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Examining the "Species" of Situated Cognition in Humans

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In the target article "Cognition Beyond Representation: Varieties of Situated Cognition in Animals," Ken Cheng describes situated cognition as a "genus" of ideas and effects whereby cognition extends beyond the central nervous system of an organism to include its peripheral nervous system and/or the environment. Although Cheng's article focuses specifically on nonhuman animals, here we apply his definitions of four "species" of situated cognition to find examples in humans. We highlight the ways in which each of distributed (e.g., a crew flying an airplane), embodied (e.g., computation in peripheral sense organs), extended (e.g., extensions of peripersonal space), and enactive (e.g., decision making reflected in movement) cognition are seen in humans. In doing so, we provide evidence for Cheng's major hypothesis that cognition is not confined solely to the central nervous system and that this may be a fundamental principle of cognition across animal organisms.

Keywords: *situated cognition*, *human behavior*, *cognition*

Introduction

In the target article, "Cognition Beyond Representation: Varieties of Situated Cognition in Animals," Ken Cheng defines a "genus" of notions that he claims have appeared in human cognitive neuroscience and philosophy whereby cognition extends beyond the central nervous system of the agent to include the peripheral nervous system and the environment. Cheng highlights four specific "species" of so-called situated cognition: distributed, enactive, embodied, and extended. Although Cheng's clear aim is to discuss evidence for these "species" in nonhuman animals, situated cognition in humans is still a controversial proposal. Thus, to both support Cheng's overall species classifications and provide some context in which to interpret the nonhuman animal work, here we outline examples of situated cognition in humans.

Distributed Cognition

According to Cheng, distributed cognition refers to the reduction of individual cognitive capacities among many to complete tasks that are otherwise too taxing

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to be completed alone. He presents ants cooperating to function seemingly as a single organism (i.e., as a "hive mind") as a canonical example from the animal kingdom. Here, we point to research of aircraft cockpit crews as exhibiting the same core features (Hutchins, 1995; Hutchins & Klausen, 1996). That is, these crews are able to safely take off, fly, and land a plane, even though no one crew member is responsible for "flying the plane." Like ants weaving a nest, information is disseminated among the crew in an organized fashion, where each individual's contribution is seemingly small but decidedly important for task completion. For example, the captain is responsible for tasks such as contacting the airline traffic controller and relaying that information to the first officer, who must perform the translation of information into physical motor actions such as heading modification or thrust adjustments (Hutchins & Klausen, 1996).

Cheng's idea of the "entire hive as a cognizing unit" comes with hypotheses about the purposes served when cognition is distributed. A distributed cognition hypothesis suggests that "hive-minded" animals may reduce metabolic costs and operate with smaller nervous systems. Although perhaps more difficult to imagine humans as "hive minded," especially in ways that could affect brain anatomy, humans do employ this mind-set to overcome our own human-scaled hive challenges. It appears that distributed cognition arises in humans when the cognizing power of a single person seems insufficient for a critical and complex situation, like the aircraft cockpit (Hutchins, 1995), the cardiac surgery theater (Hazlehurst, McMullen, & Gorman, 2007), or the emergency dispatch coordination center (Artman & Wærn, 1999). We view the distribution of cognition in an aircraft cockpit as nothing less than a scaled-up version of the honeybee hive, where neither would find success without the entire flight crew or hive operating as a whole cognizing unit.

Embodied Cognition

In his review, Cheng defines the historically broad term of embodied cognition as computation offloaded to the periphery rather than "central representational cognition" (p. 1). Here, one of Cheng's key examples is the intelligent behavior of an octopus tentacle performing complex bending computations. Of interest, a relevant human example also occurs in our distal effectors. That is, human fingertips have recently been shown to perform their own complex computation, in complete isolation from central nervous control. Here, peripheral neurons within the human fingertips have been shown to signal the edge orientation of touched objects (Pruszynski & Johansson, 2014). Edge detection is a hallmark of complex feature extraction and is the exact kind of computational problem that is efficient for an organism to offload to peripheral mechanisms.

