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Complexity and Extended Phenomenological-Cognitive Systems

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Abstract

The complex systems approach to cognitive science invites a new understanding of extended cognitive systems. According to this understanding, extended cognitive systems are heterogenous, composed of brain, body, and niche, non-linearly coupled to one another. This view of cognitive systems, as non-linearly coupled brain–body–niche systems, promises conceptual and methodological advances. In this article we focus on two of these. First, the fundamental interdependence among brain, body, and niche makes it possible to explain extended cognition without invoking representations or computation. Second, cognition and conscious experience can be understood as a single phenomenon, eliminating fruitless philosophical discussion of qualia and the so-called hard problem of consciousness. What we call ''extended phenomenological-cognitive systems'' are relational and dynamical entities, with interactions among heterogeneous parts at multiple spatial and temporal scales.

Keywords: Complexity; Dynamical systems; Extended cognition; Consciousness

1. Introduction

Despite its obvious importance in 20th century philosophy, *The Concept of Mind* (Ryle, 1949) did not contain satisfactory solutions to many of the problems it addressed. Even Ryle himself thought so, and spent many years later in life trying to address what he took to be the great shortcoming of *The Concept of Mind*. Ryle realized that his early work did not give an adequate account of the real-time activity of thinking, the sort of activity Rodin's *Le Penseur* is engaged in. Ryle's later attempts to solve this problem were aimed at explaining how

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real-time thinking was not merely speaking, aloud or to oneself, but at the same time not something other than speaking. For example in his ‘‘Thinking and Saying’’ (1979), Ryle wants to describe thinking in a way that is not reductionist, but still avoids inflating it into something mysterious, because such ‘‘Reductionist and Duplicationist theories are the heads and tails of one and the same mistake.’’(p. 80)

> The specific notion of Thinking, which is our long term concern, has been duly deflated by some philosophers into Nothing But such and such; and duly reinflated into Something Else as Well. (p. 80)

To get between the ‘‘Nothing But’’ and the ‘‘Something Else as Well’’ conceptions of thinking, Ryle asks us to consider pennies. A penny is more than a mere metal disk (it is not Nothing But a metal disk), but when you have a penny you do not have two things (you do not have a metal disk and Something Else as Well). Similarly, Ryle argues, thinking is not Nothing But speaking, but it is not Something Else as Well. We do not endorse Ryle’s story about real-time thinking, not even in outline, but we do agree with his contention that the right story about it must be neither reductionist nor duplicationist. We think the same is true of conscious experience.

In this article, we will lay out a story about conscious experience that is neither reductionist nor duplicationist. Conscious experiences, we will argue, are not Nothing But brain activity, but this does not mean they are to be reified as Something Else as Well. Telling this sort of story about consciousness seems impossible, and may in fact be impossible, given the current problem space in philosophical discussions of consciousness. That is, the landscape of the debate has become so constrained that there is no space between reductionism and duplicationism, and we are stuck with immaterial qualia, hard problems, harder problems, and really hard problems, but nothing that seems like a satisfactory solution; indeed, the hard problem seems cooked up to be straightforwardly solvable only by dualism or eliminativism. More importantly, debating the hard problem yields no empirical progress. Our goal here is to alter the landscape, and, we hope, allow some progress in understanding consciousness. This alteration to the landscape will be made by taking work in extended cognition seriously, and arguing that taking cognitive systems to be extended brain–body–environment systems makes it attractive to take experience to be an essential feature of extended brain–body–environment systems. In other words, we will be arguing that if you believe, as a growing number of cognitive scientists and philosophers now do, that cognitive systems include portions of the extra-neural, extra-bodily environment, you probably should also believe that consciousness includes portions of the extra-neural, extra-bodily environment. We believe that both cognition and consciousness are extended, and we will therefore often speak of ‘‘extended phenomenological-cognitive systems.’’[1] In such systems, conscious experience is neither Nothing But brain activity, nor Something Else as Well (i.e., qualia).

We proceed as follows. In Section 2, we introduce extended cognitive science. Our main purpose there will be to limit the scope of extended cognitive science so that it includes explanation using dynamical systems theory, but does not include wide computational explanation. Our extension from extended cognition to extended phenomenology-cognition is licensed only by cognitive science that explains using dynamical systems theory. In Section 3, we make the case for the leap from extended cognition to extended phenomenology-cognition, via a discussion of the relationship among representationalism, computationalism, and qualia. Having explained why one might take both phenomenology and cognition to be extended and inseparable, we present an outline of a theory of extended phenomenological-cognitive systems in Section 4. In Section 5, we tie our theory of extended phenomenological-cognitive systems to recent work in evolutionary-developmental biology. In Section 6, we outline some examples of extended phenomenological-cognitive science. The point of this will be to show that one can explain extended phenomenology and cognition simultaneously, and possibly make some progress in explaining consciousness. Section 7 is a brief coda on the so-called ''hard problem of consciousness.''

