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Book Review

The continuity of mind, by Michael Spivey. Oxford: Oxford University Press, 2007. 427pp. ISBN 13: 978-0-19-517078-8.

Kudos to Spivey—the self-proclaimed "zombie scientist" -- for helping stimulate the paradigmatic change needed in cognitive science. Spivey forcefully argues: for the field to progress, cognitive researchers need to acknowledge the wide-range of evidence for the continuous nature of mind, and embrace a hybrid approach consisting of Nonlinear Dynamical Systems (NDS), neural network (NN), ecological, and "embodied" perspectives.

Within each, numerous models may be used to describe changing behaviors and cognitive states. Spivey narrows the possibilities by first, providing an overview of tools for tracking mental trajectories, and breaks these down (in Chapters 2, 3 and 4) into: conceptual, experimental, and simulation categories. Spivey then spends much of the book focusing on: (a) the NDS state space (i.e., attractor space) description of mental trajectories while carefully stepping readers through various ways to visualize these trajectories, and (b) a simple recurrence net (SRN) model, and how it captures key properties of behavior.

Major themes of the book also include strong arguments against cognitive modularity (Chapter 5), and the need for cognitive research focused on temporal dynamics such as the many cited examples including work in: categorization, language comprehension, visual perception, action, and reasoning (Chapter 6). Later chapters include a unifying account of different aspects of cognition, and a final swipe at modularity theories of cognition. In the last chapter, Spivey entertains philosophical implications for consciousness, and his self-identification with "zombie" agents.

Spivey"s focus on one version of recurrence analysis (SRN) has both strengths and weaknesses. The strength is in its simplicity and thus accessibility to wide audience. Two weakness: First, its short shrift given to the many other very useful NDS tools that can be used to uncover the dynamical structure of cognition. A future revision of this book might include a description of more NDS tools, or at least provide an informed rationale for why one would choose one approach over another. Pertinent here are considerations of dimensionality, and why some NDS researchers focus on low dimensional, prominent features of behavior (without attempting a link to biology) versus those choosing to study high dimensional behavior through systematic study of subtle patterns of behavioral variability (with the implicit acknowledgement of biological

complexity underlying emergence of cognition). Many NN models, for example, are better suited to high dimensional analysis by capturing complex interactions and emergent dynamics resembling those of the brain system. Spivey briefly notes importance of NN models, along with possible generating rules such as predator-prey search examples (p. 321). Further discussion of resulting scaling and power law behaviors would be very helpful along with the role they play in cognitive and other behaviors.

A second weakness of SRN is in its key characteristic as a normalized "local" network, having features subject to similar criticism to which Spivey launches against mainstream cognitive science. SRN's use of local averaging across vectors ignores a key attribute of the human brain: its distributed structure. Similarly, modification of synaptic weights "by hand" is a far cry from (Spivey"s claim for) self-organization. Whether studying key dimensions of overt behavior or the underlying complex system, common goal is to learn whether essential dynamical structure emerges spontaneously from iteration of these simple rules in a network of activated nodes.

Spivey might also consider: (a) The relation between SRN and other low dimension descriptions of behavior such as simple differential equation (e.g., logistic equation as in Ward and West (1998), or harmonic oscillator as in Warren (2006). And (b) instead of collapsing to minimal-value functions in SRN approach, the same resulting behavior, along with its pattern of variations, can be described in terms of even simpler equations iterated over time to capture interactive dynamics of brain's neural populations (e.g., cellular automata or self-organized criticality). The latter approach deliberately takes on the link between brain and behavior, and the fact that it is a complex system.

Spivey defers to other sources on some of these issues (i.e., Ward, 2002), and to his credit, covers a vast array of research from the Cognitive literature to show support for continuous nature of mind and how it is "situated" (i.e., mediated) by both body and environment. Making the additional link to NDS is what makes Spivey's work unique, and arguably its greatest strength aside from the excellent review of cognitive behaviors best described as embodied and continuous.

My greatest reservation of the book is that its emphasis on continuity of mind is overstated. The book's objective may have been better served by placing NDS or embodied cognition at the forefront. One apparent contradiction with the continuity thesis may be found in Spivey's occasional reference to process of achieving stable mental states. These can easily be regarded as discrete states of perception and cognition. Thus, when describing mind as a trajectory— both continuous *and* discrete properties exist and can be accounted for in NDS framework. In fact, building a case for NDS theory of mind would be expected to include stable and unstable states as well as description of transitions brought on by changes in control parameters. Shelhamer (2006) is a pertinent source, (an unfortunate omission from Spivey"s book) illustrating excellent examples of transitional states in eye-movement and other behaviors. To his credit, Spivey

acknowledges he may have overemphasized "continuous" nature of mind (p. 322), but does so as "to help pry loose [entrenched] assumptions of stable representation."

In addition to NDS theory of mind not requiring that mind be continuous, it does not eliminate the need for functional-symbolic based understanding of how the mind works. In contrast to conventional stage-based theories of cognition and presumed linear (feed forward) sequence**,** research now convincingly shows that graded transitions, feedback, and recurrence are essential to high level cognition. Spivey describes this in a section on recurrence and "warping" probabilities where members of population code pass activity back and forth changing percent of activity until one set exceeds a threshold and a decision (response) is made.

Similarly, symbol-based theories of cognition rely on improved understanding of such transitional states**.** Spivey, however, trivializes this point with his insistence on the continuity of mental states, and how discretization of these states is either an illusory or artificial imposition. This focus on continuity (mis)leads him to note that symbolic dynamics (SD) "may sound like an oxymoron" (p. 112), but then counters this by (correctly) pointing out legitimate SD approaches which implement symbols by neuronal assemblies. (Chapter 10 presents SD models from cognitive science such as Anderson's ACT-R theory, and Complex Systems such as Crutchfield's deterministic model). Spivey insists though that mental representations are not likely to resemble (or be converted) to rule-based logic. However, this is exactly what might emerge from transitions across different attractor states. Since symbols can be assigned and emitted by different transitional states in a dynamical system this is likely a lucrative path to our understanding of symbolic-rule characteristic of cognition.

Noteworthy are the entertaining linguistic gems sprinkled throughout the book, These are quite revealing of Spivey's expertise in cognitive linguistics and his effort to "lay siege to the ivory tower of consciousness" and assert that "everywhere that free will goes, it scorches the theoretical terrain." One is left wondering whether the "functionalist view of mind teeters on edge of Cartesian dualism," and is this in fact **"**Veja Du-alism all over again?" Many of these perceptual-cognitive "lines in the sand" might be dissolved by seeing that mental trajectories sometimes just "flirt with attractors…," but do not reach conscious reportability. At other times, "attractors warp into repellors" permitting trajectory to continue on to new concepts."

Overall, in his grand challenge to the "pandemic of homunculitis ideas," Spivey clearly and boldly expresses his ideas in a manner cognitive psychologists can understand without getting bogged down in mathematics. No doubt, impediments of inaccessibility arise from "modular" and "encapsulated" nature of different disciplines, with their unique jargon and tools. Spivey's informal and "grounded" literary style—imbued with lots of clever metaphors makes for an enjoyable read even if you disagree with the premise of his ideas. Many are thought provoking and among these I am left pondering: Must one

really be a modularist to believe in free will? Or is the true state of our mental-being closest to that of a zombie?

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