In a similar vein, Cheng's version of embodied cognition has also been shown to occur in peripheral neurons in the visual system. It is well documented that the human retina takes in a vast amount of visual information, but the pathway from the eye to the brain presents a significant bottleneck. This is precisely the case where peripheral computation is ideal, and indeed, cells within the human retina perform computations to both systematically compress the information transmitted to the cortex and extract primitive visual features. For instance, retinal cells have been shown to respond selectively to object motion distinct from background motion in a visual scene (Gollisch & Meister, 2010). These studies show that humans, like the octopus, distribute cognition to peripheral systems, thereby reducing the computational demands on the central nervous system.

Extended Cognition

Cheng defines extended cognition as "cognition encompassing physical objects in the world, often objects constructed by the animal" (p. 2) and presents a spider's construction and use of a web as a prototypical example. Here, the examples in the human literature are more familiar, as tool use is often held up as a hallmark of human ingenuity; one needs only reach into their pocket for a smartphone to confront exactly how much intelligence is now offloaded to external devices. However, our example here is a more foundational way in which humans extend their cognition to include tools. It has been shown that as humans use a particular physical object (e.g., a rake), the neural representation of their body schema is reorganized. For example, in right-brain-damaged patients a condition known as visuotactile extinction can arise, in which patients are unable to report a visual and/or tactile stimulus on their

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left hand (contralesional) when presented with a visual stimulus near their right hand (ipsilesional). Typically, the visual extinction is most severe for stimuli presented close to the body. Farnè, Bonifazi, and Làdavas (2005) showed the malleability of the body schema by giving extinction patients experience using a long rake. After tool exposure, the visual extinction effect was physically drawn out in space—from near the hand to the end of the rake. Interesting to note, this effect was not present when patients simply held the tool, confirming previous findings in monkeys (Iriki, Tanaka, & Iwamura, 1996) that humans can elongate their body schema to include tools, but only when the tool is being used to interact with the surrounding environment.

Enactive Cognition

In his review, Cheng defines enactive cognition broadly as intelligence arising out of action. He presents play behavior in dogs and, trending into human territory, human dance as examples of enactive cognition. Here we provide a brief summary of three other relevant domains of human cognitive science that fit within the context of enactive cognition.

First, a strong body of research has shown that humans are afforded increased sensitivity for cognitive processing because of specific actions or spatial orientations. For instance, the position of one's hand in space alters vision (Abrams, Davoli, Du, Knapp, & Paull, 2008), focuses the distribution of attentional resources toward stimuli close to the hand (Reed, Grubb, & Steele, 2006), and improves detection accuracy in the blind field of a patient with unilateral damage to primary visual cortex (Schendel & Robertson, 2006). In this way, intelligence is arising out of action because performance is causally influenced by the body's position in space.

Second, a growing collection of studies argue the point that "moving is thinking" (e.g., Song & Nakayama, 2009). It is thought that movement reflects a continuously evolving cognitive state that is also influenced by the moving body. For instance, when asked to reach toward one of two targets, the trajectory of the hand in space is thought to reflect the ongoing competition between potential movements that is resolved in time (e.g., Chapman et al., 2010; for a review, see Gallivan & Chapman, 2014). Further, while this movement is taking place, information about the position of one's own body and continual information about the environment is incorporated into the ongoing competition between options (Todorov & Jordan, 2002). In this way, everyday human movements are like Cheng's examples of a dog playing or a dancer; cognition influences movements while movements influence cognition, which give rise to dynamic and continuously evolving thought.

Like dogs, then, this suggests that humans are continuously broadcasting a signal of their thinking via movement. This was recently tested in a study where participants observing someone move implicitly inferred their action intent (Pesquita, Chapman, & Enns, 2016). In this study, participants observing an actor reach for a target were faster to guess the end location of the observed movement when the actor was choosing where to reach as compared to being directed where to reach. These results confirm that signals of cognitive processes like decision making are evident in human movement and suggest that enactive cognition might lie at the heart of social cognition (and social constructs like language), which fundamentally requires the prediction of others' attentional states.

Conclusion

Although not entirely novel, the idea that human cognition extends beyond the central nervous system is still a minority position. However, the target article by Cheng lends significant credence to these ideas by discussing situated cognition across animal species. Here, we support these ideas further by giving specific human examples demonstrating just how ubiquitous situated cognition is.

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