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Embodied Cognitive Science and its Implications for Psychopathology

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Abstract

The past twenty years have seen an increase in the importance of the body in psychology, neuroscience and philosophy of mind. This 'embodied' trend challenges the orthodox view in cognitive science in several ways: it downplays the traditional 'mind-as-computer' approach and emphasizes the role of interactions between the brain, body and environment. In this article I review recent work in the area of embodied cognitive science and explore the approaches each takes to the ideas of consciousness, computation and representation. Finally I look at the current relationship between orthodox cognitive science and the study of mental disorder, and consider the implications that the embodied trend could have for issues in psychopathology.

Keywords: cognition, computation, consciousness, dynamical systems, embodiment, enactivism, extended mind, phenomenology, representation

Introduction

The past twenty years have seen a change in attitude towards the body in psychology, neuroscience and philosophy of mind. These 'cognitive sciences' had previously thought of the mind as a collection of computational processes which could be studied in abstraction from the brain which implemented those processes. The new trend in 'embodied' cognitive science has largely argued against this computational stance, and promoted the idea that studying the mind requires studying the biological brain in its natural setting: embedded within the body, interacting with the environment.

In this article, I introduce the themes and commitments of orthodox cognitive science, focusing on the computational account of cognition and the inner representational states it requires. I explore the beginnings of the embodied cognitive science movement in the works of Brooks (1991), Varela, Thompson and Rosch (1991) and Clark and Chalmers (1998), before reviewing five recent works in the embodied trend: *Boundaries of the Mind* (Wilson 2004), *Reconstructing the Cognitive World* (Wheeler 2005), *How the Body Shapes the Mind* (Gallagher 2005), *Action in Perception* (Noë 2004) and *Mind in Life* (Thompson 2007). I conclude with an examination of the relationship between cognitive science and the study of psychopathology. Orthodox cognitive science has provided a supportive framework for psychiatry, but has done so by relying on the precise commitments which are challenged by embodied cognitive science. There are, however, reasons to think that embodied cognitive science would be useful to the study of mental disorder: it provides a way of thinking about abstract cognition as strongly related to bodily activities and processes, providing possible explanations for the spread of symptoms found in many psychiatric disorder. Furthermore, much embodied cognitive science emphasizes the importance and credibility of the concept of conscious experience in scientific discourse. As such, it may provide an opportunity for the scientists of psychopathology and the phenomenological psychiatrists to integrate their research into one framework.

The Computational Mind: An Introduction to Orthodox Cognitive Science

Cognitive science is the multidisciplinary study of the mind by researchers from philosophy, artificial intelligence, psychology, linguistics, neuroscience and related areas. Since the 1950s, cognitive scientists have been using scientific methods, techniques and models to explore the processes which generate intelligent behavior. Prior to this ‘cognitive revolution’, behaviorist psychology had prohibited the study of such internal mental states and insisted that the only area of viable scientific study was the observable behavior of organisms analyzed in terms of stimulus, conditioning and response. Cognitive science challenged behaviorism by adopting the metaphor of software programs running on digital computers, giving scientific credibility to the study of the mental ‘software’ that was run on the brain’s hardware.

Orthodox cognitive science is based on the idea that cognition is representational and computational: our mental states represent features of the world, and our mental processes operate over these inner symbols, transforming and manipulating them. Thinking of the mind in terms of computation seemed to allow a causal explanation of action (and mental processing more generally) in terms of inner representational states: my desire to have *x* and my belief that doing *y* will get me *x* will, under normal circumstances, lead me to do *y*. Inner representations thus function syntactically, which allows them to be processed computationally, but they also carry semantic content or meaning: *x* might represent food, *y* might represent the opening of the fridge. [1]

As well as a commitment to computation and representations, orthodox cognitive science extends the computer metaphor by drawing a distinction between 'software' and 'hardware'. According to this way of thinking, our cognitive processes are akin to computer programs or software, which can be completely specified without reference to the hardware of the brain which is implementing them. This separation of mind from brain should not be interpreted as dualistic: orthodox cognitive scientists firmly believe that what we call 'mind' is simply the functioning of the brain, but they believe that from an explanatory point of view there is much to be gained by abstraction from the neural level – in much the same way as we benefit in daily life from taking tables and chairs to be solid objects rather than collections of shifting atoms. It is worth noting, however, that many orthodox cognitive scientists no longer adhere to the idea of a strong distinction between software and hardware, or insist on a strictly 'top-down' approach: much important work is currently being done in cognitive neuroscience, where the focus is on a plurality of levels, functional and neural, and the relationships between them.

