Defending Extended Cognition

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Abstract

In this paper, we defend extended cognition against several criticisms. We argue that extended cognition does not derive from armchair theorizing and that it neither ignores the results of the neural sciences, nor minimizes the importance of the brain in the production of intelligent behavior. We also argue that explanatory success in the cognitive sciences does not depend on localist or reductionist methodologies; part of our argument for this is a defense of what might be called 'holistic science'.

Keywords: extended cognition; dynamical systems theory; reductionism.

Introduction

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, though, extended cognition received little attention. A convergence of results in AI and robotics (Agre and Chapman 1987, Beer 1995; Brooks 1991), perception (Solomon and Turvey 1988, Warren 1984), developmental psychology (Thelen and Smith 1995), and mathematical modeling (Kelso 1995; Kugler and Turvey 1987; Port and van Gelder 1995) changed this. Now, we have philosophical theories of things called 'enactive cognition' (Noe 2004; Thompson 2007; Varela, Thompson and Rosch 1991), 'existential cognition' (McClamrock 1995), 'extended cognition—EC ' (Clark and Chalmers 1998), 'embodied cognition' (Clark 1997; Shapiro 2004), 'wide computationalism' (Wilson 2004), 'situated cognition' (Clancey 1997; Hutchins 1995), 'radical embodied cognition' (Chemero, forthcoming) and many other names for roughly the same thing—the view that cognitive systems extend beyond the skin of the cognizer. This upswing of interest has led to an inevitable backlash, with a string of largely philosophical arguments that this newly interesting view is somehow fatally flawed (Adams and Aizawa 2001, 2008; Markman and Dietrich 2000; Rupert 2004; Vera and Simon 1997).

The purpose of this talk is to defend EC from some of the charges leveled against it. We will not address all of the critiques of EC; we feel that Andy Clark and Rob Wilson have quite convincingly defended the view against the metaphysical and mereological criticisms (Clark to appear; Wilson and Clark to appear). Instead we will focus on the methodologically, empirically and scientifically oriented critiques

Extended Cognitive Science Defined

As there are many views under the rubric of "externalist" cognitive science it is best that we define what we mean by 'extended cognition' (EC). 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. While to be sure there are finer distinctions to be made within each category, we embrace all three. EC, then, is the claim that 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. Furthermore, EC claims that the non-linearly related brain, body and environment are jointly sufficient for cognition.

The claim that cognition is extended is often put in terms of "causal spread" or "dynamical spread". This can be analyzed along two axis: "smallism" (Wilson, 2004, 22-23) and what we call "localism". Smallism says that mental states and functions are determined by the smallist scale of physical reality inside or intrinsic to a cognitive system. Bickle (2005) for example, given his defense of reducing mental states and functions to molecular and genetic features of neural systems is a smallist. Localism says that mental states and functions reside inside the head. The mind/brain identity thesis is a form of localism. It should be clear that these are distinct claims. For example, if you believe that mental states and functions supervene essentially on large-scale neural dynamics (Freeman 2005) then you are a localist but not a smallist. If you believe that brain-body-world are truly dynamically coupled as some dynamical accounts of cognition maintain (Thompson, 2007), then you are neither a smallist nor a localist.

We wish to defend, against certain objections, the possibility and in our view actuality, that at least for some mental states and cognitive functions, both smallism and localism fail. Our defense of the thesis of EC will be in terms of its value as a scientific hypothesis: Does extended cognitive science have any *explanatory or predictive value or potential for such*?

Critiques of Extended Cognitive Science

Setting aside the abjectly metaphysical critiques, we can find two kinds of critiques of the EC hypothesis. These are critiques that appear in the literature and that we have heard in person. The first of these is that the EC hypothesis contradicts findings in contemporary cognitive science and neuroscience. Examples of this sort of critique are found in Adams and Aizawa 2001, Revuonso 2006 and Bickle 2003. In its strongest form (e.g., Bickle 2003) this critique accuses proponents of extended cognitive science of ignoring the sciences of the brain, of being what Churchland (2002) calls "no-brainers". We address this sort of worry in sections 4.1 and 4.2. The second critique we will address is about the scientific value of extended cognitive science. Those who make this sort of critique argue that rejecting smallism and localism will be bad for cognitive science (Markman and Dietrich 2000; Rupert 2004, to appear).[1] This concern is dealt with in 4.3.