2. Extended cognition, first pass

The idea that cognitive systems are spatially extended, encompassing more than the brain and body, is not new. For example, in the early 20th century, William James argued that acts of perception included both the perceiver and the perceived. For most of the 20th century, although, extended cognition received little attention. A convergence of results in AI and robotics (Agre & Chapman, 1987; Beer, 1995; Brooks, 1991), perception (Solomon & Turvey, 1988; Warren, 1984), developmental psychology (Thelen & Smith, 1993), and 2
mathematical modeling (Kelso, 1995; Kugler & Turvey, 1987; Port and van Gelder, 1995) changed this. Now, we have philosophical theories of things called ''enactive cognition,'' (Noe, 2005; Thompson, 2007; Varela, Thompson, & Rosch, 1991) ''existential cognition,'' 3
(McClamrock, 1995) ''extended cognition,'' (Clark & Chalmers, 1998) ''embodied cognition,'' (Clark, 1997) ''wide computationalism,'' (Wilson, 2004) ''situated cognition'' (Clancey, 1997; Hutchins, 1995) and many other names for roughly the same thing—the view that cognitive systems at least sometimes extend beyond the skin of the cognizer.

Because there are many views in this vicinity, it is best that we define what we mean by ''extended cognition.'' The literature makes a distinction between embodied, situated, and extended cognition in supposedly ascending order of radicalness. The first claim says roughly that mind exists in the entire body, and not just in the central nervous system. The second claim says that certain environmental or social background conditions are necessary for certain cognitive functions. And the third claim holds that brain–body–world are dynamically coupled and thus mental states and cognitive functions might be viewed as extending spatiotemporally beyond the skin of the organism. This last claim is the heart of extended cognition. Extended cognition, then, is the claim that at least in some cases, the environment serves as more than the mere background for and input to the cognitive system; it is a necessary part of the cognitive system. It is important to note the qualifiers ''sometimes'' and ''in some cases'' appear in the formulations above. Proponents of extended cognition need not, and generally do not, claim that all cognitive systems are extended all of the time. The claim, rather, is that sometimes cognitive systems are brain–body–environment systems, which does not preclude them sometimes being exclusively neural systems.

For current purposes, we need to limit the scope of extended cognition to more than that is typical. Typically, there are taken to be two kinds of extended cognitive science: wide 4 computationalism and dynamical systems explanation. In wide computational explanation, the cognitive system is taken to be a computational system, some of the elements of which lie outside the animal's body. The most famous example of such a system is from work in connectionist networks by Rumelhart et al., (1986). The suggestion there is that the pattern-completing brain was only a proper part of the cognitive system, the rest of which was external to the thinker's body. Rumelhart et al's example was solving mathematical problems on a chalkboard. In such a case, it was argued that the cognitive system included the brain, the chalkboard, and the act of writing on the board. Philosophers who have endorsed wide computationalism include McClamrock, (1994), Clark (1997), Anderson (2003) and Wilson 5 (2004). Therefore, the debate between wide computationalists and standard computational cognitive science is really a relatively ''in house'' dispute about the spatial scope of the computational mechanism—whether the chalkboard is a component in the computational system or merely the background against which it operates. Neither side in the debate denies computationalism, the claim that cognition is a variety of computation.

In dynamical systems explanation, one adopts the mathematical methods of non-linear dynamical systems theory, employing differential equations rather than computation as the primary explanatory tool. Dynamical systems theory is especially appropriate for explaining cognition as interaction with the environment because single dynamical systems can have parameters both inside and outside the skin. For example, we might explain the behavior of the agent in its environment over time as coupled dynamical systems, using something like the following coupled, non-linear equations, from Beer (1995, 1999):

$$\frac{dx_A}{dt} = A(x_A; S(x_E))$$

$$\frac{dx_E}{dt} = E(x_E; M(x_A))$$

where A and E are continuous-time dynamical systems, modeling the organism and its environment, respectively, and $S(x_E)$ and $M(x_A)$ are coupling functions from environmental variables to organismic parameters and from organismic variables to environmental parameters, respectively. It is only for convenience that we think of the organism and environment as separate. In fact, they are best thought of as comprising just one system, U. Rather than describing the way external factors cause changes in the organism's behavior, this model explains the way U, the system as a whole, changes over time (see Fig. 1). Among those who have endorsed dynamical systems explanations of extended cognitive systems are Kugler, Kelso and Turvey (1982), Kugler & Turvey (1987), van Gelder (1995), Port and 6 van Gelder (1995), and Kelso (1995), Thompson (2007).

When cognitive systems are non-linearly coupled brain–body–environment systems that receive a dynamical explanation, it follows that the cognitive system really is extended. A dynamical system is linear or non-linear depending on the nature of the equations of motion

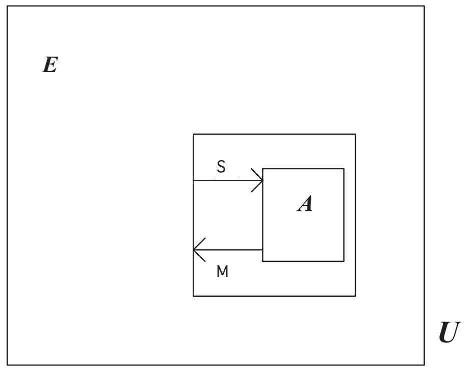

Fig. 1. Xxxx.

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describing the system. A differential equation system dx/dt = Fx for a set of variables $x = x1, x2,...,xn$ is linear if the matrix of coefficients F does not contain any of the variables x or functions of them; otherwise it is non-linear. A system behaves linearly if any multiplicative change of its initial data by a factor b implies a multiplicative change of its output by b. A linear system can be decomposed into subsystems. However, decomposition fails in the case of non-linear systems. When the constituents of a system are highly coherent, integrated, and correlated such that their behavior is a non-linear function one another, the system cannot be treated as a collection of uncoupled individual parts. Thus, if brain, body, and environment are non-linearly coupled, their activity cannot be ultimately explained by decomposing them into subsystems or into system and background. They are one extended system. This case is trickier for wide computational systems for two reasons. First, it is not obvious that brain, body, and environment are non-linearly coupled in wide computation. Second, in wide computational systems, the brain is, at least partly, operating on representations of the environment, making space for an argument that the represented environment, not the environment itself, is a component of the computational system.

