A Sears Catalog for the Developmental Psychologist

Jeffrey Bisanz, Charles J. Brainerd, and Robert Kail (Eds.)
Formal Methods in Developmental Psychology: Progress in Cognitive Development Research
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My neighbor fancies himself the consummate home handyman. He's also fairly self-indulgent: Before initiating a project, he peruses the Sears catalog in search of any new tool that might be remotely useful in his new endeavor. Consequently, his workroom is arrayed with an exotic collection of complex tools. Nevertheless, the net effect of his modifications to his home, while technically competent, have not really improved its ambience.

The point of this little parable (which might alienate my friend were he not too busy puttering to ever read this journal) is that for a serious practitioner, the value of a tool derives not from its elegance or beauty but from its usefulness. Similarly, in evaluating this book on formal methods in developmental psychology, it is instructive to consider what use could be made of the various methods described here by researchers interested in cognitive development. Some of the questions occurring to me as I read through this collection of papers—originally presented at a conference in 1985—were: (a) Is the method theoretically motivated? That is, will use of the tool facilitate the evaluation or articulation of an underlying psychological theory? (b) Is the method necessary? Is there a simpler, less costly, or more widely available alternative approach? (c) Does the method facilitate the understanding of important developmental phenomena, or is it of limited relevance? (d) Which of these chapters would I recommend to graduate students as their first exposure to a particular method?

Given the inherent difficulty of the major issues in cognitive development, and given that "research involving formal models is far from the modal approach in cognitive developmental research" (p. viii), one must applaud attempts to introduce more rigor into the field. The specific purpose of this collection is to communicate to researchers in cognitive

development some insights and methodological details necessary to adopt or develop these potentially useful techniques for their own work. Three chapters focus on different applications of Markov models, four deal with a variety of mathematical and statistical techniques, and another four illustrate different kinds of computer simulation methodologies. The substantive topics covered in the course of illustrating these methods include memory, concept learning, mental retardation, problem solving, social judgment, intelligence, genetics, number concepts, mental arithmetic, perceptual development, and search. Although the chapters vary widely in the extent to which they satisfy the criteria listed above, several of them are very successful, and well worth reading.

Tools well-described and worth considering

Miller's chapter on geometric methods epitomizes the goals of this kind of book. He describes several scaling and clustering techniques, all of which "can permit the reduction of daunting matrices of data to reveal the organization of complex skills, domains of knowledge or social structures" (p. 255). Miller provides a clear description of these methods, pointers to both basic and the advanced texts on the topic, and explanations of both the formal and the practical characteristics of the methods. Furthermore, he exemplifies them with developmentally relevant examples, while using a single domain (number development) to illustrate increasingly sophisticated applications.

Ashcraft's chapter is cast as a miniature scientific autobiography, focused on how he became interested in children's mental arithmetic, and on how, for the past decade or so, he has traversed the cycle of theory formulation and experimentation. He describes a computer simulation model intended to account both for children's performance patterns at different ages, and for the development of those processes. The autobiographical device enables Ashcraft to give theoretical, empirical, and intuitive justifications for the model's assumptions and mechanisms, as well as an interesting case history of how one goes about developing a computer simulation, and a balanced assessment of the pros and cons of the technique.

Banks presents a tantalizing demonstration of the potential importance of computer simulation models of perceptual development. He bases his use of computer simulation on Marr's (1982) key insight about how to approach theoretical issues in vision: In order to understand how a system operates, one has to understand what task it has been designed (or adapted) to accomplish. Banks provides both a compelling argument for the general importance of computer simulation and a lucid and concise summary of the empirical literature on the development of distance invariance in infancy (e.g., how the visual system learns that the vastly different spatial frequency distributions produced by the same object at different distances are coming from the same object). Unfortunately, this chapter is a bit premature, for Banks never gets around to describing his simulation. He provides only a sketch of a few alternative strategies for constructing such simulations and ends with the "next step" being the computer implementation of the strategies. Banks's subsequent work on simulation models of visual recalibration demonstrates the value of the approach (Banks, 1988).