The last important point to note about orthodox cognitive science is its relative silence on the question of consciousness. The orthodox approach focuses on the functional details of the cognitive processing itself and has traditionally had little or nothing to say on 'phenomenology', the experiential quality of conscious mental life. Computational models allow for thought processes to be considered scientifically, but it has traditionally been difficult to find a place for the subjective first-person perspective in the orthodox science of cognition.

Several more recent developments in cognitive science deserve a mention. The 1980s saw the rise of 'connectionist' cognitive science, which challenged the classical idea of sequential symbol processing by positing the distributed processing of parallel network connections. One of the motivating factors behind this trend in cognitive science is that connectionist networks seem to bear more similarity to actual brain operation than classical symbol-crunching models. The connectionist approach should still be viewed as orthodox cognitive science, however, because it is committed to cognition as a computational process over representations: parallel processing is a different form of computation from the narrow classical view, and its representations are distributed over a network rather than isolated to a symbol, but the key features are retained (Bechtel and Abrahamsen 1991).[2]

To sum up, orthodox cognitive science (both classical and connectionist) characterizes cognition as computation over inner representations; it also sidesteps the issue of consciousness (Searle 1992). Importantly, it is also radically disembodied: even those cognitive scientists exploring the biological foundations for cognition focus solely on the brain (Thompson 2007). Everything outside the brain, such as the body and the environment in which it is embedded, is assumed to be nothing more than a source of input to – and an arena for output from – the cognitive processes taking place inside the head (Wheeler 2005). All of these commitments are challenged to a certain degree by work in the embodied cognitive science.

Embodiment and Cognitive Science: The Beginnings

The importance of the body to our mental life is not a new idea: it can be traced back at least to the French philosopher Maurice Merleau-Ponty (Merleau-Ponty 1962). The incorporation of embodiment into cognitive science, however, began in earnest in the field of robotics with the work of Rodney Brooks (Brooks 1991). The orthodox approach to robotics was to construct perceptual input systems and action output systems, separated by a central cognitive system which computed over representations. Brooks realized that the disembodied, inference-based approach didn't yield results as successfully as tailoring the design of the robot body to the requirements of its physical environment. Brooks' key insight was that a certain range of (albeit limited) intelligent behavior could be modeled without recourse to explicit representations and internal models, suggesting instead that "the world is its own, best model" (Brooks 1991, 139). The idea is that if some intelligent behavior can be produced by the interactions between the robot and the world, there is no need for separate (internal) representations: bodily and environmental structures can do the work previously attributed to internal states. This focus on real-world, real-time, task-oriented robotics was completely at odds with the orthodox approach in cognitive science.

Brooks' work was soon inspiring others to rethink the commitments of orthodox cognitive science: one key work was *The Embodied Mind* (Varela, Thompson and Rosch, 1991), which aimed "to enlarge the horizon of cognitive science to include the broader panorama of human, lived experience" (Varela, Thompson and Rosch 1991, 14). They emphasized the role of consciousness in any account of our mental life, and claimed that the kinds of conscious experiences we have depends heavily on our bodies and their interactions with the world in which we are embedded. In addition to their focus on consciousness and their rejection of the neurocentric view, the authors of *The Embodied Mind* also dismissed the idea that cognition requires representation, thus hailing a radical departure from orthodox cognitive science. Representations, they contended, are only required by a theory which views the mind as having to pick up or recover objective properties of the world. *The Embodied Mind* coined the term 'enactivism' for the alternate view that "cognition is not the representation of a pregiven world by a pregiven mind but it is rather the enactment of a world and a mind on the basis of…actions that a being in the world performs" (Varela, Thompson and Rosch 1991, 9). The key idea behind enactivism is that perception and action are firmly intertwined, and that higher cognitive capacities emerge from these linkages between the sensory and motor systems.