For the purposes of this article, *only cognitive systems explained or conceived as non-linear dynamical system are extended*. We make this restriction because the claim that phenomenology is extended is not licensed by wide computational explanation. Thus, from now on, by ''extended cognitive system'' we mean ''non-linearly coupled brain–body–environment system.''

3. From extended cognition to extended phenomenology-cognition

In this section, we layout a pathway from extended cognition to extended experience, to what we call ''extended phenomenology-cognition.'' This pathway in no way constitutes a deductive argument—extended phenomenology-cognition does not logically follow from extended cognition. Rather, what we are offering is a pathway from current practice in certain segments of the cognitive sciences to a view of consciousness that avoids much of the current problematic that defines consciousness studies. Because we are not offering a deductive argument here, the reader is welcome to not follow us down the path. You can get off the highway at any point, but all exits lead to Qualia City and the hard problem of consciousness.

Step 1. Suppose that cognitive systems are extended[2], that is, suppose that cognitive systems are non-linearly coupled brain–body–environment systems, there is no good reason, other than intuition, not to believe that experience is extended. Why? Let us go to Step 2. 7

Step 2. In extended cognitive science, non-linearly coupled animal–environment systems are taken to form just one unified system. This removes the pressure to treat one portion of the system as *representing* other portions of the system—at least for many cognitive acts. That is, if the animal–environment system is just one system, the animal portion of the system need not represent the environment portion of the system to maintain its connection with it. There is no separation between animal and environment that must be bridged by representations. So extended cognition invites anti-representationalism. Of course, extended cognition does not *entail* anti-representationalism and many extended cognitive scientists are also representationalists. Nonetheless, anti-representationalism is made plausible by the non-linear connections between animal and environment one sees in extended cognitive systems.

Step 3. To paraphrase Fodor (1981), and with apologies to Piccininni (2008), we can say that there is no computation without representation. So anti-representationalist extended cognitive science is incompatible with the computational theory of cognition.[3]

Step 4. The current problem space for consciousness studies is largely the result of the influence of the computational theory of the mind, even for those who reject computationalism. Computationalism makes it seem as if there are two different mind–body problems: one for cognition and one for consciousness. That the computationally explained mind could have meaningful cognitive states is demonstrated by completeness results in formal logic. Given these, we can easily imagine that a human-made machine might have meaningful cognitive states, maybe, even meaningful cognitive states just like ours. But, for most cognitive scientists and philosophers of mind, computationalism-laden intuition recoils at the idea that metal and plastic would be a locus of conscious experience.[4] It is this presumed orthogonality of cognition and consciousness that determines the current problem space, leaving us with the following set of possible positions on the relationship between cognition and consciousness. One might reduce consciousness to cognition; one might reduce cognition to consciousness; or one might live with qualia, which after all are nothing but consciousness minus cognition (e.g., the experienced greenness of grass, without categorization of it as being green or grass). That is, we are left with the choice between consciousness being Nothing But cognition, and consciousness being Something Else as Well. But if we take Step 3, we need not take cognitive systems to be computational systems. This removes the impetus for the intuition that there are two mind–body problems, that cognition and consciousness must be separate.

Step 5. Instead, we can understand phenomenology and cognition as inseparable and complementary aspects of coupled brain–body–environment systems. On our view, experience is cognition and cognition is experiential. Our cognitive, conscious, and behavioral capacities co-explain and co-determine each other dynamically in a way to be explicated shortly. The systems that cognitive scientists have identified as extended cognitive systems are in fact extended phenomenal-cognitive systems. Taking this position has several advantages.

First, it deflates many of the seemingly insoluble problems that mark current work on consciousness, because there is only one mind–body problem, there is no hard problem of consciousness unless there is also a hard problem of meaningful cognition. That is, from the extended phenomenological-cognitive science perspective, experience is no more rare, strange, and exotic than cognition—consciousness is no cause for handwringing from this empirical perspective. In fact there is no ''mind–body'' problem as such because mind–body–behavior is simply one process. The purely metaphysical hard problem concerning why we have phenomenology at all (Chalmers 1996) is transformed into the purely empirical [8] problem of explaining how extended phenomenology-cognition works. This is still a hard problem, but clearly a tractable, empirical one—indeed it is what cognitive scientists, psychologists, and neuroscientists spend their time doing.

Second, the problematic search for neural correlates of conscious experience as a sufficient solution to the hard problem is a no-go on this view. The very idea of neural correlates of consciousness is debunked in that consciousness is not an exclusively neural phenomenon.

Third, one need not reify conscious experience in the form of qualia (Something Else as Well) nor deflate it to the point of reduction. Extended phenomenological-cognitive science has all the advantages of the identity theory, according to which conscious experiences are identical to brain states, without the problem of explaining how conscious experiences such as seeing red could be Nothing But neurochemical events; the phenomenological world of experience is neither in the head nor in the external world—it is fundamentally relational. It is important to be clear here concerning what we are *not* claiming. When one talks about extended phenomenology, it is (apparently) easy to get the absurd picture in mind of colors, tastes, and sounds floating around and hiding behinds trees. We are, of course, not claiming this. Rather, we are claiming that the some of the relationships among the parts of self-organizing, self-maintaining, dynamical, brain–body–environment systems are phenomenological. This will become more clear below.

