X. IMPLICATIONS FOR OLDER CHILDREN’S COGNITIVE DEVELOPMENT

Just as previous research on older children informed the present study of toddlers’ thinking and learning, so the present study of toddlers can inform our understanding of thinking and learning in older children. In this section, we discuss implications of the present findings for understanding several areas of cognitive development in older children: analogical reasoning, utilization deficiencies, and learning.

ANALOGICAL REASONING

Most studies of preschoolers’ and older children’s analogical reasoning and problem solving have focused on demonstrating the importance of a single component of the overall process. For example, Inagaki and Hatano (1987) focused on initial acquisition of analogies; Gentner (e.g., Gentner & Medina, 1998; Kotovsky & Gentner, 1994) focused on the role of structure mapping, and Chen (1996) focused on execution of solution procedures.

In the present study, we examined the contributions of all of these component processes, as well as others such as choice refinement, to performance on a single analogical problem-solving task. All of the component processes proved to be important, in the sense that failure on any of them could short-circuit the problem-solving process. Some failures to obtain the toy were due to children not learning to use tools even on problems on which they received instruction. Others were due to children learning in the initial context but not mapping the tool strategy onto later, superficially different problems. Others were due to children using the tool strategy only sporadically. Yet others were due to children choosing an ineffective tool rather than the target. And some occurred when children chose the target tool but used it ineffectually.
Considering the whole range of components is essential for a comprehensive understanding not just of analogical problem solving at any one age but also of learning and development in this area. Both learning over the three problems and age-related differences in that learning included improvement in all five components. No one component would have accounted very well for either the effects of experience or the age-related differences in learning. The same seems likely to hold true for older children. This is critical for understanding the learning process: Failure to obtain one’s goal is likely to interfere with learning, regardless of the source of the failure. If correct analogies do not allow the learner to achieve the desired goal, those analogies are unlikely to be strengthened as much as correct analogies that lead to goal attainment. Thus, comprehensive analyses of children’s acquisition of analogical problem-solving skills will need to consider multiple components rather than focusing on a single process.

The present analysis also sheds light on a specific controversial issue within the analogical reasoning literature: the roles of superficial features and deep structure. Some investigators, such as Gentner (1989) and Tversky and Hemenway (1984), have argued that 3- to 6-year-olds rely primarily on superficial features and perceptual correspondence in drawing analogies, whereas older children rely primarily on deep structure and functional correspondence. Other investigators, such as Brown (1990), Goswami (1996), Kemler-Nelson (1995), and Kobayashi (1997), have argued that even 2- and 3-year-olds are not limited to drawing superficial analogies, that in domains that they understand, they rely primarily on structural correspondences.

The present findings were consistent with the latter position. The 1.5- and 2.5-year-olds in this study based choices primarily on structural correspondences between previous target tools and new potential tools. On the other hand, matches in superficial features between previous target tools and new tools also influenced the toddlers’ choices. They more often chose suboptimal tools with colors and decorations that matched the previous target than otherwise identical tools with colors and decorations that did not match. This was especially true early in learning. Superficial similarities exercised a moderate effect on strategy choices on Problem B, but very little effect on choices on Problem C. Even on Problem B, however, deep structure similarities were more influential than were superficial ones. Thus, in domains in which toddlers understand the basic causal relations, their analogical reasoning, like that of older children, reflects influences of both deep structure and superficial features, though deep structure exercises a larger influence. The question is not “deep structure or superficial features,” but rather when and how each type of resemblance influences analogical reasoning.
The purpose of using a strategy is to attain a goal. Recent studies with preschoolers and older children, however, indicate that generating a new, relatively advanced strategy does not always help children achieve the goal that the strategy is intended to meet. The problem is that strategies that are useful in the long run are not always seen as useful in the short run. Sometimes, children derive no benefits in attaining goals from using new, potentially useful strategies. Other times, they benefit to a small degree, but not as much as they will once they have used the strategy more. Such "utilization deficiencies" (Miller, 1990) are quite common; they have been documented with diverse types of strategies, including attentional, memorial, and problem-solving strategies (for recent reviews of this literature, see Bjorklund, Miller, Coyle, & Slawinski, 1997, and Miller & Seier, 1994).

