Developmental Science 7:2 (2004), pp 165–166

Commentary: new kids on the connectionist modeling block

David Klahr

Department of Psychology, Carnegie Mellon University, USA

> If we can construct an information-processing system with rules of behavior that lead it to behave like the dynamic system we are trying to describe, then this system is a theory of the child at one stage of the development. Having described a particular stage by a program, we would then face the task of discovering what additional information-processing mechanisms are needed to simulate developmental change – the transition from one stage to the next. That is, we would need to discover how the system could modify its own structure. Thus, the theory would have two parts – a program to describe performance at a particular stage and a learning pro-

of cognitive development

could be described as programs, then the developmental process itself could also be described as a program that transformed the earlier program into the later one. Such a program would be a computational model possessing some of the same self-modification capacities as the

connectionist models was on learning, and although the models learned a lot, they really didn't do much with what they had learned – at least not with respect to higher-order thinking and problem-solving.

However, in recent years, the learning–performance distinction has become intentionally blurred by the creation of models that are always undergoing self-modification, even as they perform at a given 'level' or 'stage'. From the symbolic camp, perhaps the best exemplars of that kind of computational model can be seen in the hybridization of production-system architectures such as Anderson's ACT-R model and its direct application in accounting for some classical developmental phenomena, ranging from past-tense acquisition (Taatgen & Anderson, 2002) to balance scale problems (van Rijn, van Someren & van der Maas, 2003). From the connectionist side come the types of models described in this special issue. These four papers go beyond the most widely known types of connectionist models – those that use feed-forward processes and backpropagation learning, and introduce a new 'bag of tricks' – and quite powerful tricks at that – including autoassociators, Hebbian learning, adaptive resonance theory and evolutionary computation. These are important developments for developmentalists, given that the fundamental challenge we face is to provide an account of the astounding, complex and intricate process of the emergence of thought and action

Address for correspondence: David Klahr, Department of Psychology, Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, PA 15213, USA; e-mail: klahr@cmu.edu

to apply and extend this type of theoretical model.[1] A second cautionary note is that for all of its precision and elegant formalization, the ultimate assessment of these types of models rests – paradoxically – on arbitrary and vague analogical mappings between the models' behaviors and the phenomena of interest. Finally, there is the question of how these different approaches are related. With respect to a common domain of interest, these four papers show little overlap in either their proposed mechanisms or the domain of empirical phenomena they attempt to explain.[2] Perhaps at this early stage, such diversity is necessary and desirable, and, I suspect, these chapters were solicited with just a 'span' in mind. Nevertheless, it will be important in the long run to produce an account of how they all function in a single child's head.

I opened this brief commentary with a quote from Herb Simon, and I will close with one from Allen Newell – Simon's partner in pioneering the computational approach to understanding human thought. As did Simon, Newell also speculated now and then on the state of the art in developmental science. A little over a dozen years ago, he wrote:

> I have asked some of my developmental friends where the issue stands on transitional mechanisms. Mostly, they say that developmental psychologists don't have good answers. Moreover, they haven't had the answer for so long now that they don't very often ask the question anymore – not daily, in terms of their research. (Newell, 1990, p. 462)

Newell's lament was mainly true in 1990, if evaluated in terms of the proportion of journal articles and book chapters devoted to issues of transition and change. (Although even then, there existed a small but hardy band of developmentalists who had been proposing computational approaches to these issues for many years.) However, as in the case of Simon's opening comment,