Finally, this approach to phenomenology-cognition has substantial support from research in the cognitive sciences, and is fully in line with ecological, dynamical, and enactive approaches. (A small sliver of this research will be presented below.) Each of these approaches takes cognitive systems to be extended, rejects representationalism, and computationalism, and refuses to separate meaningful cognition and phenomenology.

4. Extended phenomenology-cognition

We propose that extended phenomenology-cognition be understood as a variety of niche construction, one in which the constructed niche is an animal's cognitive and phenomenological niche. In biological niche construction, the activity of some population of organisms alters, sometimes dramatically, its own ecological niche as well as those of other organisms (Odling-Smee, Laland, & Feldman, 2003). These animal-caused alterations to niches have profound and wide-reaching effects over evolutionary time. Phenomenological-cognitive niche construction has its effects over shorter time scales—an animal's activities alter the world as the animal experiences it, and these alterations to the phenomenological-cognitive niche, in turn, affect the animal's behavior and development of its abilities to perceive and act, which further alters the phenomenological-cognitive niche, and on and on.

We depict a schematic extended phenomenological-cognitive system in Fig. 2. Following enactive and ecological cognitive scientists, we take animals to be *self-organizing* systems (Chemero, 2008; Kelso, 1995; Kugler, Kelso, & Turvey, 1980; Kugler & Turvey, 1987; Maturana & Varela, 1980; Thompson, 2007). The animal's nervous system has an endogenous dynamics, which generates the neural assemblies that both compose the nervous system and constitute the animal's sensorimotor abilities. These sensorimotor abilities are the means by which the animal's niche couples with and modulates the dynamics of the animal's nervous system. These sensorimotor abilities are coupled with the niche, that is, the network of affordances available to the animal (Gibson, 1979), and interact with it over multiple time scales. Over behavioral time, the sensorimotor abilities cause the animal to act, and this action alters the layout of the affordances available, and the layout of affordances perturbs the sensorimotor coupling with the environment (causing, of course, transient changes to the dynamics of the nervous system, which changes the sensorimotor coupling, and so on). Over developmental time, the sensorimotor abilities, that is, what the animal can do, selects the animal's niche. That is, from all of the information available in the physical environment, the animal learns to attend to only that which specifies affordances complementing the

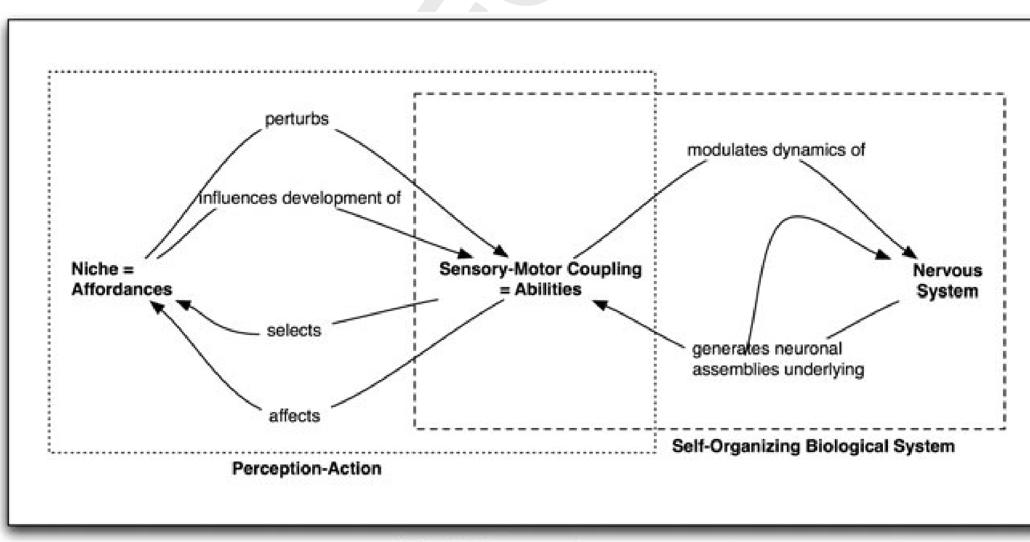

Fig. 2. Xxxx.

animal's abilities. At the same time, the set of affordances available to the animal profoundly influence the development of the animal's sensorimotor abilities. So we have a three-part, coupled, non-linear dynamical system in which the nervous system partly determines and is partly determined by the sensorimotor abilities which partly determine, and are partly determined by the affordances available to the animal.

So far, we have given no reason to think that what we have described is a phenomenological-cognitive system, as opposed to a merely cognitive system. Seeing that this is also a phenomenological system requires understanding the nature of affordances. Affordances are not just properties of an animal's physical environment. They are relational features of combined animal–environment systems, features that the animal perceives and uses to guide its action. Affordances are defined in terms of an animal's abilities; affordances and abilities also causally interact in real time and are causally dependent on one another in a non-linear fashion. Affordances are what animals perceive. The animal's behavioral niche, the set of affordances that it has learned to perceive and act upon, *just is* the environment as the animal experiences it. This underwrites a variety of *phenomenological realism*, according to which the entire system, including the environment as experienced, is required to account for phenomenology-cognition. Conscious experience, on this view, is neither Nothing But the activity of a brain, but it is also not Something Else as Well. Instead, it is inseparable from cognition, which is the ongoing activity of a nervous system, body, and niche non-linearly coupled to one another.

