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Do We (or Our Brains) Actively Represent or Enactively Engage with the World?

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Abstract

This chapter reviews scientific discussions of several problems (free will, social cognition, perception) that reflect a representational approach to cognitive science, and contrasts them with embodied, enactive approaches. It asks whether predictive coding models can adjudicate between these different views and suggests that predictive coding models can go either way. An interpretation is then offered that is designed to push such models toward the enactive camp. It concludes by considering the suggestion that enactivism is a philosophy of nature (as defined by Godfrey-Smith), rather than a scientific research program, and suggests that enactivism's attempt to rethink the nature of mind and brain also involves rethinking the concept of nature.

Introduction

Recent developments in embodied cognition motivate the following question: Is cognition *in the head* or *in the world*, or in some mix of brainy and worldly processes? There is a long tradition that takes cognition to be a fully in-the-head event. I will discuss a few of the more recent versions of this view and then offer the contrasting view of enactive cognition—an embodied approach that has roots in phenomenology and pragmatism. Enactive approaches to cognition suggest that, at least in basic (perception- and action-related) cases, cognitive processes are not just in the head. In trying to weigh the balance of these ideas, I address the challenge of predictive coding models and suggest where they might fit into this debate. In addition, I will discuss issues that concern time and dynamics, since these are important issues and are treated differently in different approaches.

To provide a framework in regard to temporality I borrow a threefold division from the work of Varela (1999). Different aspects of cognition involve processes on three different scales of duration:

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1. The *elementary* scale (varying between 10–100 milliseconds)
2. The *integration* scale (varying from 0.5 to 3 seconds)
3. The *narrative* scale involving memory (above 3 seconds)

In terms of neurophysiology, the elementary scale corresponds to the intrinsic cellular rhythms of neuronal discharges, roughly within the range of 10 ms (the rhythms of bursting interneurons) to 100 ms (the duration of an excitatory-inhibitory sequence of postsynaptic potential in a cortical pyramidal neuron). Neuronal processes on this scale are integrated into the second scale, which, at the neurophysiological level, involves the integration of cell assemblies. Phenomenologically, the integration scale corresponds to the experienced living present, the level of a fully constituted cognitive operation; motorically, it corresponds to a basic action (e.g., reaching, grasping). On a dynamic systems interpretation, neuronal events on the elementary scale synchronize (by phase-locking) and form aggregates that manifest themselves as incompressible but complete acts on the integration scale.[1] The narrative scale is meant to capture longer time periods. Further distinctions could be made, and other more rhythmic time patterns could be explicated (as suggested at this Forum by Marek McGann, pers. comm.). For purposes of this article, the threefold distinction should, however, be sufficient.

Cognition in the Head: Some Standard Approaches

Even if we define cognitive processes broadly to include not just beliefs and desires but also states that refer to bodily action and to interactions with other people, we still find that mainstream cognitive science offers narrow accounts which place all the action required for full explanation in the mind or in brain processes. The term “narrow” is a technical one in philosophy of mind, referring to internal mental representational processing or content. Standard explanations in cognitive science define cognition as constituted by mental or neural representations. A few examples will provide a good sense of this approach.

The first example concerns action, specifically issues that involve action planning and intention formation. The processes involved can be characterized at subpersonal and personal levels of explanation, but all of them remain narrowly within the traditional boundary of the mind-brain. Concerning the very basic elementary scale, consider the well-known Libet experiments. Libet et al. (1983) asked about neural dynamics involved in the readiness potential (*Bereitschaftspotential*) and its relation to our immediate sense of deciding to act (see also Soon et al. 2008). These experiments are not only well known, they are also controversial. I will not go into details about the experiments or controversies pertaining to methodology, but I will briefly summarize the basic idea and say something about the philosophical controversy.

1 This currently has the status of a working hypothesis in neuroscience (Thompson 2007:332).

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The question Libet tries to answer is whether consciousness plays a role in the initiation of action, and he interprets this to be a question about free will. Libet's results indicated that on average, 350 ms before the subject is conscious of deciding (or having an urge) to move, the subject's brain is already working on the motor processes that will result in the movement. That is, the readiness potential is already underway, and the brain is preparing to move before the subject makes the decision to move. The conclusion is that voluntary acts are "initiated by unconscious cerebral processes before conscious intention appears" (Libet 1985:529).