Defending Extended Cognitive Science

In this part of the paper, we defend extended cognitive science from the two critiques outlined above.

The Scope of Extended Cognitive Science

One form of argument against extended cognitive science, canvassed above, is to point out some cognitive phenomenon that is not plausibly extended (See Revuonso 2006.) Phenomenon X is not extended, the argument goes, so extended cognitive science must be false. This argument mistakes the scope of the claims made by EC proponents. Extended cognitive scientists need not claim that all of cognition is extended, just that some of it is. There is no *a priori* reason why some phenomenon might be given wholly brain internal explanations (e.g., dreams, certain kinds of pain), some given embodied accounts, while others will require explanations that span brain-body-environment systems (e.g., motor control, long division). Indeed, we all ought to embrace causal and explanatory pluralism about cognition. Bechtel, for example, points out that extended dynamical and localist mechanistic explanations are mutually supporting in that information about the mechanisms and their components help us to better formulate the dynamics and insight into the dynamics can help us discover key mechanisms (2002, 240). Similarly, Andy Clark (1997) has argued that wide dynamical and localist computational explanatory patterns ought to "interlock" in a complete explanation of cognition. Even dynamicists such as Kelso and Engstrom point out that dynamic patterns require pattern generators, i.e., sometimes internal causal mechanisms, and vice versa (2006, 95). Chemero and Silberstein (2008) explicitly endorse explanatory pluralism. There is much to be said for pluralism about explanation. Animal behavior and animal brains are very complex, and we can see no *a priori* reason that all aspects of them or any one aspect of them, ought to be explained in *any* one way, whether or not explanations interlock or are complementary. Extended cognitive science surely is not committed to all of cognition requiring brain-body-environment explanation.

Extended Cognitive Science and the Brain

Churchland (2002) famously mocks those who do not apply findings in neuroscience to philosophical problems as "no-brainers"; Bickle (2003) mocks anyone with traditional philosophical concerns, including "naturalistic philosophers of mind" and other neurophilosophers. It must not be overlooked that extended cognitive scientists can endorse this name calling: extended cognitive science is neither no-brainerism, nor a priori philosophy of mind.

First, extended cognitive science is not *a priori* philosophy of mind. Indeed, there is a substantial *empirical* case to be made for EC. This has been the point of much work in embodied cognitive science, whether by philosophers (Varela, Thompson and Rosch 1991, Clark 1997, Thompson 2007) or psychologists (Gibson1979, Thelen and Smith 1994, Beer 1995, Lungarella and Sporns 2006). Here we point to two recent studies specifically aimed at supporting extended cognitive science.

Chemero and Heyser (2005) have provided evidence that some research in neuroscience itself suffers precisely because it is internalist. We found that researchers who use the object exploration experimental paradigm with rodents to study the effect of drugs, genes and neurotransmitters on behavior fail to take into account that the affordances of the to-be-explored objects, what actions the mice or rats can perform on them, dramatically affect the way rodents explore the objects. In many cases, experimentalists use objects with different affordances, e.g., some objects are climbable by rats, others are not. In such cases, the effects found in the experiments are just as likely to be due to differences among the affordances of the objects as they are to be due to the drug, gene or neurotransmitter under study. That is, it turns out that, at least in some cases, when neuroscientists, behavioral geneticists, and psychopharmacologists assume that studying the brain is studying the mind, they do flawed experiments or misinterpret their results. (See Chemero and Heyser, 2005.) They argue that to fix these misinterpretations, researchers must simultaneously investigate the brains, bodies and environments of their animals. That is, they must acknowledge that cognition is extended.