The microgenetic design and componential analysis used in the present study revealed several sources of utilization deficiencies, sources that probably contribute to utilization deficiencies in other contexts as well. One source was limited mapping. At first, the tool strategy was not applied as broadly as it could be. A second source of the early utilization deficiency involved the relatively low strength of the new strategy. Even in the context of the problem on which the tool strategy was acquired, it initially was not applied as consistently as it later was. A third source of utilization deficiencies was relatively unrefined choices among alternative versions of the tool strategy. Toddlers at first often chose tools that were not very useful; this led to their using the tool strategy but not obtaining the toy. Yet a fourth source was poor execution of the new strategy. Early in learning, even when toddlers chose the target tool, they fairly often failed to wield it sufficiently skillfully to meet their goal. As has been emphasized previously in this Monograph, acquiring a new strategy is only the beginning of strategic development. Mapping, strengthening, refinement of choices, and skillful execution all are needed before strategies reach their potential usefulness. Until that point, utilization deficiencies can be expected.

LEARNING

For many years, learning was the central topic in psychology in general and in developmental psychology in particular. With the cognitive revolution and the rise of Piaget, this hegemony was overthrown. Attention shifted from learning to thinking, an emphasis that has continued to this day. Even the term "learning" became perjorative, as in the phrase,
“this is learning, not development.” The movement away from studying learning was noted by a number of authorities in the 1983 edition of the *Handbook of Child Psychology*. In a particularly evocative description, Stevenson (1983) observed,

As rapidly as the field (of learning) had developed, it went into decline. By the mid-1970s, articles on children’s learning dwindled to a fraction of the number that had been published in the previous decade, and by 1980, it was necessary to search with diligence to uncover any articles at all. . . . The discussion of children’s learning had been displaced by a newfound interest in cognitive development. (p. 213)

In a similar vein, Brown et al. (1983) noted, in their *Handbook* chapter, that although their title, “Learning, Remembering, and Understanding,” included the term “learning,” the research being reviewed focused almost exclusively on memory and comprehension.

The movement away from studying learning not only reflected a shift in interest; it also reflected an active skepticism about whether learning had much to do with development. Piaget went out of his way to distinguish between learning, by which he meant associative learning, and development, by which he meant the active construction of knowledge. This distinction was valuable in exposing hidden assumptions that had shaped earlier research on children’s learning, but it had the unfortunate side effect of producing skepticism about the importance of any kind of learning for development. This skepticism was evident in the title of a volume edited by Liben (1987), *Development and Learning: Conflict or Congruence?* Asking whether learning and development were in conflict revealed an attitude that would have been unimaginable in an earlier era.

Stevenson (1983), Brown et al. (1983), and a number of contemporaries who noted the movement away from studying children’s learning (e.g., Case, 1985) predicted that the area would make a comeback. All gave the same reason: the inherent importance of the topic. Their prediction proved prophetic—to a degree. There indeed has been increasing interest in children’s learning, but the trend would more accurately be characterized as a boomlet than as a boom. The interest also has been more evident in increased theorizing about children’s learning (e.g., Gelman & Williams, 1998; Keil, 1998; Thelen & Smith, 1998; Wellman & Gelman, 1998) than in empirical studies that examine learning as it occurs. Studies of preschoolers’ and older children’s learning have started to appear in greater numbers, but the quantity of such studies remains a small fraction of the number of studies on such specific topics as infants’ object permanence, preschoolers’ theory of mind, and preschoolers’ and older children’s eyewitness testimony. And, as noted above, the number
of studies that focus on infants’ and toddlers’ learning of cognitive capabilities is even smaller than the number that focus on older children’s learning of them.

There are numerous reasons for the paucity of empirical studies of children’s learning. It makes sense to determine what children know at different ages before trying to determine how they get from here to there. Examining what children know at any one time is easier than assessing initial knowledge and then going on to examine how they build on that base to acquire new knowledge. The great recent progress in understanding the topics that have been in vogue, such as theory of mind, has created its own momentum, raising numerous interesting questions regarding alternative interpretations and potential extensions of previous findings.