There are different interpretations of what these results mean. Most of them focus on the question of free will. Libet himself finds room for free will in the approximately 150 ms of brain activity remaining after we become conscious of our decision, and before we move. He suggests that we have time consciously to veto the movement. Others, however, think that the brain decides and then enacts its decisions; consciousness is epiphenomenal in this regard. The brain inventively tricks us into thinking that we consciously decide to act and that our actions are controlled at a personal level. On this view, free will is nothing more than a false sense or illusion.

Rather than enter this debate, I will simply point to a central assumption made about the kind of cognitive processes that are supposed to be involved in free will expressed by Haggard and Libet (2001:47), who frame the question and refer to it as the traditional question of free will: "How can a mental state (my conscious intention) initiate the neural events in the motor areas of the brain that lead to my body movement?" They are right in that this is the traditional way to ask the question: it is precisely the way that Descartes and many thinkers in the modern philosophical tradition would frame the question. It is a question of mental causation, which places the cognitive processes of free will in the head where brain and mind meet up.

To assume that this is the right way to ask the question overlooks the possibility that free will is not something that can be explained simply by looking where Libet experiments look. For example, one can argue that these experiments have nothing to do with free will (Dennett 2004; Gallagher 2006). This challenges the assumption that free will can be characterized in terms of the short, elementary scale of 150 ms, or even on the integrative scale which might involve 3–5 s. This type of response can go one of two ways. The first simply leads us back into the head, into discussions of intention formation where cognitive deliberations generate prior intentions that have a later effect on intentions-in-action. Since the Libet experiments address only intentions-in-action or motor intentions, they miss the mark since free will is more about deliberation and prior intention formation. Such explanations are worked out in representational terms of beliefs and desires in processes best characterized in terms of a space of reasons and on the narrative timescale, but still very much in the head. The second way leads to the idea that free will is not a property of one individual brain, mind, or organism, but is relational, and that social

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and environmental factors contribute to or detract from our ability to act freely (discussed in more detail in the next section).

To say that something like social relations are involved in free will, however, does not necessarily lead beyond traditional concepts of the mind. This is clear in ongoing debates about social cognition that are dominated by methodological individualism; that is, the idea that theory of mind is explained by a causal mechanism (a theory-of-mind mechanism or a mirror system) or process inside the individual's head. Today the growing consensus is that there are two networks in the brain responsible for our ability to understand others: a theory-of-mind network that includes the temporo-parietal junction, medial parietal cortex, and medial prefrontal cortex (e.g., Saxe et al. 2009), and mirror areas in premotor and parietal cortexes. Taken together, the neuroscientific findings may justify a hybrid of theory theory and simulation theory, or suggest a two-system approach of online perspective taking and offline social reasoning (Apperly and Butterfill 2009).

Complicating such views, mainstream theories of social cognition have started to take note of objections coming from embodied cognition and action-oriented approaches. This and more general concerns about the claims made by embodied cognition theorists have motivated a way of thinking about the role of the body consistent with standard representationalism—so-called "weak" or "minimal" embodiment (Alsmith and de Vignemont 2012). For example, Goldman and de Vignemont (2009) suggest that none of the things that embodied cognition theorists usually count as important contributors to cognitive processes—anatomy and body activity (actions and postures), autonomic and peripheral systems, relations with the environment—really do count. Rather, the only "bodily" things relevant to an account of cognition in general, or social cognition in particular, are body-formatted (or B-formatted) representations in the brain. As they put it, B-formatted representations offer a "sanitized" way of talking about the body and "the most promising" way to promote embodied cognition (Goldman and de Vignemont 2009:155).

B-formatted representations are not propositional or conceptual in format; their content may include the body or body parts, but they may also include action goals, represented in terms of how to achieve such goals by means of bodily action. Somatosensory, affective, and interoceptive representations may also be B-formatted, "associated with the physiological conditions of the body, such as pain, temperature, itch, muscular and visceral sensations, vasomotor activity, hunger and thirst" (Goldman and de Vignemont 2009:156). Goldman (2012:74) argues that one can develop an overall embodied cognition approach simply by generalizing the use of B-formatted representations.

Social cognition, on this view, is embodied to the extent that B-formatted representations involved in perceptual mirroring are used to represent the actions or states of others. This is precisely the sense in which Gallese talks of *embodied* simulation. Gallese (2014) endorses the idea of B-formatted representations in contrast to more enactive views of embodied cognition. Mirror

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neurons "can constitutively account for the representation of the motor goals of others' actions by reusing one's own bodily formatted motor representations, as well as of others' emotions and sensations by reusing one's own visceromotor and sensorimotor representations" (Gallese 2014:7).