Lungarella and Sporns (2006) use a series of robotic experiments to show that there is a two way flow of information between visual perception and action in the environment. That vision provides information for action is not news, of course. Lungarella and Sporns showed that the

[1] We realize that we have not said enough about these critiques. In our defense, space is very limited here. We are not attacking straw men. In fact, we believe that in section 4 we defend EC against versions of the critiques that are more compelling than those that have been published.

converse is also true, by decoupling visual information and action. In particular, they showed that providing inappropriate information about actions leads to poor visual search and that action actually creates information for perception. This, of course, is one of the main EC principles, and has been demonstrated repeatedly in studies of haptic perception of size and weight, which is impossible without actively hefting an object. (See Gibson 1966; Solomon and Turvey 1988; Amazeen and Turvey 1996; Shockley, Carello and Turvey 2004). What is unique in the Lungarella and Sporns work is that they have developed a quantitative technique to show just how much information for perception is generated by action, and how much is lost when perception and action are decoupled.

The two studies mentioned and many, many others show that EC is not a hypothesis developed from the armchair. It is a hypothesis that generates hypotheses that have been tested and confirmed. So extended cognitive science is not *a priori* philosophy of mind.

EC is also not no-brainerism. Churchland (2002) mentions (though does not follow up) the possibility that dynamical systems theory, arguably the most important explanatory tool of EC, might be the future of neuroscience. Dynamical systems theory is not only an appropriate language for understanding the activity of the brain-body-environment system, there is mounting evidence that it is also the key to understanding the brain. Recent work by Bressler and Kelso (2001), Varela and Thompson (2001), Varela, Lachaux, Rodriguez, Martiniere (2001), Bressler (2002), Oullier, de Guzman, Jantzen, Lagarde, & Kelso (2005), Kelso and Engstrom (2006), and Thompson, Cosmelli and Lachaux (2007) makes this point vividly. In all of this cited work (and much more), dynamical systems models are shown to work both in brain-only explanations and in brain-body-environment ones.[2]

Those who accuse EC of no-brainerism come close to attacking a straw man. They claim that: of course a cognitive system is not extended, only embodied and situated, because such externalist cognitive features must piggyback on the real, intrinsic cognitive "agent." Their implication is clear: just try taking the brain and its functional features out of the picture and see how much cognition gets done by what remains! But of course EC does not deny that understanding brains is vital to understanding cognition, or that cognition could occur without brains. Brains are absolutely essential to cognition, but this does not entail either smallism or localism.[3]

Defending Holist Science

Extended cognitive science, which rejects both localism and smallism as exceptionless truths, is committed to holistic (i.e., wide dynamical or wide computational) explanation.[4] Yet no small part of the accumulation of knowledge since the scientific revolution is the result of reductionist methodologies. The biggest advantage of methodological individualism and methodological reductionism is they have proven to be phenomenally successful tools for prediction, explanation and intervention in physical, chemical and biological systems. As Lewontin puts it, "This [methodological reductionism] was a radical departure from the holistic pre-Enlightenment view of natural systems as indissoluble wholes that could not be understood by being taken apart into bits and pieces…Over the last three hundred years the analytic model has been immensely successful in explaining nature in such a way as to allow us to manipulate and predict it" (2000, 72). Indeed, it is probably fair to say that the only reason more holistic scientific methodologies are being developed is that methodological reductionism has hit the wall in many scientific disciplines involving the study of complex, non-linear, multi-leveled, nested and self-organizing systems.