The idea of the embodied and embedded mind was shortly followed by the radical view of the mind as extended into the environment. In their paper 'The Extended Mind' (1998), Andy Clark and David Chalmers considered the question of where the mind stops and the rest of the world begins, and challenge the intuitive view that the boundaries of the mind are those of our skin and skull. Clark and Chalmers drew attention to the way we use parts of the external environment to 'scaffold' our cognitive processes: consider the use of a slide rule for complicated calculations, or the rearranging of Scrabble tiles to help identify words. Their claim was that external states and processes can play a sufficiently similar role in psychological explanations of behavior as their internal 'cognitive' counterparts. For at least some explanatory purposes the boundary between internal and external seems unimportant, and so restricting cognitive processes to internal mechanisms seems to stand in the way of good explanatory practice. Rather, when we are closely coupled with parts of the environment in a causally complex way, we should think of cognition as extending beyond the brain into the world. Clark and Chalmers clearly opposed the neurocentric view of orthodox cognitive science, and challenged the orthodox requirement for solely inner representations. They had little to say on consciousness however, and were not committed to its physical basis extending beyond the brain.

Most of the work in contemporary embodied cognitive science can be seen as following on from one or both of *The Embodied Mind* (Varela, Thompson and Rosch 1991) and 'The Extended Mind' (Clark and Chalmers, 1998). Within the overall embodied, embedded, enactive and extended trend, there are many differences among research programs: attitudes towards computation and representation differ, as does the emphasis on conscious experience. However, all are committed to the rejection of the neurocentric view that an explanation of our rich mental lives can come from focusing solely on the brain.

Recent Work in Embodied Cognitive Science

Boundaries of the Mind, Robert A. Wilson

Not all work in embodied cognitive science sets out to overthrow the orthodoxy. Orthodox cognitive science has yielded successful results by modeling the mind on computational principles, and some researchers have sought to retain the core commitments of computation and representation while rejecting the neurocentric element of the traditional approach. In *Boundaries of the Mind* (Wilson 2004), Robert A. Wilson attempts to reconcile the Clark and Chalmers (1998) idea of the extended mind with the standard computational picture.

Wilson's book is the first in his trilogy of works exploring the concept of the individual in the cognitive, biological and social sciences. In this volume his aim is to reject 'individualism' in cognitive science: the thesis that the mental state of an individual can and should be understood without reference to anything outside the individual. His main point of attack is not orthodox cognitive science itself, but several traditional ideas in philosophy of mind which lead philosophers to support the orthodoxy. Philosophers of mind traditionally think of mental states and processes in terms of their 'realizers' or their 'supervenience base', conceived of as internal parts of the individual. Wilson's core argument in *Boundaries of the Mind* is that these philosophical concepts can all be thought of in terms that support a wider picture of mentality: traditional philosophy of mind does not entail orthodox cognitive science.

Wilson argues that traditional philosophy of mind is mistaken in its emphasis on what he calls 'smallism': the idea that an explanation of something requires a reductive analysis of that thing into smaller and smaller components. Wilson claims that because so many of our psychological states are context sensitive, they cannot be explained by reducing them to inner mechanisms and structures. Instead, we should look at both the state and the context as the explanation, which can be understood not by breaking it down but rather by placing in a wider perspective: an explanatory strategy he labels 'integrative synthesis', which "departs from the smallist views that typically drive researchers to look further 'into' the brain in search of cognitive systems" (Wilson 2004, 212).

Without a commitment to smallism, Wilson claims we are freed from having to view computation as an internal process:

> "it is sometimes appropriate to offer a formal or computational characterization of an organism's environment, and to view parts of the brain

> of the organism, computationally characterized, together with this environment so characterized, as constituting a unified computational system". (Wilson 2004, 167)

To accompany this view of 'wide computation', Wilson proposes 'exploitative representation':

> "Representations need not be thought of as internal copies of or codes for worldly structures. Rather, representation is an activity that individuals perform in extracting and deploying information that is used in their further actions." (Wilson 2004, 183)

Wilson claims that our representational capacities are enabled not by internal mechanisms of the brain, but rather "by embodied states of the whole person, or by the wide system that includes (parts of) the brain" (Wilson 2004, 188). He is not committed to the view that cognition must be computational: his aim is rather to show that the computational view is at least consistent with an embedded, extended mind.

Wilson's focus throughout *Boundaries of the Mind* is mostly on cognitive processes rather than on conscious experience. He does, however, put forward an account of consciousness as "temporally extended, scaffolded, and embodied and embedded" (Wilson 2004, 215), but his focus is largely on the thought-like aspects of consciousness such as introspection, rather than on experiential aspects. Wilson's project is less revisionary than many in embodied cognitive science, in that it seeks to reconcile some of its commitments with traditional views in philosophy of mind.