5. Extended phenomenological cognition and evolutionary-developmental biology

In the next section of the article, we attempt to clarify these ideas via some examples of extended phenomenological-cognitive science. In order to more fully develop the idea that EPCS are multi-scale *self-organizing* systems, in this section, we connect extended phenomenology-cognition to another recent topic in biology, the relationship among plasticity, robustness, and autonomy in development (see also Thompson, 2007). Phenotypic plasticity is the phenomenon in which genetically identical individuals will develop different phenotypic traits in different environmental conditions (Kaplan, 2005, 2008). Because of pheno- 9
typic plasticity, a single genotype or genome can produce many different phenotypes depending on environmental and developmental contingencies (Gilbert and Epel, 2009). 10
Phenotypic plasticity is just one example of epigenomic processes in which various mechanisms create phenotypic variation without altering base-pair nucleotide gene sequences, altering the expression of genes but not the gene sequence. In contrast, there are cases in which genetic or environmental changes have no phenotypic effect. This persistence of a particular organism's traits across environmental or genetic changes is called *robustness*. Robustess is illustrated by various knock-out experiments whereby a particular gene (or group of genes) known to be involved in the development of some protein or phenotypic trait is disabled without disturbing the presence or production of the developmental end product in question (Jablonka & Lamb, 2005). To account for and model robustness, developmental biologists have called upon dynamical systems theory. The ongoing development

of an organism acts as a high-order constraint, which enslaves the components necessary to maintain its dynamics. Because of this, a developing system will have highly plastic boundaries, and will be composed of different enslaved components over time. This plasticity serves the autonomy and robustness of the developing organism, making it more likely to be viable. Robustness is closely related to autonomy, another key concept in evolutionary-developmental biology. Autonomy is the property of living systems to make use of their environments to maintain themselves. Autonomy is sometimes explained in terms of recursive self-maintenance. Some systems are plastic such that they can maintain stability not only within certain ranges of conditions, but also within certain ranges of *changes* of conditions: they can switch to deploying *different* processes depending on conditions they detect in the environment.

The same is true of extended phenomenological-cognitive systems. The coupled, dynamical phenomenological-cognitive system is highly opportunistic, and softly assembled from different resources at different times. Just like the developmental system, the extended phenomenological-cognitive system can be characterized as a set of order parameters that enslave components of brain, body, and niche as needed in order to maintain itself. This means that the spatial boundaries of the extended phenomenological-cognitive system will change over time, sometimes even contracting temporarily to within an animal's skin, only to re-expand moments later (see Fig. 3). As in the case of biological robustness, the plasticity of the boundaries of phenomenological-cognitive systems is a vital part of their self-maintenance.[5] There is, however, a crucial contrast with biological robustness and autonomy: In the case of extended phenomenological-cognitive systems, the softly assembled system is maintaining the affordances of its softly assembled cognitive-phenomenological niche.

6. Extended phenomenological-cognitive science

In this section, we present a few examples of extended phenomenological-cognitive science. We could easily have discussed the experiments reported in other articles in this special issue in the same terms, especially Dixon, Holden, Mirman, and Stephen (this issue). **11, 12**

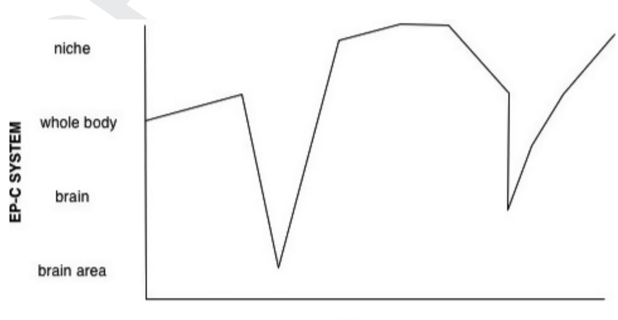

Fig. 3. Xxxx. **29**

Work this decade has shown that 1/*f* noise, also known as pink noise or fractal timing, is ubiquitous in smooth cognitive activity and indicates that the connections among the cognitive system's components are highly non-linear (Ding, Chen, & Kelso, 2002; Holden, Van Orden, & Turvey, 2009; van Orden, Holden, & Turvey, 2003, 2005; Riley & Turvey, 2002). van Orden et al. (2003) argue that 1/*f* noise found in an inventory of cognitive tasks is a signature of a softly assembled system exhibiting and sustained by interaction-dominant dynamics, and not component-dominant dynamics. In component-dominant dynamics, behavior is the product of a rigidly delineated architecture of components, each with predetermined functions; in interaction-dominant dynamics, on the other hand, coordinated processes alter one another's dynamics, with complex interactions extending to the body's periphery. Soft device assembly as the product of strongly non-linear interactions within and across the temporal and spatial scales of elemental activity can account for the 1/*f* character of behavioral data, while assembly by virtue of components with predetermined roles and communication channels cannot.