Similar strategies aiming to "sanitize" embodied cognition can be found in accounts of other aspects of cognition. As one example, several theorists point to body-related simulations (representations) as important for language and concept processing (e.g., Glenberg 2010; Meteyard et al. 2012; Pezzulo et al. 2011). All of this is consistent with the standard representationalist "mentalistic enterprise" of reconstructing the world (Jackendoff 2002), of "pushing the world inside the mind" (Meteyard et al. 2012), and a very narrow conception of embodiment.

Cognition in the World: Phenomenologically Inspired Enactive Approaches

Enactive approaches to cognition are inspired and informed by phenomenological philosophy. Varela et al. (1992), who first defined the enactive approach, found significant resources in the phenomenological tradition. For example, Husserl's (1989) concept of the "I can" (the idea that I perceive things in my environment in terms of what *I can* do with them); Heidegger's (1962) concept of the pragmatic ready-to-hand (*Zuhanden*) attitude (we experience the world in terms of pre-reflective pragmatic, action-oriented use, rather than in reflective intellectual contemplation or scientific observation); and especially Merleau-Ponty's (2012) focus on embodied practice, which influenced both Gibson's (1977) notion of affordances and Dreyfus's (1992) critique of classical cognitivism (see also Di Paolo 2005; Gallagher 2005; Noë 2004; Thompson 2007). Less noted are relevant resources in the American pragmatist tradition; many of the ideas of Peirce, Dewey and Mead can be considered forerunners of enactivism (see Gallagher 2014; Menary, this volume).

Enactive versions of embodied cognition emphasize the idea that perception is *for action*, and that action orientation shapes most cognitive processes. Most enactivists call for a radical change in the way we think about the mind and brain, with implications for methodology and for rethinking how we do cognitive science (see below). Clark (1999) provides a succinct three-point summary of the enactive view, endorsed by Thompson and Varela (2001):

1. Understanding the complex interplay of brain, body, and world requires the tools and methods of nonlinear dynamic systems theory.
2. Traditional notions of representation and computation are inadequate.
3. Traditional decompositions of the cognitive system into inner functional subsystems or modules ("boxology") are misleading and blind us to arguably better decompositions into dynamic systems that cut across the brain-body-world divisions (Thompson and Varela 2001:418).

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Enactive approaches, similar to the idea of extended mind or distributed cognition, argue that cognition is not entirely "in the head," but is distributed across brain, body, and environment. Enactivists, however, reject functionalism and claim that the specific nature of (human) bodily processes shape and contribute to the constitution of consciousness and cognition in a way that is irreducible to representations, even B-formatted representations. In contrast to Clark (1998), who argues that specific differences in body type or shape can be transduced and neutralized via the right mix of representational processing to deliver similar experiences or similar cognitive results, enactivists insist that biological aspects of bodily life, including organismic and emotion regulation of the entire body, have a permeating effect on cognition, as do processes of sensorimotor coupling between organism and environment. Noë (2004), for example, developed a detailed account of enactive perception where sensorimotor contingencies and environmental affordances take over the work that had been attributed to neural computations and mental representations (see also O'Regan and Noë 2001).

To be clear, enactivists do not deny the importance of the brain, but they understand the brain to be an integrated part of a larger dynamic system that includes body and (both physical and social) environment. The explanatory unit of perception (or cognition, action, etc.) is not just the brain, or even two (or more) brains in the case of social cognition, but dynamic relations between organism and environment, or between two or more organisms, which include brains, but also their own structural features that enable specific perception-action loops, which in turn effect statistical regularities that shape the structure and function of the nervous system (Gallagher 2005; Thompson 2007).

If I reach out to grasp something (or someone), my hand is involved, as is my arm, my shoulder and back muscles, my peripheral nervous system as well as my vestibular system, no less than my brain, which in all of its complexity is making its own dynamic adjustments on the elementary timescale as part of this process of reaching out to grasp. A full account of the kinematics of this movement does not add up to an explanation of the action, nor does a full account of the neural activity involved. Likewise, if I reach a decision about how to act, the neural components of this activity are a necessary part of it, but also where I happen to be located, who I'm with, my past practices, current physical skills, and health status, not to mention my mood, will to some degree play contributory roles in the decision formation. Some of these elements enter into the process on a narrative timescale and are not under my current control. In this respect, my body is not just a sensorimotor mechanism. Affect plays an important role—things like hunger, fatigue, physical discomfort or pain, as well as emotion and mood. Such things are not well behaved in terms of timescale—they involve all three scales. With respect to the discussion of free will, whatever agentive action is, it is both constrained and enabled by all of these different factors. As Clark and Chalmers (1998:9) suggest, if one of the extra-neural components is taken away, "the system's behavioral competence

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will drop, just as it would if we removed part of its brain." At the very least, a removal (or an addition) of any component will entail compensatory adjustments across the system.