Recontructing the Cognitive World, Michael Wheeler

In contrast, Michael Wheeler's *Reconstructing the Cognitive World* (Wheeler 2005) wholeheartedly embraces the embodied trend, calling for cognitive science "to put cognition back in the brain, put the brain back in the body, and the body back in the world" (Wheeler 2005, 11). As well as a general overview of what he calls the 'embodied-embedded' trend in cognitive science, Wheeler also outlines a framework for thinking about the issues involved in terms of Heidegger's account of everyday cognition put forward in *Being and Time* (Heidegger 1926), which he claims can clarify conceptual issues in embodied cognitive science.

Wheeler identifies several key commitments of the embodied trend in cognitive science. Whereas orthodox cognitive science takes abstract reasoning tasks as its paradigm processes, embodied cognitive science focuses on our flexible context-specific responses to environmental stimuli: examples include negotiating a complex space, and catching a ball. The motivation behind this is that our brains have evolved as action-controllers, and the 'offline' cognition that the orthodoxy focuses on is secondary to our primary 'online' real-time cognitive skills. Furthermore, in embodied cognitive science this primary online intelligence is not taken to be generated solely by brains, but by complex causal networks involving brain, body and world. Wheeler's more controversial claim is that embodied cognitive science should be committed to thinking of cognitive processes in terms of dynamical systems rather than traditional computation.

The dynamical systems approach is often favored by researchers in embodied cognitive science. Dynamical systems, like computational systems, involve processes and structures. But they are state-dependent systems that can accurately model continuous quantitative changes over time when governed by nonlinear differential equations. Given embodied cognitive science's emphasis on real-time real-world cognition, it is not surprising that they often favor this nonlinear dynamical approach. A second reason embodied cognitive science opts for nonlinear dynamicism is that whereas computational transitions require representational states over which to operate, nonlinear dynamical systems do not face any such requirements; for embodied theorists who are opposed to representational explanations, these dynamical systems provide an alternate framework. Wheeler is quick to point out, however, that "all manner of structures in a dynamical system might perform a representational function" (Wheeler 2005, 97): dynamical systems do not have to represent, but there is nothing to say they can't represent. Inner representational activity is a necessary condition for computation, but not a sufficient one.

Many people working embodied cognitive science import the idea of dynamical systems architecture as an *alternative* to a computational architecture. Wheeler, however, argues that "computational systems are a subset of dynamical systems" (Wheeler 2005, 103): computational dynamical systems feature representations and realize well-defined input–output functions, and are not temporally rich in character. Wheeler's liberal framework permits

> "the construction of hybrid explanatory models in which computational and noncomputational processes coexist and interact [which] allows us to understand the target space of possible cognitive processes using a single, fully integrated conceptual framework" (Wheeler 2005, 114).

Wheeler is not prepared to replace computation with dynamical systems: while the dynamical systems framework works well for online cognition, he admits that as far as offline cognition is concerned, the computational representational model may be correct:

> "[There is] an important but ring-fenced place for orthodox cognitive-scientific thinking within our embodied-embedded framework. Viewed this way, the historical mistake of orthodox cognitive science has been its

> enthusiasm for extending its distinctive models and principles beyond the borders of offline intelligence" (Wheeler 2005: 247).

It should be clear from this that Wheeler is not opposed to representations. He thinks there might be a place for inner representations in cases of offline cognition, such as mentally adding up how many times one has visited the dentist in the past year, or imagining a sequence of moves in a future chess game. Wheeler also wants to argue that cases of online cognition such as playing squash or escaping from a predator – despite being generated by the causal web of brain, body and world – can involve representations. The representations he has in mind are not symbolic or context independent encodings, but partial models of the world like those used by Brooks' robots: 'action oriented' representations. Wheeler realizes that once we extend the notion of representation out of the head, we run the risk of allowing anything to become a representation: to avoid this trivial spread and retain an explanatory concept of representation, he dedicates part of the book to working out criteria which would enable us to distinguish representational from non-representational features.

Wheeler suggests a Heideggerian approach to cognitive science, but despite the fact that Heidegger's method is termed 'phenomenological', Wheeler has little to say about the phenomena of human experience, or consciousness. He maintains that while Heidegger used phenomenology as a methodological tool, it should not be considered as a cure for the problems of orthodox cognitive science but "rather as a way or articulating what is, to a large extent, an independent and already happening transition in the fundamental character of the discipline" (Wheeler 2005: 124).

