

## Dynamical description versus dynamical modeling

Reply to Chemero

In a recent commentary<sup>1</sup>, Chemero raises the following two objections to our proposal<sup>2</sup> for extending the classical model of mental representation but keeping its core insights:

(1) The denial that all dynamical models have internal mediating states, contrary to our assertion that they do;

(2) The claim that many dynamical-systems researchers disagree with our statement that representations are required for complex cognition.

Chemero bases his objections primarily on the Haken–Kelso–Bunz (HKB) model of the coordination of finger movements<sup>3,4</sup>. He cites the mathematical equation:

$$V = -a \cos \varphi - b \cos 2 \varphi$$

as a clear case of a dynamical model that is free of any representation. As he correctly points out, this equation refers only to the relative phase of the fingers ( $\varphi$ ) and the relative speed of the fingers ( $b/a$ ). Neither of these quantities is an internal information-carrying state of an organism. Thus, this equation does not posit or use representations.

The main disagreement we have with Chemero about the HKB model is that it is not an explanation of the coordinated behavior, but rather a *description* of the behavior, at Marr's computational level<sup>5</sup>, that specifies the relationship between the current state of the moving fingers and subsequent states. An explanation of this behavior would have to make some reference to internal states of the organism. These internal states, even if they are best described in terms of dynamical systems, still have all of the essential characteristics of representations.

Coordination between moving fingers is something for which it is possible to create a description without mentioning any internal states. However, as the failure of behaviorism as an explanatory paradigm makes clear, more complex behaviors require some internal states

(see, for example, Ref. 6). In fact, many dynamicists are quite clear about the necessity of representation at many different levels in explaining cognition<sup>7</sup>. The two fundamental characteristics that distinguish dynamical representations from classical ones are that the representations emerge from the underlying dynamics and, therefore, at least some of the representations are continuous. We will not debate these two issues here, for even emergent, continuous mediating states satisfy the minimal definition of representation that we proposed in our original paper and elsewhere<sup>2,8</sup>. Every genuine dynamical model we know of posits internal mediating states of some sort.

As to Chemero's second point, we know that many dynamicists are anti-representationists. That is why we wrote our paper and why we have undertaken to defend representations at some length<sup>2,8–10</sup>. We have argued extensively that advocates of dynamic systems are wrong to eschew representations. Our argument has two main prongs. First, as mentioned above, no genuine dynamical model of any aspect of cognition gets by without positing some sort of internal mediating state. True, not all such states need to be enduring, or symbolic, or propositional or amodal, which are the hallmarks of classical representations, but all mediating states satisfy a reasonable and useful notion of representation<sup>8,9,11,12</sup>. That not all mediating states need be classical representations is precisely why we proposed extending the classical view of representation in the first place.

Second, quite independently of actual practice, it is simply not possible to explain higher-level cognition without positing representations of some sort. Cognitive agents engage in many behaviors that are a lot more complicated than simply moving their fingers (they move their fingers in order to type research papers, for example). Successfully explaining such behavior requires positing internal states of some kind. These states are crucial to the production of complex behaviors *because* they contain the information that they do in the form that they do.

Furthermore, these states satisfy a minimal definition of representation that stops well short of the classical view<sup>2,8,9,11,12</sup>. Hence, even dynamical-system explanations posit mental representations. As we have said in other papers, the real work of cognitive science is in figuring out the characteristics of these mental representations, not in figuring out whether representations exist. That said, dynamical *descriptions* of some sensorimotor behaviors need not posit mental representations, but this is no threat to the idea of representations in the explanation of cognition.

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### References

- 1 Chemero, A. (2001) Dynamical explanation and mental representations. *Trends Cognit. Sci.* 5, 141–142
- 2 Markman, A.B. and Dietrich, E. (2000) Extending the classical view of representation. *Trends Cognit. Sci.* 4, 470–475
- 3 Kelso, J.A.S. (1995) *Dynamic Patterns: The Self-Organization of Brain and Behavior*, MIT Press
- 4 Haken, H. et al. (1985) A theoretical model of phase transitions in human hand movements. *Biol. Cybern.* 51, 347–358
- 5 Marr, D. (1982) *Vision*, W.H. Freeman & Co.
- 6 Busemeyer, J.R. and Townsend, J.T. (1993) Decision field theory: a dynamic-cognitive approach to decision making in an uncertain environment. *Psychol. Rev.* 100, 432–459
- 7 Bickhard, M. (1998) Levels of representationality. *J. Exp. Theor. Artif. Intell.* 10, 179–215
- 8 Markman, A.B. and Dietrich, E. (2000) In defense of representation. *Cognit. Psychol.* 40, 138–171
- 9 Dietrich, E. and Markman, A.B., eds (2000) *Cognitive Dynamics: Conceptual and Representational Change in Humans and Machines*, Erlbaum
- 10 Dietrich, E. and Markman, A.B. (1998) All information processing entails computation, or 'if R. A. Fisher had been a cognitive scientist'. (Commentary on *The Dynamical Hypothesis in Cognitive Science* by T. van Gelder). *Behav. Brain Sci.* 21, 637–638
- 11 Anderson, J.R. (1978) Arguments concerning mental representations from mental imagery. *Psychol. Rev.* 85, 249–277
- 12 Uttal, W.R. (1971) The psychobiological silly season – or what happens when neurophysiological data become psychological theories. *J. Psychol. Gen.* 84, 151–166