Arrayed against these varied reasons that militate in favor of continuing to focus on children’s knowledge, rather than on their learning, is one central fact: Learning is omnipresent in children’s lives. Brown and DeLoache (1978) aptly characterized young children as “universal novices.” The only way in which they can acquire greater expertise is through learning. Knowing what children’s thinking is like at different ages, without knowing how they get from here to there, is an inherently unsatisfying state of affairs.

A major purpose of the present study was to illustrate that we can move beyond this unsatisfying state. Very young children’s learning, like older children’s learning, can be studied in ways that yield rich and revealing data, data that broaden our understanding of developmental differences, individual differences, and a variety of other topics.

In addition to yielding interesting data about an omnipresent aspect of children’s lives, studies of learning have an additional advantage: They can help unify our understanding of cognitive development. A number of recent reviewers have lamented the fragmentation of the field of cognitive development into a number of small, specialized subareas without unifying theories or frameworks (e.g., Case, 1998; DeLoache, Miller, & Pierroutsakos, 1998; Haith & Benson, 1998). The deemphasis of learning may have a great deal to do with this. When learning theory was ascendant, the stated goal was to identify universal “laws of learning” that would apply across ages, species, and conditions. This proved to be a dead end; learning is influenced by the kind of organism doing the learning, the content being learned, and the conditions under which learning occurs.

Newer theories of learning recognize the importance of considering the learner’s species and developmental status, as well as the content being learned and the context within which the learning is occurring. These newer theories, however, also are beginning to identify similarities in learning processes across these variables. In one notable example, Gelman and Williams (1998) highlighted the importance of constraints for facilitating
learning in all types of domains, both biologically privileged and nonprivileged. Similarly, Keil (1989, 1998) and Wellman and Gelman (1998) emphasized formation of theories that stress causal linkages as a crucial part of children's learning in a broad range of domains. Thelen and Smith (1998) and Bertenthal and Clifton (1998) focused on the importance of considering the physical situation; the learner's anatomical properties, coordination, and learning history inside and outside of the current situation; and numerous other influences for understanding acquisition of cognition, perception, and action. In yet another example, Siegler (1989) noted that the best-specified models of children's learning all shared the same structure, a structure within which learning consisted of mechanisms for generating variation, mechanisms for selecting among the variants, and mechanisms by which the more successful variants became increasingly common.

The present observations of toddlers' learning provided evidence supporting all of these theoretical perspectives on learning. Toddlers' choices among tools were constrained in useful ways even before they received any instruction on the task. They predominantly chose tools with shafts long enough to reach the toy and with a head that could be useful for pulling it in. This tendency to choose tools from the outset that had the right causal properties, together with the rapidity with which children benefited from the modeling and hint, suggested that they were attending to causal relations between properties of the tools and requirements for obtaining the toy. Success in obtaining the toy depended not just on acquiring the tool strategy but on the toddlers' motoric skill and coordination, base-rate of using tools to try to obtain the toy, previous exposure to modeling or hints, and a host of other influences. The toddlers generated a variety of strategies, they tended to choose the most useful strategy, and they preserved the lessons of past experience in mapping their learning onto novel problems.

The present results also illustrated a number of other cross-domain and cross-age similarities in learning processes. The 1.5- and 2.5-year-olds' learning about tools reflected the same component processes as 5-year-olds' learning about conservation and 8-year-olds' acquisition of an arithmetic insight (Siegler, 1995; Siegler & Stern, 1998). Strategic change involved improvement in all five components, rather than just substitution of a more advanced strategy for a less advanced one. Although amount of learning varied with the learner's age, sex, and initial knowledge, the components of learning were the same for older and younger toddlers, boys and girls, and children with greater and lesser initial knowledge.