How the Body Shapes the Mind, Shaun Gallagher

One book which does emphasize the role of phenomenology in embodied cognitive science is Shaun Gallagher's *How the Body Shapes the Mind* (Gallagher 2005). Gallagher puts forward a strong argument for the importance of first-person conscious experience to much recent scientific work, including examples from developmental psychology on the newborn baby's awareness of its own movements, and work in neuroscience on amputees' experience of phantom limbs. His insistence on the importance of the body puts him firmly in opposition to orthodox cognitive science, but so does his commitment to the role of phenomenal experience. For Gallagher, the two are strongly linked: his major claim in the book is that consciousness and cognition are shaped and structured by the details of our embodiment. Bodily movement, he claims, "contributes to the shaping of perception, emotional experience, memory, judgment, and the understanding of the self and others" (Gallagher 2005, 10).

In addition to furthering research in embodied cognitive science, Gallagher's aim is also a methodological one. He realizes that as interest in embodiment grows across philosophy, psychology and neuroscience, it becomes increasingly important to develop a conceptual framework and common vocabulary to integrate discussions between people from different disciplines. His key contribution is to distinguish between the 'body image' and the 'body schema': our body image is constituted by our conscious beliefs about and attitudes towards our bodies, whereas our body schema is the system of processes which function without our reflective awareness to constantly regulate our movement.

Gallagher uses empirical examples involving bodily posture, muscular tension and emotion to argue that changes to our body schema can affect our perceptions of our bodies and our environments. Once he has established the role embodiment plays in shaping conscious perceptual experiences, he argues that perception is basic to all other forms of cognition to build up a general framework. Gallagher's strategy for establishing the importance of embodiment for cognition is thus an indirect one: the idea of conscious experience as shaped by the body is an essential stepping-stone in his argument.

Gallagher takes his arguments for the importance of the body to be an argument against the computational view of cognition:

> "In so far as cognition is reducible to computations, and computations can, in principle, run on silicon-based hardware, nothing like a human body seems to be required for cognition." (Gallagher 2005, 134)

Gallagher argues that he has shown that the human body does seem to be required for cognition, therefore cognition cannot be computation. He does not offer an alternative account, but seems to be open to the dynamical systems model: he emphasizes the temporal nature of experience, and the dynamic structures shared by embodied movement and cognition. He claims that some aspects of cognition are best explained by reference to our bodies themselves, not by reference to inner symbols which represent the bodily states in question.

Gallagher's account is radical in that it takes an embodied approach to not just online, action-related intelligent behavior but also to the types of offline intelligence many feel is more difficult to characterize without inner representations. Take the example of how we understand each other's beliefs, desires, intentions and emotions: the orthodox picture assumes that we either theorize or simulate internally and then communicate in speech or action. Gallagher, however, suggests that prior to the acquisition of a capacity to theorize or simulate, we have the non-conceptual ability to understand others that comes from embodied interaction. He posits that our "embodied practices constitute our primary access for understanding others" (Gallagher 2005, 224), that is, we have a direct understanding of a person's intentions because their intentions are explicitly expressed in their embodied actions. For those researchers in embodied cognitive science who downplay internal representations, explaining higher-level cognitive processes such as mental state attribution is a major challenge: Gallagher (2005) takes the first steps toward meeting this challenge.

Perception in Action, Alva Noë

Like Gallagher, Alva Noë is interested in the role played by the body in shaping conscious perceptual experience. *Perception in Action* (Noë 2004) is an exploration of how bodily activity determines what we perceive. Orthodox cognitive science takes perception to be a process in the brain which constructs an internal representation of the world, whereas those working in embodied cognitive science often highlight the body-environment interactions that make perception possible. Noë follows this line of thinking, stressing the idea of "perception as a species of skilful bodily activity" (Noë 2004, 2). He labels his approach 'enactive' to emphasize the role of action in perception. To perceive is not to passively receive sensations; rather we gain perceptual content by active enquiry and exploration: "Perception is not something that happens to us, or in us. It is something we do." (Noë 2004, 1)

Noë argues against our tendency to think of vision in terms of snapshot-like experiences of scenes, sharply focused and highly detailed. The snapshot conception is the starting point for most empirical work on vision, but Noë rejects it as an illusion. He uses results from recent work by psychologists to show that vision is attention dependent, and that it is much more like touch than like depiction. He defines vision as "a mode of exploration of the environment drawing on implicit understanding of sensorimotor regularities" (Noë 2004, 29-30), where this understanding is practical knowledge of the way sensory stimulation changes as we move our bodies.

