

Accepted Manuscript

Title: The problem of multimodal concurrent serial order in behavior

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PII: S0149-7634(15)00194-3
DOI: <http://dx.doi.org/doi:10.1016/j.neubiorev.2015.07.009>
Reference: NBR 2234

To appear in:

Received date: 3-1-2015
Revised date: 13-7-2015
Accepted date: 16-7-2015

Please cite this article as: Oren Kolodny, Shimon Edelman, The problem of multimodal concurrent serial order in behavior, *Neuroscience and Biobehavioral Reviews* (2015), <http://dx.doi.org/10.1016/j.neubiorev.2015.07.009>

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The problem of ^{multimodal} concurrent serial order in behavior*

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July 12, 2015

Abstract

The “problem of serial order in behavior,” as formulated and discussed by Lashley (1951), is arguably more pervasive and more profound both than originally stated and than currently appreciated. We spell out two complementary aspects of what we term the generalized problem of behavior: (i) multimodality, stemming from the disparate nature of the sensorimotor variables and processes that underlie behavior, and (ii) concurrency, which reflects the parallel unfolding in time of these processes and of their asynchronous interactions. We illustrate these on a number of examples, with a special focus on language, briefly survey the computational approaches to multimodal concurrency, offer some hypotheses regarding the manner in which brains address it, and discuss some of the broader implications of these as yet unresolved issues for cognitive science.

1 Background and motivation

What does it take for an animal species to survive and flourish in the world? Intuitively, embodied and situated behaving agents that are capable of sensing and acting — a broad category, which includes all animals from yeast to cephalopods, insects, and vertebrates, and even some plant species — must balance the dynamic flow of events arising from their own endogenous motivational and cognitive processes, cues derived from sensory data, and decisions that shape and control the agent’s ongoing covert comportment and overt behavior.

In psychology and in neuroscience, behavior is too often implicitly assumed to be reducible to a succession of stimulus/response bouts, a notion that has a counterpart in machine learning and artificial intelligence, where the preoccupation is with the input-output mappings arising from specific problems, as in “object recognition” or “question answering.” In a recent review, Edelman (2015b) documented the pervasiveness of the stimulus/response doctrine, noting that its resilience is particularly surprising, given that it had been considered problematic already over a century ago, when John Dewey first offered a critique of “the reflex arc concept in psychology”: “What we have is a circuit, not an arc or broken segment of a circle. [...] The motor response determines the stimulus, just as truly as sensory stimulus determines movement. [...] There is simply a continuously ordered sequence of acts [...]” (Dewey, 1896, p.365).

*The title is modified from Lashley (1951).

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