Research on the role of 1/*f* noise in cognition has allowed a series of studies that bring complex systems research to bear on central issues in cognitive science. In one example Stephen, Dixon, and Isenhower (2009), Stephen and Dixon (2009), Stephen, Boncoddo, Magnuson, and Dixon (2009) have modeled insight (the phenomenology of the ''aha moment'' and changes in performance) in problem solving as a phase transition in a non-equilibrium dynamic system. They found that learning a new strategy for solving a problem coincides with a temporary increase appearance in 1/*f* noise, as measured in hand and eye movements. Dixon et al. (this issue) use this story to construct a multi-fractal theory of cognitive development, explicitly connecting their theory to complex systems work in a broad range of disciplines. Moreover, research concerning 1/*f* noise in cognition has made theoretical questions that initially seemed ''merely philosophical'' accessible to experimental examination. For example, van Orden et al. (2003) use 1/*f* noise to gather direct evidence showing that, in certain cases, cognitive systems are not modular; rather these systems are fully embodied, and include aspects that extend to the periphery of the organism.

Drawing on this work, Dotov, Nie, and Chemero (2010) have shown that cognitive systems can be made to extend beyond the periphery to include artifacts that are being used. Participants in these experiments play a simple video game, controlling an object on a monitor using a mouse. At some point during the 1-min trial, the connection between the mouse and the object it controls is disrupted temporarily before returning to normal. Dotov, Nie and Chemero found 1/*f* noise at the hand-mouse interface while the mouse was operating normally, which decreased during the disruption. This indicates that, during normal operation, the computer mouse is part of the smoothly functioning interaction-dominant system engaged in the task; during the mouse perturbation, however, the 1/*f* noise at the hand-mouse interface decreases temporarily, indicating that the mouse is no longer part of the extended interaction-dominant system.[6]

Crucially for current purposes, the Dotov et al. experiments were designed to gather evidence for an aspect of Heidegger's phenomenological philosophy, his purported transition from ready-to-hand to unready-to-hand modes of experience (Heidegger, 1962). When we experience tools as ready-to-hand, we ‘‘see through’’ them and our awareness is of the activity we are using the tools to engage in. When the tool malfunctions temporarily, we can no longer see through it, and it becomes the focus of our attention. In the experiments, when the mouse was controlling the on-screen pointer appropriately, participants experienced their control of the pointer in the simple video game; the mouse was experienced as ready-to-hand. When the connection between mouse movements and the on-screen pointer is disrupted, the participants paid explicit attention to the mouse; it was experienced as unready-to-hand. This phenomenological transition was apparent in the character of the noise at the hand-mouse interface. Like the Stephen et al. experiments on insight and the ‘‘aha moment,’’ the Dotov et al. experiments highlight the explicit study of phenomenology in extended phenomenological-cognitive science.

7. Coda concerning the ‘‘Hard Problem’’

Because we have been arguing that phenomenology and cognition are inseparable, there is no reason to invoke qualia in our explanation of consciousness. The motivation behind qualia is that we could explain all of cognition, but fail to explain phenomenal consciousness. With this possibility, phenomenology is Something Else as Well. This is not possible if, as suggested above, phenomenology and cognition are inseparable. There are no qualia. But sometimes it is argued that a version of the hard problem of consciousness arises even if there are no qualia. The problem, when put this way, is why does subjectivity exists at all. Even phenomenologists like Gallagher and Zahavi (2008), who are quaila doubters and who 13 believe that phenomenology and cognition are inseparable, believe in this version of the hard problem.

> And the hard problem does not dissapear if one (rightfully) denies the existence of [qualia], and if one, so to speak, relocates the phenomenal ‘outside’ rather than ‘inside’. The hard problem is not about the existence of non-physical *objects* of experience, but the very existence of *subjective experience* itself; it is about the very fact that objects are *given* to us. (2008, 118)

But our account does account for the existence of subjective experience, and in so doing obviates the hard problem.

To see that this is the case, consider that the primary objects of experience are affordances. Affordances are relations between the action abilities of an animal and the features of the environment surrounding it (or him or her). When an animal perceives affordances, it (or he or she) perceives the world in terms of what it (or he or she) can do (Chemero, 2003, 2008, 2009). That is, what we perceive is for us precisely because it is defined in terms of us. Subjective experience exists because the objects of perception (and experience) are not fully independent of the experiencer—perceivers and perceivables are non-linearly, causally coupled to one another at multiple time scales. The affordances a subject experiences belong to the subject.

We can make the same point using Gibson's original account of affordances. Gibson described them as follows.

> [A]n affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer. (1979, 129)

The hard problem is the problem of accounting for subjectivity in a world of objects. Affordances, however, are not objects. Indeed, as Gibson notes, they point out the inadequacy of the dichotomy between subjectivity and objectivity. Without this hard and fast subjective–objective cut, accounting for the existence of subjectivity does not seem at all impossible. Indeed, 25 years of scientific research on affordances indicates that there is no barrier at all to scientific accounts of subjective–objective hybrids. This research provides a possible way forward in the science of cognition and consciousness, allowing a way to see between a Nothing But and a Something Else as Well.

