibility to be applied to changes due to development, training and expertise in the usage of artifacts and tools.

Szokolszky et al. (2019) aim to offer a detailed overview of the three main contributions in perceptual learning within the post-cognitivist literature: Eleanor J. Gibson's ecological approach to perceptual learning, the direct learning approach, and the organicist approach applied to perceptual learning. They consider perceptual learning as an essential part of both development and evolution, and they highlight the importance and benefits of the ecological approach as the vanguard of a post-cognitivist approach to perceptual learning. After a presentation of the main principles of ecological psychology (perception and action are inseparable, perception is direct and involves ecological information, and perception is of affordances), they analyze the main challenges and research paths of the ecological approach: the physical basis of organismic systems and the need for a stronger notion of organism in the ecological approach. After this, they delve into the intricacies of perceptual learning from an ecological approach. They summarize the view of ecological perceptual learning as a way of making sense of how we manage to deal with a continuously changing environment: we are always readjusting our ways of dealing with the world and learning from experience because the layout of objects and events is always changing. The authors argue that, within the ecological approach, we cannot differentiate between perception and learning, because a fully-fledged explanation of perceptual processes should include an explanation of perceptual learning processes.

Szokolszky et al. (2019) offer a rich account of Eleanor J. Gibson's ideas in a historical manner, detailing different experiments and results that work as milestones in her career, and showing

how they helped her to build her line of research. The authors emphasize the idea of Eleanor J. Gibson by which exploration behavior is as natural to human beings as breathing, so there is no reason to expect a failure to see how humans make their behavior more efficient. Therefore, they claim that E. J. Gibson's contributions are key, and her experimental results would not have been obtained otherwise if she would not have pursued an ecological approach to perception. Then the authors focus on direct learning and emphasized that there is an innovation in the use of lawful explanations for explaining perceptual learning. Furthermore, the authors deal with the concept of organism and its importance within the ecological view, claiming that this approach needs a theory of the organism that makes justice to different levels of change, such as learning, development, and evolution, and the relation among them. For this reason, they aim to strengthen the connections between the extended modern synthesis and the ecological approach because both views emphasize the constructive and exploratory character of organisms. The emergence of concepts like affordance landscape (Walsh, 2014) or the application of niche construction to ecological psychology (Heras-Escribano & De Pinedo-García, 2018) could be examples of how that suggestion of Szokolszky et al. can be incorporated to the ecological approach. After a succinct mention of the importance of language and tool use for perceptual learning within the ecological approach, the authors establish a dialogue with enactivism and claim that they are pursuing the same goals from similar starting points, but that the contact between both views is minimal. They propose to overcome the mischaracterizations in the debate and to offer a fruitful dialogue on the common interests that will help to overcome the differences. They end up summarizing the benefits of the ecological approach and the importance of its account of perceptual learning for a post-cognitivist approach.

Higueras-Herbada et al. (2019) summarize the main contributions of the enactive approach to perceptual learning and aim to complement it with the main advances from the direct learning theory. Regarding the (indirect) dialogue between ecological psychology and enactivism, they claim that it has not been fruitful, and they review the different perspectives on the relation between enaction and ecological psychology. Regarding perceptual learning, they propose to retain the main contributions

from the enactive approach and include the experimental framework from direct learning, that includes the ecological methodology for collecting empirical data from in vivo experimental setups. In particular, they propose to include the idea of the information-calibration space and the transitions found in the direct learning framework. They illustrate the potential of direct learning explanations with two examples from the specialized literature, one of cart pole balancing and another one of haptic touch. These two empirical examples show how the theoretical aim of enactivism, illustrated with five requirements by Di Paolo et al., (2017) and mentioned above, are already fully achieved within the ecological framework, also including a specialized methodology for in vivo experimentation that increase the robustness of the post-cognitivist proposal. Nevertheless, the aim of the authors is not to subsume one approach into another, but to establish a ground for a balanced approach in the post-cognitivist view that includes the contributions of both approaches.