Evan Thompson (2014) provides a nice analogy. Saying that cognition is in the brain is like saying that flight is inside the wings of a bird. Just as flight does not exist if there is just a wing, without the rest of the bird, and without an atmosphere to support the process, and without the precise mode of organism-environment coupling to make it possible (indeed, who would disagree with this?), cognition does not exist if there is just a brain without bodily and worldly factors. "The mind is relational. It's a way of being in relation to the world" (Thompson 2014:1). For some, these claims may seem obvious or even trivial, and yet we often find ourselves doing science as if the only things that counted as explanatory were neural representations.

Processes of social interaction are also not reducible to neuronal processes (or B-formatted representations) within the individual, since they include physical engagement with another person and/or a socially defined environment, processes of "primary intersubjectivity," affective processes where distinct forms of sensorimotor couplings are generated by the perception and response to facial expression, posture, movement, gestures, etc. in rich pragmatic and social contexts. Again, this is not to say that all the essential processes of social cognition are extra-neural. Mirror neurons may indeed make a contribution, not by simulating actions of others, repeating a small version of them inside one's head, but by being part of larger sensorimotor processes that respond to different interaction affordances (e.g., Caggiano et al. 2009). On the enactive view, social cognition is an attunement process that allows me to perceive the other as someone to whom I can respond or with whom I can interact. In the intersubjective context, perception is often *for inter-action* with others. In some cases, a relational understanding is accomplished in the social interaction between two people where some novel shared meaning (or some decision or even some misunderstanding) is instituted in a way that could not be instituted within the single brain of either one of them (De Jaegher et al. 2010).

Embodied Prediction: How to Be an Embodied Theorist without Losing Your Head

Take any example of cognition and one can run two different explanations: a standard representationalist one and an enactivist one. Sometimes it seems to be simply a vocabulary substitution; sometimes the enactivist description seems to work better, especially if we think of examples that involve problem solving rather than belief, whereas at other times the representationalist description seems to have the upper hand. Even when the representations involved are action-oriented, minimal, or B-formatted there are clear differences in explanation.

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Consider the example of fielding (trying to catch) a ball. We can run the account in both ways, where running it in one case means representing various aspects of speed and trajectory, and in the other case literally running rather than representing.

In the classical representational account, the problem is first solved in the fielder's head. Speed and trajectory of the ball are calculated and represented by the brain, which, having solved the problem offline, then simply sends instructive signals to the limbs to move in the most efficient way to catch the ball. It is unlikely that anyone believes this story, and there is evidence against it since it does not predict the actual pattern of movement that the fielder makes to catch the ball. In a more likely, weak-embodied, *action-oriented representation* (AOR) account, calculations are made online as we move, but part of the process involves quick (on the elemental timescale) offline AORs formed in forward models that contribute to motor control. Sensory feedback is too slow to update the system in a timely fashion; the forward model generates a simulation or representation (an internal model) that anticipates sensory feedback from intended body positions on the run and allows for a fine-tuning of motor control. The AOR stands in for a future state of some extra-neural aspect of the movement—a body position (or proprioceptive feedback connected with a body position) that is just about to be accomplished in the action of catching the ball. Since the model represents a state of the system that does not yet exist—a predicted motor state—it is said to be offline, or decoupled from the ongoing action (Clark and Grush 1999), and to occur in the self-contained brain. Such representations can then be taken further offline and reused (e.g., in memory systems), scaling up to enable additional cognitive states. The brain can run such offline models to accompany states in which no running and catching is involved at all—when, for example, I imagine or remember catching a ball. No need for the body itself or for "a constant physical linkage" (Clark and Grush 1999:7).

