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Neuroconstructivism: A new manifesto for child development research

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Abstract: This book is an excellent manifesto for future work in child development. It presents a multidisciplinary approach that clearly demonstrates the value of integrating modeling, neuroscience, and behavior to explore the mechanisms underlying development and to show how internal context-dependent representations arise and are modified during development. Its only major flaw is to have given short shrift to the study of the role of genetics on development.

Books like *Neuroconstructivism* (Mareschal et al. 2007a; 2007b) come along far too infrequently. This two-volume set is nothing short of a manifesto for how the study of child development in the twenty-first century should proceed.

The three most important chapters of Volume 1 are Chapters 1 (Introduction), 5 (Principles, mechanisms and processes) and 13 (Conclusions and challenges for the future). Taken together, these chapters alone can be viewed as a manifesto for how research in child development should proceed in the future. This book covers a wide range of interdisciplinary topics, with a particular emphasis on modeling, especially modeling of the connectionist kind.

The connectionist revolution came to psychology in the mid 1980s. The ideal starting point for connectionist models at that time was generally considered to be an undifferentiated (artificial) neural network substrate with few, if any, constraints that corresponded even remotely to what might be going on in an actual brain. But we must not forget that connectionism 20 years ago was still dueling with symbolic AI and that many of the early models, while necessary as proofs of the power of connectionism, were uninteresting from the standpoint of actually contributing to an understanding of the mechanisms underlying cognition. Now that those early battles are a thing of the past, connectionist models have gradually adopted a far more sensible middle ground in which modularity, and even rules, are acceptable, as long as they can be linked in some reasonably broad fashion to neural substrate This book incorporates constraints from real brain functions into the connectionist models it describes, successfully integrating, insofar as possible, low-level neural constraints, brain-level constraints, and behavioral constraints.

To begin with, Mareschal et al.'s manifesto puts internal representations back at center stage in an attempt to understand not only how they drive cognition throughout the course of development, but how they emerge and are modified by both the “external” environment (i.e., embodiment) and the “internal” environment consisting of other

regions of the brain (what they call "embrainment").

Representations have been somewhat out of fashion since the antirepresentational stances of Brooks (1990), Port & van Gelder (1995) and, especially important in the context of development, Smith & Thelen (1993) became popular.. The authors of *Neuroconstructivism* seamlessly fold these more radical perspectives into their own via the notion *partial representations* and *proactivity*. To me, the authors' partial representations look for all the world like a retread of Hebb's notion of a cell assembly (Hebb 1949). (In perhaps the most surprising oversight of the entire book, the authors do not even cite Hebb's work, which is so intimately connected with their own in many ways.) They go on to summarize neuroconstructivist development (Ch. 5) as being "about how context-dependence is progressively expressed through partial representations" (p. 93). For someone who has spent more than 20 years preaching the gospel of flexible, context-dependent representations (specifically, in the area of analogy-making) that are gradually built-up by means of a continual interaction between high- and low-level constraints, these words were music to my ears. The authors propose three underlying domain-general and level-independent mechanisms that implement context-dependent representation-building – namely, cooperation, competition, and chronotopy (the "idea that there is a temporal order in the emergence of functional units" (p. 12). These cores ideas of neuroconstructivism are right on target.

The authors correctly reject Marr's (1982) tripartite division of cognitive levels of description. The independence of these levels was one of the cornerstone principles of traditional AI. The authors' unambiguous rejection of these ideas in favor of a view in which interaction between levels and with the environment is paramount for the emergence of the partial representations. They appeal, however, to parsimony as one of their reasons for rejecting Marr's views. This is a mystery to me. Parsimony may be fine as a guiding heuristic for physics, but it's a lousy one for cognition, simply because cognition came to us via the twists and turns and inability ever to back up that characterize evolution. And this is anything but parsimonious.

This then leads to perhaps the most serious criticism of this book: namely, that is has given short shrift to the role of evolution in general, and genetics in particular, in development. As a manifesto of how child development should be approached done, I find it strange to see but a single page page (pp. 218-219) devoted to genetics and development, and to find that the page concludes with, "...in humans, genes provide only very broad sorts of constraints on the representations that emerge in cortex." (p.219). This statement borders on incomprehensible to me. That the interaction of genetics, environment, and behavior has profound and lasting effects on behavior and development is no longer open to serious debate. To cite a few examples, CREB genes certainly play a role in memory and recall, even if the exact mechanisms are not; BDNF genes affect visual development; FOX2P almost certainly has some role in enabling language, even if, once again, the details are still unclear. And the list grows longer by the day. And memory and recall, vision and language are without question crucial to the development of representations in the cortex. In other words, the message for future developmentalists should be: While you (almost certainly) don't have to go to the level of physics or

quantum mechanics to explain cognitive development, you (equally certainly) can no longer be content to stop at the level of neurons. So, just as the authors rightly reject Marr's computationalism in which the implementational substrate was not supposed to matter to cognition, it seems equally valid to criticize their not including this important area in their vision of the way forward in developmental research. The closest the book comes to taking up some of these issues is in the chapter on atypical development. But a much fuller development of this is absolutely necessary.

There are other, more minor points that should be corrected in later editions of this work. The authors write, "...one of the most important conclusions from the formal study of learning is there *there is no such thing as an unbiased or unconstrained learner...,* so cognitive development therefore reflects the outcome of constrained adaptation." (p. 20) These words could have come straight from Terry Regier's (1996) book on constrained connectionism, entitled *The human semantic potential;* and yet, this work is not even cited.

In conclusion, this is a first-rate book, a major contribution to the literature on development. I hope it will serve as a broad research manifesto on how interdisciplinary research in child development should be done in the upcoming years.

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