Notes

1. Throughout this article, we use the words ''consciousness,'' ''experience,'' and ''phenomenology'' as synonyms to describe awareness of the rich type that humans have. We typically use the word ''phenomenology'' and ''experience'' to describe our own views because they have less baggage among cognitive scientists and philosophers of cognitive science than ''consciousness.'' The term ''qualia'' is supposed to refer to raw, uninterpreted feels—the ''what it is like'' to experience a particular shade of purple, that is supposed to be separable from your knowing that it is a part of the sunset you are viewing. We do not believe in qualia.
2. This is, of course, a very contentious claim. It has been disputed by Adams and Aizawa (2001, 2008) and Rupert (2004) among others, and defended by Clark and Wilson 27 (jointly and together: Clark, 1997; Wilson, 2004; Wilson and Clark, to, appear), among others (e.g., us: see Chemero and Silberstein, 2008a, 2008b). For now, pretend that it is true.
3. This is partly why wide computationalism was set aside earlier. Wide computationalism is a representational theory of cognition.
4. Ironically, this separation of meaningful cognition and consciousness was institutionalized by Dennett's (1969), despite the fact that Dennett has consistently argued against the intuition that machines could not have conscious experience and has consistently attempted to debunk qualia.
5. Clark (2007) is apologetic about the changing boundaries of extended cognitive systems. This, we think, is a mistake. Plastic boundaries are essential features of extended cognitive systems.

6. Whether 1/*f* noise definitively indicates that a system is interaction dominant has been controversial. For example, Thornton and Gilden (2005) and Torre and Wagenmakers (2009) argue that 1/*f*-like scaling might result from a component-dominant system. Recently, however, Ihlen and Vereijken (2010) have shown that the presence of multifractality demonstrates definitively that a system is interaction dominant. Ihlen and Vereijken reanalyze the data from van Orden et al. (2003), and show that it is multifractal. Dotov, Nie, and Chemero (forthcoming) demonstrate multifractality in the results from Dotov et al., 2010.

References

Adams, F., & Aizawa, K. (2001). The bounds of cognition. *Philosophical Psychology*, *14*(1), 43–64.

Adams, F., & Aizawa, K. (2008). *The bounds of cognition*. Malden, MA: Blackwell.

Agre, P., & Chapman, D. (1987). *Pengi: An implementation of a theory of activity*. Proceedings of AAAI-87. Menlo Park, CA: AAAI Press.

Anderson, M. (2003). Embodied cognition: A field guide. *Artificial Intelligence*, *149*, 91–130.

Beer, R. (1995). Computational and dynamical languages for autonomous agents. In R. F. Port & T. van Gelder (Eds.), *Mind as motion* (pp. 121–147). ???: MIT Press. 14

Beer, R. (1999). Dynamical approaches to cognitive science. *Trends in Cognitive Sciences*, *4*, 91–99.

Brooks, R. (1991). Intelligence without representation. *Artificial Intelligence*, *47*, 139–159.

Chemero, A. (2003). An outline of a theory of affordances. *Ecological Psychology*, *15*(2), 181–195.

Chemero, A. (2008). Self-organization, writ large. *Ecological Psychology*, *20*, 257–269.

Chemero, A. (2009). *Radical embodied cognitive science*. Cambridge: MIT Press.

Chemero, A., & Silberstein, M. (2008a). After the philosophy of mind. *Philosophy of Science*, *75*, 1–27.

Chemero, A., & Silberstein, M. (2008b). Defending extended cognition. B. Love, K. McRae, & V. Sloutsky (Eds.), In Proceedings of the 30th Annual Meeting of the Cognitive Science Society (pp. ???–???). Austin, TX: Cognitive Science Society.

Clancey, W. (1997). *Situated cognition*. New York: Cambridge University Press.

Clark, A. (1997). *Being there*. Cambridge: MIT Press.

Clark, A. (2007). Soft selves and ecological control. In D. Ross, D. Spurrett, H. Kincaid, & G. L. Stephens (Eds.), *Distributed cognition and the will: Individual volition and social context* (pp. 101–122). Cambridge: MIT Press.

Clark, A. (2008). *Supersizing the mind: embodiment, action and cognitive extension*. Oxford, England: Oxford University Press, 224 pp. 15

Clark, A., & Chalmers, D. (1998). The extended mind. *Analysis*, *58*, 10–23.

Dennett, D. (1969). *Content and consciousness*. London: Routledge & Kegan Paul.

Ding, M., Chen, Y., & Kelso, J. A. S. (2002). Statistical analysis of timing errors. *Brain and Cognition*, *48*, 98–106.

Dixon, J., Holden, J., Mirman, D., & Stephen, D. (this issue). Multi-fractal development of cognitive structure. *TopiCS in Cognitive Science*, *????*, ????–????. 16

Dotov, D., Nie, L., & Chemero, A. (2010). A demonstration of the transition from readiness-to-hand to unreadiness-to-hand. *PLoS ONE*, *5*(3), e9433. doi:10.1371/journal.pone.0009433.

Dotov, D., Nie, L., & Chemero, A. (forthcoming). Readiness-to-hand, unreadiness-to-hand, and multifractality. *Journal of Mind and Behavior*, *????*, ????–????. 17

Fodor, J. (1981). *Representations: Philosophical essays on the foundations of cognitive science*. Cambridge, MA: The MIT Press.

van Gelder, T. (1995). What might cognition be if not computation? *Journal of Philosophy*, *91*, 345–381.

Gibson, J. (1979). *The ecological approach to visual perception*. NJ: Houghton Mifflin. 18

Gilbert, S., & David, E. (2009). *Ecological developmental biology: Integrating epigenetics, medicine and evolution*. ???: Sinauer Associates, Inc. Publishers. 19

Haken, H., Kelso, J. A. S., & Bunz, H. (1985). A theoretical model of phase transitions in human hand movements. *Biological Cybernetics*, *51*, 347–356. 20

Heidegger, M. (1962). *Being and time* (J. Macquarrie & E. Robinson Trans.). New York: Harper & Row. (Original work published 1927).