On the enactive account, we solve the problem by vision and movement. We run on a curved line so as to keep the ball's trajectory pointed straight. This reliably gets the fielder to the catching spot (McBeath et al. 1995). There is no need to compute in-the-head mental representations of the ball, its speed, its trajectory, and so on. Rather, the cognitive component of this action depends to a significant extent on how we directly act in the world. The processes involved are dynamic sensorimotor processes that are fully online. Indeed, it is unclear in what sense the AOR account should describe anticipatory motor control processes as offline or decoupled. On the enactive account, this kind of forward anticipatory aspect of neural processing is a constitutive part of the action itself, understood in dynamic terms, rather than something decoupled from it. The anticipation of a future state or position (of the ball, or of the body grabbing the ball in the next second) requires ongoing reference or "constant physical linkage" to current state or position. To think that such processes are decoupled (or in some sense off-line) is to think that

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such anticipations are in someway detached from perceptual and proprioceptive input, which they clearly are not. Such processes may be one step ahead of real-world proprioceptive feedback, but they are also at the same time one step behind the previous moment of feedback, integrated with ongoing movement and perception.

On some views, decouplability is part of the very definition of representation (Clark and Grush 1999). On the enactive account, however, to scale up to cognitive states such as imagining or remembering, the brain does not decouple or recreate a process that was not representational in the first place (since the process had not been decoupled from the action itself); rather, the system (using the same motor control or forward control mechanism) enacts (or reenacts) a process that is now coupled to a new cognitive action. In remembering, for example, there may be reactivation of perceptual areas that had been activated during the original experience. We do not know to what extent other nonneural bodily factors may be (re-)activated (e.g., subliminal tensing of muscles, facial expressions, gestures).

Here, however, the line between accounts of AORs and the idea of enactive cognition gets blurred, and some may suspect that the difference is merely one of preferred vocabulary. Thus, defenders of AORs, like Wheeler (2005:219), give up the criterion of decouplability as part of the concept of an AOR, and both Wheeler as well as Rowlands (2006:224) suggest that AORs involve aspects of a system that includes brain, body, and environment: "The vehicles of representation do not stop at the skin; they extend all the way out into the world." What enactivists refer to as affordances, proponents of weak embodiment call AORs (Clark 1998:50).

Can predictive coding models somehow adjudicate between representationalist and enactivist accounts? One might think that predictive coding has already settled on the representationalist side, since much of the predictive coding literature assumes or adopts the representationalist vocabulary (e.g., Hohwy 2013; Hohwy, this volume). An alternative interpretation could push predictive coding a bit toward the enactivist account.

On one reading of predictive coding, the brain is pictured as having no direct access to the outside world; accordingly, it needs to represent that world by some internal model that it constructs by decoding sensory input (Hohwy 2013). On this basis, the brain makes probabilistic inferences about the world and corrects those inferences by addressing prediction errors. This process involves synaptic inhibition based on an empirical prior. Predictions are matched against ongoing sensory input. Mismatches generate prediction errors which are sent back up the line, and the system adjusts dynamically back and forth until there is a relatively good fit.

Do we have to think that the outcome of this process is the creation of a representation in the brain? Why should we not rather think of this process as a kind of ongoing dynamic adjustment in which the brain, as part of and

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along with the larger organism, settles into the right kind of attunement with the environment—an environment that is physical but also social and cultural.

We know that one's beliefs and values as well as one's affective states and cultural perspectives (phenomena defined for the most part on the narrative scale) can shape the way that one quite literally sees the world. How such cognitive and affective states and perspectives enter into (elementary-scale) subpersonal processes can be explained in terms of predictive coding models. With respect to affect, for example, Barrett and Bar's *affective prediction hypothesis* "implies that responses signaling an object's salience, relevance or value do not occur as a separate step after the object is identified. Instead, affective responses support vision from the very moment that visual stimulation begins" (Barrett and Bar 2009:1325). Along with the earliest visual processing, the medial orbital frontal cortex is activated initiating a train of muscular and hormonal changes throughout the body, "interoceptive sensations" from organs, muscles, and joints associated with prior experience, and integrated with current exteroceptive sensory information that help to guide response and subsequent actions. Accordingly, along with the perception of the environment, we also undergo certain bodily affective changes that accompany this integrated processing. In other words, before we fully recognize an object or other person, for what it or he or she is, our bodies are already configured into overall peripheral and autonomic patterns based on prior associations. In terms of the predictive coding model used by Barrett and Bar (2009), priors, which include affect, are not just in the brain, but involve a whole body adjustment.

