The Dynamical Hypothesis: One Battle Behind

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Robert M. French
Psychology Department
University of Liège, Liège, Belgium
rfrench@ulg.ac.be

Elizabeth Thomas
Institut Léon Frédéricq
University of Liège, Liège, Belgium
ethomas@ulg.ac.be

Abstract

What new implications does the dynamical hypothesis have for cognitive science? The short answer is: None. The *Behavior and Brain Sciences* target article, "The dynamical hypothesis in cognitive science" by Tim Van Gelder is basically an attack on traditional symbolic AI and differs very little from prior connectionist criticisms of it. For the past ten years, the connectionist community has been well aware of the necessity of using (and understanding) dynamically evolving, recurrent network models of cognition.

Our views on the current target article by Tim van Gelder are nicely summed up by paraphrasing the opening lines of a recent article by him (1998) about connectionism and the philosophy of mind: What new implications does the dynamical hypothesis have for cognitive science? The short answer is: None. In what follows, we will sketch out the longer version of this answer.

Van Gelder's article is a clarion call for the rejection of the old and deeply flawed Computational Hypothesis and the establishment of a new basis for modeling cognition — the Dynamical Hypothesis. But the battle that van Gelder is waging was waged (and largely won) a decade ago. Connectionism *really did* usher in a new era, a radically different alternative to the prevailing paradigm based on the Physical Symbol System Hypothesis. One can quibble about some of the contributions of the connectionist revolution, but the fact remains that the advent of connectionism demanded a qualitatively different way of modeling cognition. Reading van Gelder's article, one has the impression that he believes that the Dynamical Hypothesis is another such sweeping, radically different way of viewing cognitive modeling. Unfortunately, it is not.

To show this, we suggest a very simple experiment. Download a copy of this target article into your favorite word processor. Then replace every occurrence of "the dynamical hypothesis" with "connectionism", of the words "dynamical" and "dynamicist" with "connectionist", of DST with "connectionist theory," etc. Then print out a copy of the modified paper. You will have a paper that, basically, could have been written around 1990, once the necessity of recurrent networks for modeling cognition was clearly established within the connectionist community.

The point is that van Gelder's article reads almost exactly like earlier connectionist attacks on the old symbolic AI paradigm — what he has re-baptized the Computational Hypothesis — and adds very little of significance to those criticisms. The author himself points out that connectionism "models cognition as the behavior of dynamical systems," (§1, para. 3) referring to a major article by one of the leading members of the connectionist research community (Smolensky, 1988). Elman (1990) published an important article entitled, "Finding Structure in Time" that emphasized the recurrent (dynamical) aspects of connectionist modeling. In short, by the late 1980's, the importance of dynamics in connectionist modeling was well understood. That researchers in symbolic AI are not particularly concerned with dynamical modeling is beside the point. We suggest that van

Gelder would have had a far more difficult time convincing people of the novelty of his ideas had he contrasted them with the decade-old principles underlying research on recurrent connectionist networks.

Van Gelder continually emphasizes the need to apply the tools of modern dynamical systems theory to models of cognition. This is certainly sound advice. According to the author, the use of the DH framework provides a viable empirical alternative to the Computational Hypothesis. As he correctly points out, investigators in the area of cognitive science currently only use the tip of the dynamical systems theory iceberg. What he doesn't say is that this may have to remain the case for a very long time. Indeed, it may never be possible to make use of much of dynamical systems theory in studying cognitive (or even biological) processes. These theories were originally developed as mathematical models and applied to highly controllable physical systems, e.g., electrical circuits. Biological systems, on the other hand, contain large amount of noise and, more seriously, have a high degree of nonstationarity. Nonstationarity refers to the lack of constancy in the laws governing the evolution of the system. Many of the measures which are used to characterize dynamical systems and on which much of dynamical systems theory is based, require very large amounts of data (Rapp, 1993). Cognitive systems, however, tend to move rapidly from one state to another, making it frequently impossible to collect the quantity of data required to appropriately apply dynamical systems theory. But, even allowing for these problems, the target article goes far beyond merely advocating new tools to analyze recurrent systems; it is a call for the establishment of an entirely new modeling paradigm in cognitive science.

The one area in which our word-replacement experiment fails is in the discussion of anti-representationalism. The debate concerning the ultimate necessity of representations is an important one. But it is hard to understand what the author means when he says, "Within the dynamical approach, such systems [devoid of representations] can be not only imagined, but they can be modeled and constructed." (§4.2.3.9) But these dynamical systems rely on the emergence of attractors, and what are attractors other than internal representations with a new name? Is the author attempting to make some principled distinction between patterns of activation that persist in time (internal representations à la D.O. Hebb) and attractors? Anti-representationalists bear the responsibility of clarifying this distinction, if indeed it can be done.

Particularly puzzling to us is what van Gelder calls "False Objection 3 — Dynamical systems are computable." Does van Gelder's reply to this objection translate into the following claim: Even though a digital computer could, at least theoretically, simulate to an arbitrary degree of precision any analog function necessary for cognition, nonetheless, no digital computing device could ever be a cognitive agent? Even though functions which are "effectively computable" might *theoretically* require something more powerful than a computer (read: Turing machine, in this case) to compute them, the burden of proof lies with van Gelder to tell us i) what those functions might be and ii) why they are important to cognition. He has done neither.

References

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