In general, the process of learning may share more commonalities across ages, domains, and tasks than the products of learning. What children know at a given time inevitably reflects the amount of experience...
that they have had in the domain, the rate at which they learned from their experiences, the difficulty of the material being learned, the conditions under which learning occurred, and many other variables. The processes through which children learn, however, may share many commonalities that hold over diverse types of learners, material being learned, and learning contexts. If this is the case, focusing on the processes through which children learn may help unify the fragmented field of cognitive development.
XI: CONCLUSIONS: BRIDGING THE GAP

The main goal of this study has been to bridge the gap between research on very early and later cognitive development. Research on infants' and toddlers' cognition has differed from research on the cognition of older children in the questions that have been asked, the methods and measures that have been used, and the way that knowledge has been represented. In the present study, we applied the overlapping waves theory and the microgenetic method, which had been developed in the context of older children's cognitive development, to examining toddlers' problem solving and learning. Not only did the general theory and methodology prove applicable to this much younger population, but a specific componential analysis, developed to account for older children's learning of scientific and mathematical concepts, also proved useful for characterizing how toddlers learn to use tools to obtain toys that are out of reach.

Many specific results also were similar. Like older children, the toddlers used several problem-solving strategies from the beginning of learning; they continued to use less advantageous strategies even after they learned a more advantageous one; they chose among strategies in fairly adaptive ways from the beginning of learning; their choices became increasingly adaptive with problem-solving experience; their mapping of what they had learned to novel problems was influenced primarily by structural similarities; superficial similarities also exerted some influence on their choices; they switched strategies not only from problem to problem but also from trial to trial within a problem; they fairly often switched strategies within a single trial; and improved execution was necessary for the optimal strategy to consistently allow them to achieve their goal.

A more general similarity also was present: Toddlers, like older children, emerged as active thinkers and learners. This was perhaps most evident in their success in learning from their own problem-solving experience. Children who had received the modeling or verbal hint showed a certain amount of direct transfer when they encountered a novel problem. They went on, however, to learn from their efforts to solve the novel
problem, so that their performance continued to improve without further instruction. Children in the control group did not show comparable learning over these trials. Thus, children learned through integrating earlier instruction with subsequent problem-solving experience.

This integration of instruction with the lessons of one’s own experience is not what would be expected if toddlers were passive learners. But, of course, they are not. Studying children’s learning in no way requires that we buy into the assumptions of the learning theories of the 1950s and 1960s. It does demand, however, that we recognize that the only way to understand development as a process is to study learning while it is occurring.
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ACROSS THE GREAT DIVIDE


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A KEY BRIDGE TO UNDERSTANDING THE DEVELOPMENT OF THINKING AND PROBLEM SOLVING

Marvin W. Daehler

A major difficulty for anyone attempting to write a commentary on this Monograph is selecting only a few of its many significant points to single out as the more noteworthy contributions. This work is filled with ample illustrations of informative, thought-provoking advances bearing on theory and methodology; as a consequence, it offers many insights into our understanding of toddlers and their early problem-solving capacities. The application of overlapping waves theory, and the detailed observations of performance over multiple tasks on which it hinges, seems like such an obvious way to explore cognitive development in 2-year-olds that the reader will surely ponder why it has taken so long to put the theory and method to the test.

Fortunately, Chen and Siegler help to ease our dismay over failing to recognize the enormous potential of a microgenetic analysis of toddler problem solving. They point out the problem of different agendas as well as different methods and measures often used to evaluate infant and toddler cognition compared to the cognitive development of older children. Questions directed at when capacities emerge have dominated the infant literature, whereas a focus on how various competencies are established has become an increasingly pointed concern in research with older children.

Yet it would be misleading to exaggerate the emphasis on the “when” question among infant researchers. The polemics surrounding the “how” question seem to occur on a different plane. The debate over how cognitive development proceeds during the first months and years of life typically has been framed within the controversy of nativism versus empiricism (cf., Haith, 1998; Haith & Benson, 1998; Spelke, 1998), an issue
that loses much of its potential interpretive appeal as examination of cognitive development shifts to older children. Given the difficulty of resolving the role of inborn mechanisms versus acquired factors with respect to cognition in infancy, we can be virtually assured that it will be an even more arduous task, and probably considerably less productive, for understanding later development. Wisely, investigators have steered away by focusing instead on the various component processes that underlie thinking and problem solving in older children. To our good fortune, Chen and Siegler have now effectively extended this approach to include toddlers.