On the enactivist view, brains play an important part in the dynamic attunement of organism to environment. Social interaction, for example, involves the integration of brain processes into a complex mix of transactions that involve moving, gesturing, and engaging with the expressive bodies of others; bodies that incorporate artifacts, tools, and technologies are situated in various physical environments, and defined by diverse social roles and institutional practices. Brains participate in a system, along with all these other factors, and it would work differently, because the priors would be different, and therefore the surprisals would be different, if these other factors were different.

Changes or adjustments to neural processing will accompany any changes in these other factors, not because the brain represents such changes and responds to them in central command mode, but because the brain is part of the larger embodied system that is coping with its changing environment. Just as the hand adjusts to the shape of the object to be grasped, so the brain adjusts to the circumstances of organism-environment. It is not clear that we gain anything by saying that the shape of the grasp represents the object to be grasped (Rowlands 2006). At the very least, it remains an open question about how the neural processes described by predictive coding models are most usefully characterized, whether as inferential and representational or as part of a dynamic attunement of organism to environment.

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Concluding Remarks

Enactive embodied cognition approaches present a challenge for science. By focusing on not just the brain, not just the environment, not just behavior, but on the rich dynamics of brain-body-environment, enactivists offer a holistic conception of cognition. To put it succinctly, however, it is difficult to operationalize holism. Neither experimental control nor the division of labor in science allows for all factors to be taken into consideration at once. It is also unclear whether there could be one critical experiment that might decide the issue between the representationalist and the enactivist.

This motivates serious consideration of a suggestion made made by Cecilia Heyes at this Forum, drawing on work by Peter Godfrey-Smith (2001). Godfrey-Smith, discussing developmental systems theory, distinguishes between a "scientific research program" and a "philosophy of nature." Enactivism, Heyes suggests, has elements of both, but may be more successful as the latter.

On one hand, enactivism makes empirical claims, for example, about the work of sensorimotor contingencies, and in this sense it resembles a research program that can suggest new experiments and new ways of interpreting data. On the other, its emphasis on holism presents problems for empirical investigations. One does not get far in experimental science without controlling for variables. With respect to its holistic approach, enactivism resembles a philosophy of nature. As Godfrey-Smith makes clear, a philosophy of nature is a different kind of intellectual project from science, and although science may be its critical object, the two enterprises do not have to share the same vocabulary. A philosophy of nature "can use its own categories and concepts, concepts developed for the task of describing the world as accurately as possible when a range of scientific descriptions are to be taken into account, and when a philosophical concern with the underlying structure of theories is appropriate" (Godfrey-Smith 2001:284). A philosophy of nature takes seriously the results of science, and its claims remain consistent with them, but it can reframe those results to integrate them with results from many areas of knowledge. The requirements of such a reframing may indeed call for a vocabulary that is different from one that serves the needs of any particular science. To work out a philosophy of nature is not to do science, although it can offer clarifications relevant to doing science, and it can inform empirical investigations. In this sense, a philosophy of nature is neither natural philosophy nor the kind of naturalistic philosophy that is necessarily continuous with science. It offers critical distance and practical suggestions at the same time. In some cases it may make doing science more difficult.

Is enactivism a philosophy of nature? Indeed, from the very start enactivism involved not only a rethinking of the nature of mind and brain, but also a rethinking of the concept of nature itself (see Di Paolo 2005; Thompson 2007:78ff). If enactivism is a form of naturalism, it does not endorse the mechanistic definition of nature presupposed by science, but contends that nature

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cannot be understood apart from the cognitive capacity that we have to investigate it. As Heyes suggests, in the context of a philosophy of nature meant to offer an encompassing view, holism is a strength rather than a practical complication.

Does this make enactivism irrelevant to the actual doing of science? Enactivism may still motivate experimental science in very specific ways. Even if in some cases it is difficult to apply a holistic view to a given question, in many cases there may not be any special complication in designing experiments that can test enactive ideas. It is not that in every case we must include absolutely everything when addressing a particular concrete question, but in the end it may be easier to include than to ignore a factor that is crucial. For example, including embodied interactions in explanations of social cognition might actually involve less complexity if keeping them out of the picture requires the elaboration of more convoluted explanations in terms of theory or simulation mechanisms (De Jaegher et al. 2010). Athough in this, and other cases, much will depend on circumstances like the availability of the right lab technology, the whole may sometimes lead to simpler explanations. In short, even if enactivism is to be considered a philosophy of nature, it would not be right to conclude that it cannot offer or test concrete hypotheses or raise novel scientific questions.

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