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Cognitive and movement measures reflect the transition to presence-at-hand

Dobromir Dotov [a, *], Lin Nie [b], Kevin Wojcik [c], Anastasia Jinks [d], Xiaoyu Yu [c], Anthony Chemero [d]

[a] Centro de Ciencias de la Complejidad (C3), Universidad Nacional Autónoma de México, Mexico
[b] Center for the Ecological Study of Perception and Action, University of Connecticut, USA
[c] Department of Psychology, Franklin&Marshall College, USA
[d] Center for Cognition, Action and Perception, University of Cincinnati, USA

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ABSTRACT

The phenomenological philosopher Martin Heidegger's proposed transition from readiness-to-hand to presence-at-hand and the hypothesis of extended cognition were addressed empirically in an experiment on tool use. It involved a video game of steering erratically moving objects to a target while performing a secondary cognitive task. A strong perturbation of the hand-pointer linkage in the video game induced the transition from ready-to-hand to present-at-hand. In Experiment 1, this perturbation resulted in decreased motor performance and improved recall of task-irrelevant features. Experiment 2 replicated these results and addressed additional questions. Measures of movement variability based on the multifractal formalism confirmed the hypothesized decrease in functional integration of the tool during the perturbation. Dynamical interactions allow user and tool to act as a system. The tool is properly described as ready-to-hand during normal operation but as present-at-hand during perturbation. Physiological measures showed that the ready-to-hand to present-at-hand transition does not necessarily lead to a stress response.

1. Cognitive and movement measures reflect the transition to presence-at-hand

Heidegger's phenomenological philosophy has had a surprisingly significant influence on the cognitive sciences. This influence began when the critiques of AI by Hubert Dreyfus in the 1960s and 1970s (Dreyfus, 1972) were transformed into several positive research programs such as Heidegerrian AI (Agre & Chapman, 1987), enactive cognitive science (Varela, Thompson, & Rosch, 1991), and dynamical systems cognitive science (van Gelder, 1995) that have continued into the 21st century (Stewart, Gapenne, & DiPaolo, 2011; Thompson, 2007; Wheeler, 2005; Wilson, 2004). Heidegger has also been an inspiration to those who argue in favor of the thesis of extended cognition, the claim that cognitive systems sometimes encompass portions of the nonbodily environment (Chemero, 2009; Clark, 1997; McClamrock, 1995; Wilson, 1995, 2004). Yet despite the profound influence of Heidegger's philosophical ideas on cognitive science, there had been no attempt to verify his ideas empirically until recently (Dotov, Nie, & Chemero, 2010). That is, Heidegger's ideas have been very influential on research in the cognitive sciences, but no one had bothered to evaluate their worth empirically.

1.1. The phenomenology of tool use

The portions of Heidegger's views that have been most relevant to cognitive science are empirically testable. In Chapter III of Division 1 of *Being and Time*, Heidegger (1962) distinguishes three modes of experiencing the world. Most human activity, Heidegger argued, is absorbed, skillful engagement with entities in the world. When we are coping skillfully with the world, we experience entities around us as *ready-to-hand*. To use Heidegger's example, a hammer is encountered ready-to-hand, as a piece of equipment, when it is being simply used to drive in nails. Our engagement with entities ready-to-hand does not involve explicit awareness of their properties; instead, we "see through" them to the task we are

* Corresponding author. Circuito Mario de la Cueva 20, Insurgentes Cuicuilco, Ciudad de México, D.F., Mexico.
E-mail address: dobri.dotov@gmail.com (D. Dotov).

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engaged in. When we are smoothly driving in nails with a hammer, we are aware of the thing we are building, but not the size, shape or color of the hammer.

Heidegger argues that skilled coping, the way we engage with entities as ready-to-hand, is the primary way of engaging with the world. Sometimes, though, our skillful coping is severely disturbed. When this happens, we encounter entities as *present-at-hand*. The hammer is encountered as present-at-hand when we can no longer use it, when we must stop hammering and consider the hammer's shape or color or weight. When considered this way the hammer is no longer experienced as a useful tool, but merely an object with various properties that may or may not be relevant to the task. Indeed, when hammering is no longer possible, not just the hammer, but also the whole situation we are in—from the nails, the wood, and the whole network of entities that the hammer is connected to—are revealed to us and experienced as objects separated from the context of their functions.

Within cognitive science, this phenomenology has been one of the inspirations for the hypothesis of extended cognition, i.e., the claim that cognitive systems sometimes extend beyond the biological body (Chemero, 2009; Clark, 1997; McClamrock, 1995; Wilson, 1995). A thinker, Heidegger argues, is a being-in-the-world. Hammers and other tools that are ready-to-hand are literally part of the cognitive system, the being-in-the-world, in which the tool plays a role in completing a task. When you are smoothly coping with a hammer that is ready-to-hand, the ready-to-hand hammer recedes in your experience, and your focus is on the task you are completing. Your experience of the hammer is no different than the experience of the hand with which you are wielding it.[1] When a tool malfunctions, however, it hinders the task at hand and becomes an object of concern. Hence, rather than being part of an extended cognitive system, it is now an object that requires attention from the cognitive system. When the tool breaks entirely, it becomes present-at-hand, an object we experience as not serving a function. The hypothesis of extended cognition is controversial, but all parties to the debate, whether pro (Clark, 2008; Menary, 2007; Sutton, 2010) or con (Adams & Aizawa, 2008; Rupert, 2009), agree that whether cognitive systems extend beyond the biological body is an empirical matter (Wagman & Chemero, 2014).