The Power of Observation and the Persuasion of Hints

In applying overlapping waves theory and the microgenetic approach, Chen and Siegler have identified a number of component processes characterizing strategic behavior. The results provide insights relevant to many of these processes. Among them is the question of how new strategies are acquired. Certainly one of the more remarkable findings among the many reported in this work is just how essential it was for toddlers to observe a tool's use or receive a hint to initiate a tool selection strategy for successful performance on the task. Children in the control condition, left to their own devices, rarely engaged in a tool selection strategy, and as a consequence seldom succeeded in retrieving the toy. Indeed, there was little evidence that children, some approaching 3 years of age, were making any progress in implementing the tool selection strategy over the 15 trials of the task.

This finding is reminiscent of the results of another recently published microgenetic study of problem solving, involving 5- to 9-year-olds and a very different kind of problem (Thornton, 1999). The task was to create a bridge crossing over an imaginary “river.” To do so, children had to use wooden blocks of the kind commonly found in various preschools. No single block was long enough, however, to span the river by itself. A successful solution required children to join two blocks (or possibly more) to cross the river. An additional constraint was that no block could be placed in the middle of the river to serve as a stanchion to support the juncture formed by the separate blocks. Thus, the weight of the blocks projecting over the river needed to be offset in some manner, for example, by assembling a tower of blocks atop the ends extending onto the river bank to act as a counterweight.

Needless to say, this was not an easy task to complete, even for the 7- and 9-year-olds. But consider the plight of 5-year-olds, who rarely were able to derive a solution. One 5-year-old did produce a correct solution right away. More interesting, only one of nine 5-year-olds not immediately successful came up with an acceptable resolution to the problem within
the approximately 25 min permitted to work on the task. This child literally stumbled on the solution strategy while pressing her hands, and eventually other blocks she held in her hands, on opposite ends of the two spans to keep them joined and suspended above the river. In her analyses of these results, Thornton (1999) emphasized that constraints established within the problem itself permitted this child to arrive at the principle of counterbalance and led to her achieving the goal of the task, a reasonable explanation for that child’s success. To repeat, however, only one of the nine 5-year-olds who spent any time working with these materials was able to come up with a solution strategy. In fact, one of the 5-year-olds devoted the entire 25-min period searching throughout the room for a single block of sufficient length to span the river!

Thornton’s results, along with those observed in the Chen and Siegler control group, dramatically bring home the point that children, and very likely adults as well, are not always very good at inventing or detecting new strategies for solving problems when left to their own brute cognitive processing devices. Researchers have witnessed this difficulty elsewhere. For example, one of the most powerful influences on successful transfer involving analogical reasoning for both children and adults is that of noticing the relevant solution principle; hints are among the most effective ways of encouraging this process (Brown & Campione, 1984; Gick & Holyoak, 1980, 1983; Weisberg, DiCamillo, & Phillips, 1978). At every age we often seem to need assistance in coming up with new strategies just as it appeared to be very important for the toddlers in order for them to be successful.

Although Thornton did not provide a helping hand to the 5-year-olds in her study, the experience of watching as one of them searched for a block of sufficient length for the entire 25 min surely must have been a painful one. In fact, researchers often comment on how difficult it is for parents as well to avoid helping their children when attempting to solve a problem in an experimental setting. Perhaps that says something about their parenting concerns more broadly. It also has implications relevant to the enormous value of modeling and hints as resources for cognitive processing and for the development of learning more generally. Chen and Siegler present a helpful discussion about modeling and hints as factors for initiating cognitive change. They also comment on the rise and fall of learning as a central topic of study in psychology. Perhaps the two phenomena are more closely coupled than many investigators concerned with cognition are comfortable to admit. Researchers have traditionally focused on learning in very limited contexts. As psychologists simplified and sanitized experimental settings, procedures, and materials in order to test the basic processes underlying learning, they may well have removed some of the most powerful means by which cognitive
development is promoted. That is, the richer context may provide the best opportunity to observe and become informed about becoming a better thinker and problem solver.