Whatever the cause of their creation, holistic scientific methodologies have been introduced with great success in physics and biology as well as in cognitive science. The principle worry raised about extended cognitive science here is that too much holism makes science impossible, or at least unnecessarily difficult. (Kitcher 2003 makes this claim with respect to evolutionary biology.) For given enough holism, what is thought to be a 'system' or sub-system is, after all, just a convention (Rupert has raised this issue with regard to the individual cognitive agent). Science seems to be predicated on dividing the world objectively into the relevant explanatory parts or systems per the explanatory task at hand. And, indeed, this was Einstein's worry about quantum mechanics. Contrary to popular opinion what really bothered Einstein about quantum mechanics was not so much its possible indeterminism but the failure of locality and separability:

> But that which we conceive as existing ("real") should somehow be localized in time and space. That is, the real in one part of space A, should (in theory) somehow exist independently of that which is thought of as real in another part of space, B…However, if one renounces the assumption that

[2] Notice, though, that decades of work by Walter Freeman (e.g., Skarda and Freeman 1987) shows that dynamical systems theory can also provide explanations of internal brain processes. The EC vs. internalism (or localism) debate and the mechanism vs. dynamicism debate are orthogonal (See Chemero and Silberstein 2008.)

[3] The most common and most convincing arguments for localism and smallism (i.e., against EC) stem from imaging studies, mechanism hunting and lesion studies that claim to localize cognitive functions to particular regions within the brain. These arguments are, of course, hardly definitive and their weight greatly exaggerated. See Uttal 2001, Hardcastle and Stewart 2005, and Prinz 2006 for retorts.

[4] "Holistic" is a fuzzy notion but as Clark says of wide dynamical explanations, "such interactions may be highly complex, nested and non-linear. There may be no viable means of understanding the behavior and the potential of the extended cognitive ensembles by piecemeal decomposition and additive reassembly…such that the larger explanatory targets here are [necessarily] whole processing cycles" (forthcoming, 26). The point here is that the more coupled and non-linear body-brain-world is, the more decomposition and localization will fail to use Bechtel's widely accepted vocabulary.

what is present in different parts of space has an independent, real existence, then I do not at all see what physics is supposed to describe. For what is thought to be a "system" is, after all, just conventional, and I do not see how one is supposed to divide up the world objectively so that one can make statements about the parts (Einstein, 1948).

Unfortunately for Einstein, it is now well known that quantum entanglement and EPR correlations force us to abandon either separability and/or locality[5]. Einstein thought that both these principles, but especially the latter, were transcendental grounds for the very possibility of science. He was wrong. Quantum systems such as electrons are *coupled* in far more radical ways than is being contemplated in the case of elements of cognitive systems. Quantum mechanics has succeeded wildly in devising dynamical equations to predict and explain the behavior of such systems. While the non-linear equations involved in extended cognitive science are in many ways more daunting, there is no reason to abandon hope. One reason for hope is that complexity theory and dynamical systems theory have had a reasonable bit of success finding non-linear equations that apply to any number of disparate many-bodied systems with quite different elements such as cars, ants, neurons, etc (Abrahamsen and Bechtel, 2006). Thus *a priori* arguments against holistic cognitive science should hold no water.

None of this shows that holistic methods are the best methods for cognitive science, of course. They must however be taken seriously. First, even if one does not truly believe that brain-body-world constitutes a non-decomposable coupled system, there may be good reasons to attempt extended cognitive science. There may be pragmatic or practical reasons for embracing methodological holism even if you are a staunch metaphysical individualist. As Herbert Simon put it, "in the face of complexity, an in-principle reductionist may be at the same time a pragmatic holist" (1969, 86). Second, the extended cognition thesis might really be true. The holism question is an open and empirical one—the reason to attempt full-blooded extended cognitive science is that the world might really be that way and such methods may capture that. Such questions cannot be settled *a priori* by any kind of *essentialist* arguments about what is and what is not a cognitive system.