In the orthodox cognitive science of the 1980s, vision was taken to be a computational process building up detailed inner representations by processing the external stimuli. As a computational process, it is independent of its implementation. However, Noë claims that to perceive like me one must have a body like mine: sensorimotor knowledge varies according to what sort of body one has. So vision, he argues, cannot be computational. Noë is careful not to argue that there are no representations in vision, but rather that the role of representations in perceptual theory needs to be reconsidered, and that detailed internal models of the world "can be demoted from their theoretical pride of place" (Noë 2004, 23).

Just as Clark and Chalmers (1998) argue for cognitive processes extending beyond the head and involving brain, body and world, Noë argues that the basis of conscious experience may do similarly. He points out that if the quality of conscious experience is not determined solely by the neural functioning of the brain, but rather the way the brain is embedded in and interacting with the body and environment, then the scientific search for the 'neural correlates of consciousness' won't reveal the whole story:

> "the neural substrate of a given particular perceptual experience will never be nomically sufficient for the occurrence of that experience, for it gives rise to the experience only given the background of the subject's consciousness. […] There is no good reason for assuming the only relevant background is the activity of the brain." (Noë 2004, 222)

Mind in Life, Evan Thompson

Enaction, the term Noë uses to describe his approach to perception, was first articulated in the influential work *The Embodied Mind* (Varela, Thompson and Rosch 1991). *Mind in Life* (Thompson 2007), Evan Thompson's follow-up to the book he co-authored with Varela and Rosch sixteen years previously, offers the clearest statement yet of the enactivist position. The central commitment of enactivism, Thompson states, is that "the human mind emerges from self-organizing processes that tightly interconnect the brain, body and environment" (Thompson 2007, 37). The concept of 'self-organization' is vitally important to Thompson's account of the relationship between life and the mind.

Like many others in the embodied approach to cognitive science, Thompson adopts the framework of dynamical systems theory. For Thompson, however, dynamical systems are more than just a way of describing cognitive processes without resorting to classical computation. He emphasizes the self-organizing features of dynamical living systems: biological organisms exhibit 'organized' behavior without an internal controller or programmed instructions, because order emerges from low-level local interactions. Thompson's main claim in this book is that these self-organizing features of life are a basic form of the same self-organizing features that create minds.

Self-organizing biological systems, Thompson claims, can also be seen as autonomous: they set their own tasks, rather than receiving inputs as computers do. Basic biological autonomy is a system's capacity to regulate and modify its interactions with the environment, so an autonomous system must be one which is always tightly coupled to its environment. Thompson wants to claim that this organism–environment coupling is such that that all representations, however we think of them, will belong to the coupled system of organism and environment rather than the organism alone. As such, representation is always context dependent: it is an enactment of an environment rather than an internal representation of an external world:

> "from the autonomy perspective a natural cognitive agent – an organism, animal or person – does not process information in a context-independent sense. Rather it brings forth or enacts meaning in structural coupling with its environment." (Thompson 2007, 58)

Thompson's exploration of how biochemical self-organization gives rise to sentience and conscious experience emphasizes the extent to which cognition and consciousness can be thought of as emergent biological phenomena. This deep continuity of mind and life – the overarching message of Thompson's book – runs counter to orthodox cognitive science's reliance on artificial intelligence and computational modeling.

Many researchers in embodied cognitive science have adopted dynamical systems approaches for online action-based intelligent behavior while accepting that some high-level abstract reasoning may be computational, but Thompson appears to be committed to dynamical systems for all cognitive processes. He rejects the concept of inner symbolic representations, but is prepared to hold onto a looser concept of representation, where these are thought of as "temporally extended patterns of activity that can crisscross the brain-body-world boundaries" (Thomson 2007, 59). Like his contemporaries in embodied cognitive science, Thompson is skeptical of a neurocentric approach to cognition:

> "the brain is not all we have, and […] it is far from obvious that any bodily process or environmental resource used in representing the world needs to be represented inside the brain." (Thompson 2007, 241-242)

These breadth of positions taken in these recent works by Wilson (2004), Wheeler (2005), Gallagher (2005), Noë (2004) and Thompson (2007) highlight the number of different standpoints which are held by those who work within the general framework of embodied cognitive science. What primarily unites researchers working in embodied, embedded, enactive and extended cognition is their opposition to orthodox cognitive science. There are many different aspects of orthodox cognitive science which can be challenged – the commitment to computationalism, the emphasis on inner representations, the neglect of conscious experience, the focus on abstract disembodied reasoning rather than on real-time interactions with the world, for example – and one's particular brand of embodied cognitive science will vary according to which aspects of orthodox cognitive science one is most interested in challenging. This means that when considering the implications of embodied cognitive science for psychopathology, it is important to remember that different varieties of embodied cognitive science may have different entailments, depending on their emphases and commitments.[3]