This is certainly not a revolutionary idea. Brown et al. (1983) emphasized that cognitive activity very often proceeds in the context of others rather than in isolation. For dialecticians, the matter of dialogue is pivotal to development (Vygotsky, 1978), and those who have built upon this theoretical tradition, along with many other psychologists, have expanded upon the central role that both verbal and nonverbal interactions play in cognitive development (Rogoff, 1990, 1998; Wood, 1989; Wood, Bruner, & Ross, 1976). But as Rogoff (1998) pointed out in a recent review of studies concerned with cognition as a collaborative process, the notion still seems to be novel for many researchers. Perhaps the findings presented here will help to convince us that modeling, hints, and other informational contexts can provide an integral link to establishing new strategies. A major issue then becomes one of determining what kinds of instruction the toddler can most effectively assimilate into his or her understanding of the problem to be solved.

Still Other Divides to Conquer?

The use of the microgenetic approach as a means of crossing the great divide has paid off handsomely in helping to appreciate the strategic behavior of toddlers. But are there other divides yet to cross? Another interesting finding in the present study was that the older and younger toddlers differed in the degree to which they benefited from the experimenter’s verbal hints to use a tool. This age difference was not evident when children could observe the experimenter select a tool to obtain the toy. Both experimental procedures appeared equally effective for the older children but not for the younger children, as a smaller proportion of the younger children seemed to respond to the verbal hint. Chen and Siegler suggest that the modeling of tool selection and its use offered more concrete information than did the verbal hint. That is a reasonable explanation for the age and condition differences, but the finding also raises other questions. For example, what might the results have looked like for even younger children than those tested in this study? Based on the research on imitation with 12- to 18-month-olds (e.g., Barr & Hayne, 1999; Meltzoff & Moore, 1999), perhaps they, too, would have had some success, at least with respect to the modeling condition. Would the verbal hints, however, have promoted a tool selection strategy at this earlier age? Perhaps not, because of limits in verbal comprehension. More important, the difference reported in this Monograph between performance in the
modeling and verbal hint conditions further opens the door to another persistent problem: how language affects our thinking and problem solving.

The relevance of the potential great divide associated with language's influence on thought comes from one other bit of information. At several places in this Monograph, Chen and Siegler note that the microgenetic approach for studying toddlers mirrored the way it has been carried out with older children—*with one exception*. That exception was the inability to exploit verbal reports from toddlers as a means of revealing their strategy use. This methodological limitation does not detract from the findings in the Monograph. The lack of access to verbal resources, however, along with the differences reported for the effectiveness of certain kinds of assistance, highlights the reality that older children are able to both interpret and represent strategies in linguistic form, whereas infants are unable to do so (or do so much less effectively). This divide still has to be crossed. Here again we are confronted with an issue that has plagued developmental psychology from its beginning, but one that continues unresolved. What exactly is the nature of the representations available to the infant and toddler that underlie their cognition, or in this particular case, strategic behavior? And is it possible that developmental changes with respect to these, for example, the appearance of propositional or linguistically based representations, have a substantial bearing on both children's conceptual understanding and the particular components of their strategic activity such as acquiring, mapping, or effectively executing strategy choices? The results of the present study are comforting in suggesting that a microgenetic analysis yields extremely valuable information about strategic development despite the lack of availability of verbal reports. The jury remains out, however, on whether the development of symbolic representational systems has important consequences for the various component processes underlying problem solving. And even if the nature of the available representations has little bearing on the fundamental components of strategic learning, it surely has implications for the kinds of context in which their acquisition is fostered. In fact, it is conceivable that for older children certain kinds of learning may proceed more effectively as a result of being told, rather than observing, what to do.

*Biases and Knowledge*

One of the most exciting aspects of the microgenetic approach is how much information it provides about mapping, strengthening, refining, and executing strategies in addition to their acquisition. Chen and Siegler were able to offer insights for each of these learning components...
as a result of the innovative design of their study. Various types of stimulus or response biases, often a part of the behavioral repertoire of very young children, apparently were not seen with sufficient frequency to be considered among the "strategies." Because children in the control condition generally did not engage in tool selection, any bias, such as picking out a specific tool or a tool in a particular location in the array, would not have been easy to measure. Furthermore, in the experimental conditions, perhaps the modeling or hint was sufficiently powerful to override possible position or other response tendencies so that refinement of the correct tool selection strategy did not compete with such biases. Position biases and perseverative response have been reported most frequently in somewhat different kinds of problems, for example, in classic discrimination tasks or where retrieval of hidden objects is a central aspect of the situation (e.g., DeLoache, 1999; O'Sullivan, Mitchell, & Daehler, 1999; Stevenson, 1972; Zelazo, Reznick, & Spinazzola, 1998). The absence of response biases and stimulus preferences in the tool-use problem helped to make the analysis of tool selection strategies far more manageable.

