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Testability of the Claim That Cognitive Science Can Be Effectively Applied to Embodied Non-Neural Systems

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Introduction

Many researchers and thinkers have been drawn to the mind-body problem, at times drifting from their primary area of work. Non-experts may struggle to distinguish established expertise from fringe tendencies. This essay explores a distillation of a claim related to this topic: that cognitive science can be effectively applied to embodied non-neural systems. I will argue that it is possible to test this claim in relation to *some* embodied non-neural systems, but not to confirm or falsify it in relation to all such systems.

Contemporary Background

In the 1960s, philosopher Hilary Putman argued that pain is a functional state of the organism, not a brain state [Putnam, 1967]. Later, Jerry Fodor expressed doubt that psychological kinds are coextensive with neurological kinds [Fodor, 1976, p. 17]. Today, the topic appears in popular discourse through researchers like Michael Levin, who discusses scale-free intelligence and proposes understanding systems through their computational surface [Levin, 2019, p. 1]. Levin emphasizes testing such claims [Levin, 2022].

The Scope of Cognitive Science in Relation to the Claim

Cognitive science studies the mind and self. Core domains include perception, attention, memory, learning, and executive control. These processes contribute to adaptive behavior, such as the pursuit of system-specific goals. Here, a cognitive-style model may be 'effective' when it improves or simplifies our ability to predict, generalize, or control a system compared to bottom-up physical descriptions. An 'embodied' system is one housed in non-computational physical substrate. A 'non-neural' system lacks biological or technological (including simulated) nerves or neurons. The claim does not assert that a non-neural system possesses cognition, only that cognitive techniques can be applied effectively.

Testing the Claim: A Framework

The claim can be addressed in a strong (all systems) or weak (some systems) form. The strong form is falsifiable by presenting an embodied non-neural system to which cognitive techniques are not effectively applicable. The weak form is testable case by case, but not practically falsifiable.

A meaningful test can ask whether modeling the system as if it had innate goals and constraints improves prediction or control. Here, a 'goal' is an attractor in state space. A 'constraint' is a limitation to the perception and state transitions of a system. Each test adopts the following structure:

1. **Cognitive definition:** Create a hypothesis regarding the system's goals and constraints.
2. **Obstacle design:** Design and execute an obstacle to the goal within the system's constraints.
3. **Evaluation:** Determine whether the observations provide new information, enable new interaction/functionality, or simplify bottom-up physical explanations of the system.

We can now consider this framework for different example systems.

Small-Scale Biological System: Single White Blood Cell

The cell's tested goal could be reaching and remaining near an inflammatory signal from surrounding tissue. Constraints may be limitations to chemical sensing in local space. Place a leukocyte in a series of environments containing various inflamed tissues (perhaps testing maze-like conditions, already done with other non-neural systems [Yamada et al., 2000]), using non-maze chemotaxis environment as control. Measure navigation, duration/pauses, morphological changes, and efficiency variations across runs. If this helps us predict cell behavior better than a bottom-up biochemical or mechanistic model [Renkawitz et al., 2019], cognitive science has been effectively applied.

Simple Non-Biological System: Metals

A partial example comes from Bose's metal experiments [Bose, 1902]. Step 1 of the testing framework (cognitive definition) was not methodically applied. Obstacle design included mechanical stimuli, conflicting inputs, chemical interventions, history-dependent manipulation [Bose, 1902, pp. 273–294]. In evaluation, Bose identifies electric excitability as a unifying variable governing the material's behavior and demonstrates methods for predicting the material's response [Bose, 1902, pp. 293–294]. He likens the phenomena to those found in living tissues [Bose, 1902, p. 290].

Potentially Untestable System: Earth's Tectonic Plates

Earth's tectonic plates may not be meaningfully testable in this framework. We can define the system's goal as sinking into the Earth's lower mantle. But simulating or observing the subject is unlikely to offer insights into why a plate sinks, stagnates, or deforms on collision with another. Any findings would be too low-fidelity compared to plate composition and inherited structure obtained through seismic imaging[Yang et al., 2025].

Challenges and Belief Effects

Our tendency to anthropomorphize can impact testing of this claim. As with pareidolia, we readily attribute human properties to non-human things. This interpretive flexibility risks overstating if a cognitive model is superior to a mechanistic one. As a counterpoint, Levin informally suggests that anthropomorphism does not exist [Levin, 2024].

The term 'cognitive' risks confusion. We must not conflate applying cognitive *techniques* with asserting whether a system has a mind, or consciousness. Otherwise, we drift into broader claims about collective mind, universal consciousness, etc, which have been in our milieu since 5th century BCE [Curd, 2007] until today [Strømme, 2025]. Practical claims should be sequestered from broader thought experiments.

Conclusion

This essay explored the testability of effectively applying cognitive science to embodied non-neural systems, and the claim's relation to the greater mind-body debate. The strong form of the claim is in principle falsifiable, in practice the application of cognitive science to embodied non-neural systems is only testable on a case-by-case basis. A framework for testing the claim in its weaker (some systems) form is proposed.

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