How to Understand Brain-Body-Environment Interactions? Toward a systemic Representationalism

Frédéric Alexandre

How to Understand Brain-Body-Environment Interactions? Toward a Systemic Representationalism

Frédéric Alexandre
Inria Bordeaux Sud-Ouest, France
frederic.alexandre/at/inria.fr

> Upshot • The target article discusses the influence of the enactivist account of perception in computer science, beyond subjectivism and objectivism. I suggest going one step further and introduce our VirtualEnaction platform, proposing a federative systemic view for brain-body-environment interaction for this analysis.

Introduction

« 1 » Thanks to recent advances in philosophy and computer science, the authors of the target article propose a new analysis of the problems of misrepresentation and comparability of visual experience that were judged essential by Francisco Varela (Varela, Thompson & Rosch 1991). In this commentary, I would like to go one step further and evoke other advances that allow us not only to revisit these problems but also to associate them more closely.

« 2 » In §1 and §25 of their target article, Adrián Palacios, María-José Escobar and Esteban Céspedes clearly explain that, in an enactivist framework, perception is due to the co-determination between inner mechanisms of the neurophysiological structure (subjectivism of neuronal feedback or lateral interactions, §23) and ecological interaction in the environment (objectivism of a spectral reflectance for color perception, §22). We have recently built a global software simulator called VirtualEnaction (Denoyelle et al. 2014; 2015) that implements not only models of cerebral regions but also models of the body of an agent and of the environment in which it acts. With this platform, which also takes care of the simulation of interactions between these models, we are consequently able to observe in a unique and unified framework how perception is a property of the world enacted by the animal-environment co-determination, as proposed in §25 for color perception.

« 3 » Even if problems of misrepresentation and comparability emerge from concepts of representation, it is explained in §5 that a weak contextualist notion of representation is needed to analyze these problems and is still compatible with enactivism. A major interest of the target article is to argue, based on philosophical analysis, that a "non-representationalist notion of representation" (§35) is necessary in our informational world and does not compromise the central view of enactivism, rejecting the representation of both purely objective and subjective properties. Instead, it can be supposed that, in the process of co-determination, some kind of representation (in the weak sense) is constituted, in idealized dimensional spaces. The representation of color perception in the weak sense, described in §31 as the state of the agent, of the environment, of sensorimotor activity and evolutionary history, is the kind of distributed representation that is built in VirtualEnaction. This computational platform is consequently the ideal tool to revisit most concepts of the target article and raise new questions.

VirtualEnaction

« 4 » Researchers designing systemic models of the brain with the aim of implementing large-scale executive functions have to consider the brain as a system in interaction with the body and the environment, and design robotic setups to emulate the emerging behavior. My team, together with neuroscientists, studies certain high-level behaviors, i.e., survival strategies in a world with punishing and rewarding stimuli and agents, related to respondent and operant conditioning. The tasks are organized in long-lasting protocols, so that we can study the evolution of learning, elaborate some statistics, and make comparisons with biological observations. It proved difficult for us to use physical robots for long periods, and we also found it necessary to measure, quantify and control details of the brain model as well as of the environment, including the body. This was our initial motivation for designing the VirtualEnaction platform.

« 5 » VirtualEnaction is an adaptation of the Minecraft open game platform, where the usual human player is replaced by a software application corresponding to the model of the brain. The platform allows one to define the structure of the world and its intrinsic rules (e.g., moving agents, gravity, surface reflectance), the characteristics of the body (e.g., sensors for vision as well as for pain, actuators), and, of course, a module corresponding to the cerebral architecture defined for the considered task. Since every component is defined as a programmable software application, it is consequently possible to define precisely (and complexify at will) the kind of survival task, the characteristics of the body, and the level of details in the neuronal module.

« 6 » This software platform has been designed and already used to analyze, with neuroscientist colleagues, some classical protocols of learning like Pavlovian learning (Carrere & Alexandre 2015) or decision making (Carrere & Alexandre 2016). Here, I propose to analyze a prospective experiment in which we adapt this platform to build a subjective representation (as in active computer vision, §16) in the brain module and specifically consider introducing, in the visual processing regions, some neuronal mechanisms known to induce contour illusions (Grossberg & Raizada 2000), other mechanisms proposed to induce illusions of color constancy (§10), top-down processes transmitting expectancies in the lower levels of processing (Grossberg & Versace 2008).

Analysis of the experiment

« 7 » Firstly, the above-mentioned neuronal mechanisms have already been proven to generate some kinds of illusion but they are not able to detect them locally because illusions are only emerging from local neuronal mechanisms. Secondly, it is also clear that other parts of the software platform will represent the environment and accordingly the veridical perception. Rephrasing §36, we could consequently propose that our platform is a support for a good theory of perception.