Extended Cognitive Science at Work

We have already argued that extended cognitive science is coherent. In order to show that it is not unworkable, we simply point out that it is in fact working. There are many, many examples that we could point to. Here we will limit our discussion to just one variety of embodied cognition explanation: coordination dynamics. Kelso and Engstrom (2006) describe coordination dynamics as "a set of context-dependent laws or rules that describe, explain and predict how patterns of coordination form, adapt, persist and change in natural systems. …[C]oordination dynamics seeks to identify the laws, principles, and mechanisms underlying coordinated behavior among different types of components in different kinds of systems at different levels of description" (2006, 90). The methodology of coordination dynamics is as follows: first, for the system as a whole, discover the key coordination variables and the dynamical equations of motion that best describes how coordination patterns change over time. Second, identify the individual coordinated elements (such as neurons, organs, clapping hands, pendulums, cars, birds, bees, fish, etc.) and discern their dynamics. As Kelso and Ensgtrom say, this is non-trivial because the individual coordinated elements are often themselves quite complex, and are often dependent upon the larger coordinated system of which they are components (2006, 109). They put the point even more strongly, "in the complex systems of coordination dynamics, there are no purely context-independent parts from which to derive a context-independent coordinative whole" (2006, 202). This is extended cognition with a vengeance. Third, derive the systemic dynamics from the description of the non-linear coupling among the elements. It is this non-linear coupling between elements that allows one to determine connections across different levels of description. It is important to note that, as in all dynamical explanation, discovering both the systemic dynamics and that of their component parts requires specifying boundary conditions that "establish the context for particular behaviors to arise" (Kelso and Engstrom 2006, 109). The behavior of the whole system "emerges" from the non-linear interactions among the elements of the system in a particular context where the elements and the contextual features are coupled and mutually co-dependent. The individual coordinating elements form a collective whole in the sense that microscopic degrees of freedom are reduced to a much smaller set of context-dependent coordination variables or order parameters that greatly constrain the behavior of the elements. Mathematical physicists often call this process "enslavement" by the order parameters or the slaving principle.

Consider, for example, an experiment by Oullier, de Guzman, Jantzen, Lagarde, & Kelso (2005), which uses coordination dynamics to account for spontaneous interpersonal coordination. They asked two subjects to sit across from one another, close their eyes and move their fingers up and down at a comfortable rate. Each trial was divided into three temporal segments. In one condition (C-O-C), subjects kept their eyes closed in segments one and three, and open in segment two. In another condition (O-C-O), subjects kept their eyes open in segments one and three, and closed in segment two. The same results were found in both conditions. When the subjects have their eyes closed,

[5] Separability principle: any two systems A and B, regardless of the history of their interactions, separated by a non-null spatio-temporal interval have their own independent real states such that the joint state is completely determined by the independent states. Locality principle: any two spacelike separated systems A and B are such that the separate real state of A let us say, cannot be influenced by events in the neighborhood of B.

their finger movements were out of phase with one another. When subjects have their eyes open, their finger movements spontaneously synchronize, only to desynchronize when the subjects are asked to close their eyes again. Earlier research indicates that these finger movements are mirrored by rate-dependent activity in sensorimotor cortex (Kelso, Fuch, Lancaster, Holroyd, Cheyne and Weinberg 1998). So in each subject, there is a spontaneous coordination of brain activity and behavior with an external source (in this case the other subject). That is, the synchronization crosses brain, body and environment. These results are explained using coordination dynamics. In accounting for the behavior of their subjects, Oullier *et al* need not worry about the mechanisms by which finger movements structure light, which impacts retinal cells, which impacts neural cells, which impacts muscles, which move fingers, and so on. The dynamical explanation of this interpersonal coordination abstracts away from all this detail, simply positing that the movements of the fingers are non-mechanically or *informationally coupled* (Kugler and Turvey 1987, Schmidt, Carello and Turvey 1990, Kelso 1995, Kelso and Engstrom 2006) when, and only when, the subjects have their eyes open. Indeed, the dynamics of the system can be modeled by attending to just one parameter—the state of the subjects' eyes. This is the hallmark of a good dynamical explanation: the change over time of a very complex extended cognitive system, one comprising brain, body, and environment, is modeled with a comparatively simple set of equations.

Conclusions

Our aim in this paper is quite humble. We primarily hoped to establish that whether or not extended cognition is true (either metaphysically or methodologically), or at least a useful operating assumption, is an open empirical question and must be settled as such. The history of science tells us this is the only safe way to progress lest our theories become self-sealing.

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