Rabinowitz, Grant, and Dingley present an interesting and comprehensive summary of dozens of developmentally relevant computer simulation models. (Notably absent is Siegler & Shrager's, 1984, simulation model of children's addition processes, which *is* described in Ashcraft's chapter.) However, the chapter's usefulness as a methodological explication is weakened by several factors: (a) It does not focus on a particular domain; (b) it does not draw on extensive familiarity with computer simulation; and (c) it sacrifices technical details and depth in favor of breadth, and thus fails to provide a worked out example of the application of computer simulation to a specific developmental topic. Futhermore, in several places, Rabinowitz et al.'s account of the field misses the mark. For example, the term *cognitive architecture* did not originate with Langley, as implied on page 264; the production-system example and subsequent discussion (pp. 264–265) is somewhat bizarre, and unlike any production system with which I am familiar; contrary to the assertions on pages 265–266, Newell and Simon did not formulate their General Problem Solver as a production system. Nevertheless, this chapter provides a good entry point to the literature, as well as a sample of various opinions about the pros and cons of computer simulation. Although I do not share several of their appraisals of the area, I must reluctantly agree with their final observation that the "intrinsic complexities of [computer simulation] models . . . continue to challenge the communications talents of the most articulate among us, as well as the comprehension abilities of the most gifted" (p. 296).

Tools for the collector, rather than the user

One of the evaluative criteria listed earlier was whether the formal method is applied to centrally important issues, and whether, once applied, it advances our understanding in some fundamental way. Although nearly one third of the book (chapters by Brainerd; Kingma; and Wilkinson and Haines) is devoted to the use of Markov models, I feel that the benefit/cost ratio of these chapters is fairly low. The major advances in the study of children's memory over the past decade have dealt with the underlying organization of knowledge; the processes and strategies used in retrieval and storage; and the interaction between capacity, knowledge, and strategy. Unfortunately, the memory domain to which both Brainerd and Kingma apply their formal models is classical list learning. Wilkinson and Haines propose some novel answers to the important question of how children assemble simple component skills into reliable strategies. However, they couch their analysis at the abstract level necessitated by Markov models, while their discussion in the text is rife with undefined processes whereby the child "discovers," "adopts," "retains," "invokes," "moves," "prefers," "abandons," or "reverts." As is often the case in the use of mathematical models, the formalism of the mathematics obscures the informality of the underlying theory.

Sternberg focuses on the measurement of people's implicit theories of intelligence. The methods covered range from initial free-form generation of terms and attributes to correlation, clustering, and scaling. Although the results of the 11 studies reported here present an interesting picture of how different categories of laypersons define "intelligence," the chapter seems out of place in this volume. The only developmental relevance comes from the one study dealing with different implicit theories of intelligence over the life span. (Surprisingly, in that particular study, Sternberg asserts that "implicit theories of intelligence change over the lifespan"—a tenuous conclusion based on cross-sectional data in a domain where social norms, exposure to pop psychology, and level of education are all likely to be confounded with the cohort being studied.) Another problem is that the defining

properties of implicit theories are left implicit. Does an implicit theory have to be unarticulated, imprecise, untested, idiosyncratic? The chapter does present a practical set of guidelines for how to go about generating data on constructs held by ordinary people, whether they are about psychological entities or anything else. Indeed, it is not clear that the structure or assessment of implicit theories of intelligence is fundamentally different from other attitudes or belief systems.

Weekend specials: Neat tools, maybe

Thomas has an axe (actually, an X) to grind. His chapter makes a case for X-linked influence on IQ, and it makes it with technical elegance. Unfortunately, his chapter *assumes* a high degree of familiarity with the sophisticated statistical techniques being demonstrated. As such, it fails to meet the "first look" criterion listed above.

Surber attempts to use functional measurement techniques in order to determine whether or not social judgments are based on reversible mental operations. After a 30-page review of the literature, she states: "At this point the reader may feel that studying the reversible operation of correspondence of interaction patterns is not only fruitless . . . but also somewhat purposeless" (p. 143). Yes. Surber finally addresses the issue of what representations and processes underlie social judgments, and she concludes by proposing a few interesting possibilities, based on Anderson's (1983) ACT model.

Heth and Cornell demonstrate how one can construct simulation models incrementally, by adding and integrating subcomponents of the model and comparing its performance with children's actual behavior. Their chapter also illustrates some of the properties of Monte Carlo simulation, although it does not go very deeply into the underlying cognitive processes.

Conclusion

Would I buy this book? Probably not. It is very expensive, perhaps because of the cost of setting the very complex matrix expansions for the Markov models. Would I encourage my university library to buy one? Two. And I would put them both on reserve for graduate students to read selectively, because some, but definitely not all, of these chapters provide an excellent introduction to formal methods that could be usefully applied to developmental psychology. (As you may have guessed, I do occasionally borrow my neighbor's tools.)

References

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