Heidegger's phenomenology also suggests a non-representational account of dealing with the world (Dreyfus, 2002), an account that might seem to contradict most of cognitive science. Not all human activity, however, consists of skillfully dealing with the world. The approach allows for a form of cognition consistent with traditional cognitive science to occur (van Gelder, 1997, pp. 439–448). This is often overlooked by both proponents and opponents of the approach. Instead of posing cognitivist against embodied theories, here we provide empirical support for an interpretation according to which these correspond to separate modes of dealing with the environment. The importance of this hinges not only on the promotion of explanatory pluralism but also on delineating theoretically and empirically the actual fit between the approaches.

According to Heidegger's taxonomy, encountering the world can occur either in cognitive or non-cognitive modes (Dreyfus, 2007). On the one hand, Heidegger argued that most of our engagement with the world is situated, skillful, absorbed coping that does not involve representing the environment. It has been shown repeatedly that the theoretical tools of cognitivism fail to apply to the part of phenomenology dealing with absorbed coping (Dreyfus, 2002, 2007; Dreyfus & Kelly, 2007; Kelly, 2000, 2002). Not surprisingly, cognitivism has little to say about skillful action. In particular, the motor control aspects of skillful action are better accounted for using dynamical systems theory (Kelso, 1995; Thelen & Smith, 1994). On the other hand, when dealing with a workspace and faced with problematic or new situations we need to study the workspace, think about what has gone wrong, what to do next, and learn a new skill (Dreyfus, 2002). This seems to demand a representational, cognitivist approach. This form of skill learning can be accounted for using traditional approaches in cognitive psychology (e.g., Anderson, 1982). To summarize the stance,

> "… the Heideggerian claim is that action-oriented coping, as long as it is involved […] is not representational at all and does not involve any problem solving, and that all representational problem solving takes place offline and presupposes involved background coping. Showing in detail how the representational un-ready-to-hand in all its forms depends upon a background of holistic, nonrepresentational coping is exactly the Heideggerian project and would, indeed, be the most important contribution that Heideggerian AI could make to Cognitive Science." [Dreyfus, 2007, p. 1150]

How do the modes of encountering the world and the transition between them relate to measurable aspects of cognition and behavior? Our goal is to answer this question by applying the empirical methods of cognitive science and human movement science in the context of an experimental task that instantiates the transition from an absorbed coping mode dominated by skillful action to a cognitive mode dealing with a situation that resists skillful action. By providing evidence for Heidegger's modes of experiencing tools, particularly skillful coping with ready-to-hand tools, we can also provide evidence in favor of the hypothesis of extended cognition.

1.2. Empirical approach

The primary objective of the present study was to investigate behavioral aspects of the transition from ready-to-hand to present-at-hand. Participants played a computer game that allowed them to engage with it in absorbed coping mode. The game also allowed the breakdown of the tool to be induced experimentally. Its *task space*[2] (Saltzman & Kelso, 1987) was constructed in analogy with pole balancing. It constituted an unstable and fluctuating dynamical system that could be stabilized if the participant applied the appropriate mapping from patterns of movement on the screen to patterns of movement of the mouse (for details, Appendix A). A perturbation was incorporated by manipulating the linkage from mouse movements to patterns of movement on the screen, i.e. the tool could be perturbed temporarily while the participant was engaged in the task.

Previously, Dotov et al. (2010) used motion tracking to record

[1] Reports of neural correlates of such effects exist as well. In a study where macaque monkeys were trained to use a rake, bimodal neurons sensitive to objects within reach by hand expanded their visual receptive fields to match the enlarged space accessible by hand and rake (Iriki, Tanaka, & Iwamura, 1996).

[2] The notion of task space resembles the notion of subspace in linear algebra. It refers to the *minimal set* of internal and external forces and informational variables that make possible the satisfactory performance of a given task of moving in a real environment (Mottet, Guiard, Ferrand, & Bootsma, 2001; Park, Collins, & Turvey, 2001; Wilson & Golonka, 2013). The minimal description of the task space points to the minimal motor control required from the participant. It is useful to think of task space as a system of constraints instead of dividing it in external (physics) and internal (information processing) parts (Oyama, 1993; Oyama, Griffiths, & Gray, 2001). It is also useful to distinguish it from the notion of workspace which is a larger set and in the context of the current study would comprise things such as the type of computer screen used in the experiment.