Cognitive Science and Psychopathology

By the time cognitive science became a recognized discipline, many neurological symptoms involving linguistic and sensory dysfunctions had been correlated with lesions in specific parts of the brain. Meanwhile, psychiatric disorders continue to elude such localization: they don't appear to be related to obvious abnormalities of brain structure. Orthodox cognitive science, however, focuses not on brain structure but on cognitive function, and the computational model it posits allows us to view the symptoms of mental disorders as resulting from 'functional lesions':

> "The rise of information processing models within cognitive psychology in the 1960s and 1970s provided a springboard for explanations of abnormal function… An information-processing model can…be easily 'lesioned' conceptually." (Shallice 1998, 15)

The distinction between software and hardware in orthodox cognitive science permits mental disorders to be thought of as the result of 'bugs' in the software. Concepts and theories of psychiatric disorders thus appear to have a strong grounding in a mechanical, material view of the mind, giving them scientific credibility despite not being correlated with any obvious damage to the hardware of the brain.

As a result of orthodox cognitive science, psychiatrists no longer have to restrict their studies to neuropathology in order to be taken seriously as medical scientists. Nancy Andreasen pioneered this approach, arguing that "a relatively sophisticated picture is emerging that conceptualizes mental illnesses as disorders of mind arising in the brain" (Andreasen 1997, 1586). Examples of the impact of orthodox cognitive science abound in the current literature:

> "Psychological disturbances experienced by psychiatric patients are slowly coming to be understood in terms of disturbances — excesses as well as deficits — to recognized information-processing systems." (Halligan and David 2001, 209)

The advancement of functional magnetic resonance imaging (fMRI) techniques has undoubtedly assisted this trend, and also given rise to the field of cognitive neuropsychiatry.

A further explanation for the success of the orthodox model in psychiatry could be its ability to reconcile two competing models of psychopathology: the biomedical model and the biopsychosocial model. The biomedical model thinks of mental disorders as purely medical problems arising from the molecular biology of the brain, and in so doing is often accused of being reductionist and sterile. The biopsychosocial model (Engel 1977) sees mental disorders as interrelations between the patient's brain and their psychological and social environment, but offers no account of any mechanisms underlying the interactions. Orthodox cognitive science seems to offer the best of both worlds: the computational processes provide a mechanistic account of cognition, while the inner representations allow for the involvement of psychosocial matters. Dominic Murphy (Murphy 2005) has recently defended this view of psychiatry as clinical cognitive neuroscience:

> "The contemporary understanding of the brain is of a social and cognitive organ…that looks tailor-made for synthesizing the virtues of both the medical model and the biopsychosocial approach" (Murphy 2005, 114)

It seems, then, that orthodox cognitive science provides a credible framework for understanding psychiatric disorder. The explanatory work, however, is being done by the concepts of computation and representation: precisely those aspects of the orthodox model about which the embodied cognitive science has serious reservations.

Thus far, embodied cognitive science has had relatively little to say on matter relating to psychopathology. To a certain extent, this can be attributed to the embodied trend's emphasis on the primacy of online cognition: given that the brain evolved to control action and negotiate the environment, researchers in embodied cognitive science think that the best way to understand cognition is to explore the relationship between perception and action. Most mental disorders, however, seem to be prime examples of disorders of offline cognition. Consider thought disorder or delusional belief formation: the problems here are most naturally thought of as dysfunctions of the sort of inner inferential mechanisms which embodied cognitive science plays down. Furthermore, recall that even researchers such as Wheeler (2005) who reject the idea of conceiving online cognition in terms of computation and inner representations are open to possibility that offline cognition might be best understood by these traditional models. This raises the possibility that embodied cognitive science might have few or even no implications for the study of psychopathology.

This characterization of mental disorders as dysfunctions of inner inferential mechanisms, however, does not stand up to close scrutiny. The symptoms of depression, for example, involve dysfunctions of abstract thought and memory processes accompanied by lower level bodily symptoms such as psychomotor retardation and sleep and appetite problems. Disorders of affect seem to be obvious candidates for a more embodied approach to the mind, particularly considering recent work on the relation between body and emotion (Damasio 1999). Eating disorders and body dysmorphic disorders are other areas of psychopathology in which it seems natural to think that an embodied approach will be more explanatory than the orthodox cognitive science alternative. These considerations reflect the similar concern in phenomenological psychiatry that some disorders may result from disturbances in embodied interaction with the environment: if this is the case, it is not clear that treating mental disorder as a problem of high-level cognitive mechanisms will solve the problem (Stanghellini 2004).