In this special issue there are also contributions that aim to clarify the detection of information that occurs in an organism-environment system. Specifically, how the changes to detect more useful information are possible taking into account that the improvement needs to pursue (some-how) a specific direction; that is, the direction pointed-out by *specificity* (see Richardson, Shockley, Fajen, Riley, & Turvey, 2008). Raja (2019) claims that ecological psychology lacks an account of how these changes in the detection of information take place. He aims to provide an explanation of detection of information without computation thanks to the idea of resonance proposed within the ecological approach by J. J. Gibson (1966). Raja tries to clarify this idea of ecological resonance (which has not been sufficiently well-developed in the literature, according to him) using the idea of resonance in physics, described as the effect that occurs when one system drives other system because they are coupled by some variable that couples them (mechanically, for example). As Raja claims, this is achieved because "the activity of the perceiver in her environment (i.e.- the perceiver-environment dynamics) generates perceptual information that subsequently constrains the dynamics of perceptual systems (e. g., the neural dynamics of perceptual systems) in terms of informational coupling or synchronization, such that perceiver's perceptual systems resonate to the perceiver-environment

dynamics" (Raja, 2019). These two dynamic scales (the perceiver-environment dynamics and the perceptual systems' dynamics) are described in terms of dynamical systems so as to fit with the ecological scientific methodology. He proposes a formalization to operationalize the dynamics in particular situations (see Figure 1 in Raja, 2019). Here, perceptual (ecological) information is the variable that constrains perception at different scales. Raja claims that this kind of architecture is better than Bayesian architectures and some other architectures that includes somehow a notion of resonance because this one is purely post-cognitivist and do not appeal to cognitivist aspects like computational processes. Finally, Raja aims to combine his formalization of resonance with direct learning to apply it to the field of perceptual learning. Thus, he aimed to analyze the role of neural processes in direct learning processes. According to Raja, his formalization is compatible to direct learning, because it explains neural dynamics when the dynamics of the organism-environment are taking place in a direct learning process. Raja's idea is to go from metaphor from theory because, according to him, the idea of resonance in the ecological tradition has not been sufficiently exploited so as to offer genuine contributions in the explanation of cognitive processes from an ecological perspective.

Finally, in the last contribution, Favela (2019) starts his paper explaining how ecological psychology, embodied cognition, machine intelligence and dynamical systems can be integrated. Thus, it is possible to establish a framework that provides both a methodological and a theoretical approach to make sense of cognition in general. Interestingly, this framework would be capable of dealing with practical skills –as ecological psychology currently does–, but also including an explanation of the contribution from different scales that go from the nervous systems to the use of artifacts and tools by humans. In sum, this framework allows us to offer an explanation of the integration of brain, body, tools, and environment in a single picture. In particular, Favela shows that soft-assembling could be a key concept to understand human beings as brain-body-tool-environment systems that are not rigidly constrained but are functional. In fact, in such systems there is flexibility, so there can be multiple combinations of the elements of the system: the functionality is maintained

even when some elements are playing different roles. Focusing on perceptual learning, Favela encourages other researchers to apply this framework to learning situations, using the methodology of non-linear dynamics systems theory in order to check is such a process indicates a soft-assembling -for example, as it happens to the case of 1/f scaling dynamics (pink noise). It seems that there is a considerable amount of literature that shows that the patterns of variability that can be found in one short timescale, regarding a spatial or a temporal structure, can be found also in longer timescales. These analogous patterns found at different scales seem parts of a fractal structure that relates to the degree in which the system is assembled and working together. Interestingly, the concrete range of pink noise appear when the system shows flexibility to adapt to different configurations. This framework, in sum, could also be an important step towards a unified post-cognitivist view that addresses quite different scales.

Conclusion

As we can see, there is a wide variety of proposals that aim to combine different approaches and tools that are part of the post-cognitivist family. Two main ideas can be concluded from the contributions of this special issue: (1) all perspectives presented as post-cognitivist views on perceptual learning aim to integrate their views in a framework that will not subsume one theory into another, hence researchers are not afraid of proposing concepts and methods from different disciplines and theories; (2) contrary to what some cognitivist-oriented researchers claim, this post-cognitivist approach to perceptual learning does not obviate the role of sub-personal systems or mechanisms. In this sense, the different viewpoints that can be found in this special issue take into account the role of the brain, the body, and the environment altogether, portraying a picture of human cognition that is richer than a computer of sense data. I hope this special issue will be useful to inspire future research about perceptual learning from a post-cognitivist approach.

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