« 8 » The target article has little problem in defining veridical perception (§38), and finds it more difficult to define illusions (§40). Our approach gives an easier access to illusions. Particularly, we could say that internal mechanisms in the brain module will always modify the sensory input and, accordingly, will always generate a kind of illusion. We could also add that only some sensory inputs will generate very few modifications, because their characteristics are well adapted to the current state and internal mechanisms of the brain module and might give "the illusion of no illusion." Perhaps here we meet the idea of correct perceptual experience "in correspondence with the relevant enactive conditions of the perceiver and its environment" (§41).

« 9 » At the end, with this analysis in mind, is the problem of misrepresentation so important? A certain situation might lead to a representation in the environment module corresponding to veridical perception and a representation in the brain module corresponding to an illusion. Whereas the former representation is simply due to the game engine of Minecraft simulating the environment, the latter is the kind of weak representation evoked above, built from sensory input and internal neuronal dynamics, including local mechanisms prone to illusions for certain input. That illusion might lead to an erroneous decision, but we can also propose that the most important point is to be able to check that each module of the platform obeys its own local rules and that the platform conveys two different phenomena, the veridical perception and its internal processing, and not a misrepresentation.

« 10 » As an answer to the problem of comparability, it can be stated that no two organisms are strictly identical and neither do they share identical perceptual experiences, with an identical series of perceptual episodes received by two identical biological organisms (§34 and §43). This platform might go beyond this statement and offer a more quantitative analysis of the differences observed in the parameters describing the brain module as a function of changes in parameters describing perceptual episodes and the initial state of the brain module. It might be reasonably supposed that this function is most of the time continuous (in the mathematical sense) and, accordingly, that two similar organisms experiencing similar episodes will have few differences. In addition, we could also imagine that singularities of this function (still in the mathematical sense) might occur in situations where only one organism has an illusion.

« 11 » Concerning the structure supporting shared aspects of perceptual experience (§13), monitoring the activity of the brain module during a set of experiences can lead to quantifying modifications that have taken place in the module, corresponding to a kind of prior of the agent. Even if it is unlikely that agents with different experiences have a well-identified structure with shared aspects, one can envisage quantifying the level of overlap between two histories of modification, at a global level or concerning a specific domain, and consequently evaluating an estimation of their degree of resemblance. On this view, comparability would be rather a matter of degree.

Summary

« 12 » Our VirtualEnaction platform is a convenient tool for manipulating enactivist concepts because it offers, on the same platform, access to monitor characteristics of the brain-body-environment system quantitatively in space and time. It addition, it extends the target article because it defines, in the brain module, a representation built in the weak sense by co-construction between inner neuronal mechanisms and ecological interactions in the environment, which can ease the interpretation of the problems of misunderstanding and comparability. The fact that this weak representation is consistent with the concept of enacted reality can be defended more strongly here because the brain module is developed in a systemic view, including not only sensory but also motor regions that can modify the environment, giving a concrete anchoring to the principle of co-determination between the agent and the environment.

« 13 » The role of action ("action shapes perception" §1) is central for enactivism and has been often discussed when actions are oriented toward the environment. In our systemic models of the brain, we introduce other kinds of actions with no visible effect in the outer world but modifying the internal world, like covert attention (Fix, Rougier & Alexandre 2011) or decisions for changing the current goal (Carrere & Alexandre 2016). Our platform could be a convenient tool to study the effects of such internal actions on perception. Enactivism has already had a focused but strong influence in modeling sciences and in robotics (Buzsaki, Peyrache & Kubie 2014; Friston 2010; Froese & Ziemke 2009); exploiting and developing this platform in that direction is a new illustration of that influence.

Questions to the authors

« 14 » It is stated in §34 that enacted reality can be observed in the system perceiver-environment and is objective. Even if we build here only a model of this system, is objectivism still present? (Q1)

« 15 » The framework that we present here considers the combined effect of different agents (brain, body, environment), with representations built in the brain module from interactions between sensory inputs and inner neuronal mechanisms, not only for the sensory analysis of the environment but also to act and modify it. Is the idea of weak representationalism still valid here or is it pertinent to introduce instead the idea of systemic representationalism? (Q2)

« 16 » Could linking our analysis of the problem of comparability (no two organisms are strictly identical but sometimes the differences – priors – are weak and the organisms can be judged similar and able to share some experience) and of the problem of misrepresentation (a functioning brain always modifies sensory inputs and, strictly speaking, generates some illusion, but sometimes these modifications are minor and have no strong impact on the perceptual analysis and subsequent behavior) explain some common-sense assumptions? (Q3)

Frédéric Alexandre is an Inria Director of Research, head of the Mnemosyne team affiliated to Inria, CNRS, Université de Bordeaux, Bordeaux INP, through UMR LaBRI and IMN. The team aims at developing systemic models of the brain using formalism of computational neuroscience and is specifically interested in understanding how high-level cognitive functions emerge from the synergy between different kinds of memory. This approach is very consistent with the enactivist view of brain-body-environment interactions. The team is hosted in the neuroscience laboratory on the Bordeaux hospital campus, favoring medical and neurobiological applications, but investigations in machine learning and artificial intelligence are also considered.

Received: 19 October 2017
Accepted: 27 October 2017