Certain mental disorders pose more of a challenge to embodied cognitive science. Delusional beliefs seem to be cases where the external world is being misrepresented internally, and therefore posit the sort of traditional representations many embodied theorists would have us do without. One way to deal with such cases is to redescribe them: recall Gallagher's (2004) attempt to explain our 'theory of mind' capacities without internal inferential mechanisms. Gallagher uses his account of embodied interactions to argue that autism, often seen as involving a deficit in an internal 'theory of mind mechanism', is actually the result of disruption to more basic sensorimotor processes. Even where orthodox cognitive science has seemingly produced good explanatory models of psychopathology (such as Frith's (1992) account of cognitive processes in schizophrenia, which Gallagher (2004) explores), the embodied theorist can point to a neglect of the phenomenology of the disorder in question, or its biological basis, or to the temporal aspects which a computational account can't capture. If sensory and motor processes are basic to all other cognition, as much research in embodied cognitive science posits, then disorders which have traditionally been viewed as dysfunctions of higher cognitive processes could in fact be explained by lower-level sensorimotor processes.

If psychiatry were to adopt the central points of embodied cognitive science, what would be the practical repercussions of so doing? A new model of psychopathology would be required, one which conceived of mental disorders as disorders of embodied brains embedded in their natural and social environments. Under the dynamical systems framework favored by embodied cognitive, it is not clear that mental disorders could still be thought of as caused by functional 'lesions': talk of such lesions seems to rely on the sorts of mechanistic explanations which dynamical systems arguably don't provide (Bechtel 1998). Furthermore, brain imaging studies would lose their status as 'pictures of the mind': if the neural aspect is only part of the cognitive system comprising brain, body and world, then neuroimaging is only telling part of the a much larger and more complicated story. The brain functions in question may be necessary for the mental activity, but not sufficient.

There may also be ethical implications of some of the ideas in embodied cognitive science. The very fact that there is now a discipline of 'neuroethics' suggests that interfering with people's brains, pharmacologically or surgically, for example, is perceived to raise issues that aren't posed by therapeutic intervention in people's environments or patterns of behavior. But if the brain is only a part of the wider cognitive system, as some work in embodied cognitive science suggests, it is not clear that this grounding assumptions of neuroethics can be retained. At the least, it

> "alters the focus of neuroethics, away from the question of *whether* we ought to allow interventions into the mind, and toward the question of *which* interventions we ought to allow and under what conditions." (Levy 2007, 3)

For many people working in psychopathology, the main problem with orthodox cognitive science was its disinterest in conscious experience. Phenomenological psychiatry, with its emphasis on lived experience and personal meaning, has traditionally seemed at odds with the scientific model of biological psychiatry; but embodied cognitive science may offer a way to 'naturalize' phenomenology, making it a respectable subject for scientific study (Morley 2002). The embodied approach to cognitive science could provide researchers with a framework which emphasizes both the experiential qualities and the bodily aspects of mental life and its disorders. It is important to remember, however, that there is much work in embodied cognitive science which is not concerned with the structure or quality of conscious experience, and that many of the implications of embodied cognitive science for psychopathology may have little to say on phenomenology. Given the different stances on representation and computation highlighted in the recent work, it seems that a major challenge for embodied cognitive science will be to come up with an explanatory model of the origin and development of psychiatric disorders which can adequately compete with the current orthodox model.[4]

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[1] This view of cognition has been challenged most notably by John Searle (1984), who argues that we are not entitled to see the symbolic structures in computations as representational: “syntax alone is not sufficient for semantics, and digital computers insofar as they are computers have, by definition, a syntax alone” (Searle 1984, 34).

[2] Ramsey (2007) argues that what are termed ‘representations’ in connectionist networks are not representational in the same sense as the symbols of classical computationalism and do not play the same explanatory role.

[3] The different varieties of embodied cognitive science outlined here may be in tension with each other: some seem to suggest that the details of our embodiment play a special and non-eliminable contribution to our mental states, whereas for others the body plays a vital part in cognition in virtue of its particular functional role. See Clark (2008) for further discussion.

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