Holden, J. G., Van Orden, G. C., & Turvey, M. T. (2009). Dispersion of response times reveals cognitive dynamics. *Psychological Review*, *116*(2), 318–342.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge: MIT Press.

Ihlen, E. A. F., & Vereijken, B. (2010). Interaction-dominant dynamics in human cognition: Beyond $1/f^{\alpha}$ fluctuation. *Journal of Experimental Psychology: General*, *139*(3), 436–463.

Jablonka, E., & Lamb, M. (2005). *Evolution in four dimensions genetic, epigenetic, behavioral, and symbolic variation in the history of life*. Cambridge: MIT Press.

Kaplan, J. (2008). Review of genes in development: Rereading the molecular paradigm edited by Eva M. Neumann-Held and Christoph Rehmann-Sutter. *Biological Theory*, *2*, 427–429.

Kelso, J. (1995). *Dynamic patterns*. Cambridge: MIT Press.

Kim, J. (1998). *Mind in a physical world*. Cambridge: MIT Press. 21

Kugler, P. N., Kelso, J. A. S., & Turvey, M. T. (1980). Coordinative structures as dissipative structures I. Theoretical lines of convergence. In G. E. Stelmach & J. Requin (Eds.), *Tutorials in motor behavior* (pp. ????–????). Amsterdam: North Holland. 22

Kugler, P., & Turvey, M. (1987). *Information, natural law, and the self-assembly of rhythmic movement*. Hillsdale, NJ: Erlbaum.

Maturana, H. R., & Varela, F. J. (1980). Autopoiesis and cognition: The realization of the living. Boston Studies in the Philosophy of Science, vol. 42. Dordrecht: D. Reidel

McClamrock, R. (1995). *Existential cognition*. Chicago: University of Chicago Press.

Noe, A. (2005). *Action in perception*. Cambridge: MIT Press.

Odling-Smee, F., Laland, K., & Feldman, M. (2003). *Niche construction: The neglected process in evolution*. Princeton, NJ: Princeton University Press

van Orden, G., Holden, J., & Turvey, M. T. (2003). Self-organization of cognitive performance. *Journal of Experimental Psychology: General*, *132*, 331–351.

van Orden, G., Holden, J., & Turvey, M. (2005). Human cognition and 1/*f* scaling. *Journal of Experimental Psychology: General*, *134*, 117–123.

Piccininni, G. (2008). Computation without representation. *Philosophical Studies*, *137*, 205–241.

Port, R., & van Gelder, T. (1995). *Mind as motion*. Cambridge, MA: MIT Press.

Riley, M. A., & Turvey, M. T. (2002). Variability and determinism in motor behavior. *Journal of Motor Behavior*, *34*, 99–125.

Rumelhart, D. et al. (1986). Schemata and sequential thought processes in PDP models. In D. Rumelhart & J. McClelland and the PDP Research Group (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition, vol. 2, psychological and biological models* (pp. 7–57). Cambridge, MA: MIT Press. 23

Rupert, R. (2004). Challenges to the hypothesis of extended cognition. *Journal of Philosophy*, *101*(8), 389–428.

Ryle, G. (1949). *The concept of mind*. London: Hutchinson.

Ryle, G. (1979). *On thinking*. K. Kolenda (Ed.), Oxford, England: Blackwell.

Silberstein, M. (2006). *The re-emergence of emergence. Chapter 9*. In P. Davies (Ed.), *In defense of ontological emergence and mental causation* (pp. ??????. ???: Oxford University Press 24

Solomon, H., & Turvey, M. (1988). Haptically perceiving the distances reachable with hand-held objects. *Journal of Experimental Psychology: Human Perception and Performance*, *14*, 404–427.

Stephen, D. G., Boncoddo, R. A., Magnuson, J. S., & Dixon, J. A. (2009). The dynamics of insight: Mathematical discovery as a phase transition. *Memory & Cognition*, *37*, 1132–1149.

Stephen, D. G., & Dixon, J. A. (2009). The self-organization of insight: Entropy and power laws in problem solving. *Journal of Problem Solving*, *2*, 72–102.

Stephen, D., Dixon, J., & Isenhower, R. (2009). Dynamics of representational change: Entropy, action, cognition. *Journal of Experimental Psychology: Human Perception and Performance*, *????*, ????–????. 25

Thelen, E., & Smith, L. (1993). *A dynamic systems approach to the development of cognition and action*. Cambridge: MIT Press.

Thompson, E. (2007). *Mind in life: Biology, phenomenology, and the sciences of mind*. Cambridge, MA: Harvard University Press.

Thompson, E., & Stapleton, M. (2008). Making sense of sense-making: Reflections on enactive and extended mind theories. Topoi, DOI 10.1007/s11245-008-9043-2. 26

Thornton, T. L., & Gilden, D. L. (2005). Provenance of correlations in psychological data. *Psychonomic Bulletin & Review*, *12*(3), 409–441.

Torre, K., & Wagenmakers, E. J. (2009). Theories and models for $1/f^{\beta}$noise in human movement science. *Human movement science*, *28*(3), 297–318.

Varela, F., Thompson, E., & Rosch, E. (1991). *The embodied mind*. Cambridge: MIT Press.

Warren, W. H. (1984). Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 683–703.

Wilson, R. (2004). *Boundaries of the mind*. New York: Cambridge University Press.

Wilson, R., & Clark, A. (forthcoming). How to situate cognition: Letting nature take its course.

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