In reporting the results concerned with the refinement of strategy choices, Chen and Siegler note that at least some children entered the problem-solving task with an understanding of the tool-use strategy. For example, on the first three trials of the problem, before they were given encouragement to select a tool, children used one or more tools on about 20% of the trials. On these trials children also were more likely to choose the longer tool, and, among the longer ones, they were more likely to use the tool with a head than would be expected by chance. But we need to be cautious in making inferences about the type of knowledge children possess about the tools at the beginning of the task. For example, some toddlers, as Chen and Siegler conclude, may realize that the length of the tool is the relevant aspect in determining which one should be chosen. It also is possible, however, that the typically closer proximity of the endpoints of the longer tools in relation to the toy made them better candidates than the shorter tools for trying to make contact with the toy. Alternative interpretations for why children chose tools with heads more frequently than tools without heads are less easy to generate. But until a simple preference test is carried out evaluating the extent to which children this age interact with a tool (in a context other than using it to retrieve a toy), we cannot eliminate other potential explanations for these choices as well.

These are relatively minor points. Perhaps the real power of the type of research described in this Monograph comes from the opportunities created to explore other questions about strategic behavior, problem solving, and transfer in very young children. Is the positioning of the tools a factor? For example, would children this age, as a consequence of
particular kinds of instructions, generalize the tool selection strategy to arrays in which the tools are set out on a table to the side of the child rather than immediately in front and in the line of sight for reaching for the toy? How durable are the strategies once they are acquired? For example, if some type of intervening activity took place between the problems, would younger and older toddlers show the same levels of transfer and might instructional condition have a bearing on this as well? These are just a couple of the many possibilities for further exploring the path, rate, breadth, variability, and sources of cognitive change in toddlers. A major purpose of the present study was to begin the task of understanding these dimensions of change in the toddler years; the results have provided a superb foundation on which to continue to build this understanding.

Some Concluding Comments

Many other important findings could be highlighted. For example, boys displayed greater success than girls at retrieving the toy, probably because they also were more likely to use a tool strategy. Does this sex difference arise from the generally higher activity level typically ascribed to boys? Or perhaps from a greater orientation toward instrumentality or some other social or personality characteristic that differentiates the behaviors of boys and girls? Or are the sex differences somehow linked to the spatial aspects of this particular type of problem or a few of the basic components of strategic behavior? Sex differences have not always been found in other types of tasks involving tool use. For example, in a recent study in our laboratory 30-month-old girls, after observing a model, were as likely as boys to select the correct tool and imitate its appropriate action from among various tools associated with a child's workbench (MacConnell, 2000).

Noteworthy, too, is the chapter on individual differences in learning, an aspect of developmental research that all too rarely is included in studies of thinking and problem solving. As Chen and Siegler emphasize, the microgenetic approach is particularly useful in being able to provide such information. Especially informative here was the attempt to identify the influences of both distal (e.g., age, sex, and training condition) and proximal factors (the various components of learning taking place within the task) on the performance of a tool selection strategy.

My guess is that readers will find many other positive aspects pertaining to the theory, method, and findings reported in this Monograph. That is one of the primary reasons that this work will gain wide recognition. It reflects a pivotal approach to bridging the gap between infancy and older
children and will help to reconcile the different vistas that seem so apparent when looking to either side of the great divide. Just as important, I suspect the route along which this work has traveled will be one many researchers will follow, and find extraordinarily valuable, in their efforts to integrate the very different perspectives that, from the present vantage point, seem to veil our understanding of how cognition in infants corresponds with cognition in older children.

References


