Cognitive Development in School-Age Children: Conclusions and New Directions

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CHAPTER 3

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What is the nature of children's knowledge? How does their knowledge change with development? In pursuing these fundamental questions in the study of cognitive development, researchers often expand their focus to include a range of children's behaviors extending far beyond the standard meaning of knowledge.

In the two primary cognitive-developmental traditions, the questions typically take different forms. In the structuralist tradition, influenced strongly by the work of Jean Piaget, Heinz Werner, and others, the questions are: How is behavior organized, and how does the organization change with development? In the functionalist tradition, influenced strongly by behaviorism and information processing, the question is: What are the processes that produce or underlie behavioral change? In this chapter we review major conclusions from both traditions about cognitive development in school-age children.

The study of cognitive development, especially in school-age children, has been one of the central focuses of developmental research over the last 25 years. There is an enormous research literature, with thousands of studies investigating cognitive change from scores of specific perspectives. Despite this diversity, there does seem to be a consensus emerging about (1) the conclusions to be reached from research to date and (2) the directions new research and theory should take. A major part of this consensus grows from an orientation that seems to be pervading the field: It is time to move beyond
opposition of structuralism and functionalism and begin to build a broader, integrated approach to cognitive development (see Case, 1980; Case, 1973; Fischer, 1980; Flavell, 1982a). Indeed, we argue that without an integration attempts to explain the development of behavior are not med.

The general orientations or investigations of cognitive development are lar for all age groups—infancy, childhood, and adulthood. The vast of investigations, however, involve children of school age and for e children a number of specific issues arise, including in particular the ionship between schooling and cognitive development.

This chapter first describes the emerging consensus about the patterns of tive development in school-age children. A description of this con- us leads naturally to a set of core issues that must be dealt with if developmental scientists are to build a more adequate explanation of demental structure and process. How do the child and the environment borate in development? How does the pattern of development vary s traditional categories of behavior, such as cognition, emotion, and l behavior? And what methods are available for addressing these issues research?

Under the framework provided by these broad issues, there are a number ferent directions research could take. Four that seem especially prom- to us involve the relationship between cognitive development and ontal dynamics, the relationship between brain changes and cognitive lopment, the role of informal teaching and other modes of social in- tion in cognitive development, and the nature and effects of schooling literacy. These four directions are taken up in a later section.

**PATTERNS OF DEVELOPMENTAL CHANGE**

One of the central focuses in the controversies between structuralist and ionalist approaches has been whether children develop through stages. o of this controversy has been obscured by fuzzy criteria for what counts age, but significant advances have been made in pinning down criteria Fischer and Bullock, 1981; Flavell, 1971; McCall, 1983; Wohlwill, 1982. In addition, developmentalists seem to be moving away from pitting uralism and functionalism against each other toward viewing them as ementary; psychological development can at the same time be stagelike me ways and not at all stagelike in other ways. As a result of these t advances in the field, it is now possible to sketch a general portrait of status of stages in the development of children.

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**The General Status of Stages**

Children do not develop in stages as traditionally defined. That is, (1) their behavior changes gradually not abruptly, (2) they develop at different rates in different domains rather than showing synchronous change across domains, and (3) different children develop in different ways (Feldman, 1980; Flavell, 1982b).

Cognitive development does show, however, a number of weaker stagelike characteristics. First, within a domain, development occurs in orderly sequences of steps for relatively homogeneous populations of children (Flavell, 1972). That is, for a given population of children, development in a domain can be described in terms of a specific sequence, in which behavior a develops first, then behavior b, and so forth. For example, with Piaget and Inhelder's (1941/1974) conservation tasks involving two balls or lumps of clay, there seems to be a systematic three-step sequence (see Hooper et al., 1971; Uzgiris, 1964): (1) conservation of the amount of clay (Is there more clay in one of the balls, even though they are different shapes, or do they both have the same amount of clay?), (2) conservation of the weight of clay (Does one of the balls weigh more?), and (3) conservation of the volume of clay (Does one of the balls displace more water?). The explanation and prediction of such sequences is not always easy, but there do seem to be many instances of orderly sequences in particular domains.

Second, these steps often mark major qualitative changes in behavior— changes in behavioral organization. That is, in addition to developing more of the abilities they already have, children also seem to develop new types of abilities. This fact is reflected in the appearance of behaviors that were not previously present for some particular context or task. For example, in pretend play the understanding of concrete social roles, such as that of a doctor interacting with a patient, emerges at a certain point in a developmental sequence for social roles and is usually present by the age at which children begin school (Watson, 1981). Likewise, the understanding of conservation of amount of clay develops at a certain point in a development sequence for conservation.

More generally, there appear to be times of large-scale reorganization of behaviors across many (but not all) domains. At these times, children show more than the ordinary small qualitative changes that occur every day. They demonstrate major qualitative changes, and these changes seem to be characterized by large, rapid change across a number of domains (Case, 1980; Fischer et al., in press; Kenny, 1983; McCall, 1983). Indeed, the speed of change is emerging as a promising general measure for the degree of reorganization. We refer to these large-scale reorganizations as levels. We use
the term steps to designate any qualitative change that can be described in terms of a developmental sequence, regardless of whether it involves a new level.

Third, there seem to be some universal steps in cognitive development, but their universality appears to depend on the way they are defined. When steps are defined abstractly and in broad terms or when large groups of skills are considered, developmental sequences seem to show universality across domains and across children in different social groups. When skills of any specificity are considered, however, the numbers and types of developmental steps seem to change as a function of both the context and the individual child (Bullock, 1981; Feldman and Toulmin, 1975; Fischer and Corrigan, 1981; Roberts, 1981; Silvern, 1984). For large-scale (macrodevelopmental) changes, then, there seem to be some universals, but for small-scale (microdevelopmental) changes, individual differences appear to be the norm. The nature of individual differences seems to be especially important for school-age children and is discussed in greater depth in a later section.

Large-Scale Developmental Reorganizations

In macrodevelopment there seem to be several candidates for universal large-scale reorganizations—times when major new types of skills are emerging and development is occurring relatively fast. Different structuralist frameworks share a surprising consensus about most of these levels, although opinions are not unanimous (Kenny, 1983). The exact characterizations of each level also vary somewhat across frameworks. Our descriptions of each level, including the age of emergence, are intended to capture the consensus.

Between 4 and 18 years of age—the time when many children spend long periods of time in a school setting—there seem to be four levels. The first major reorganization, apparently beginning at approximately age 4 in middle-class children in Western cultures, is characterized by the ability to deal with simple relations of representations (Bickhard, 1978; Biggs and Collis, 1982; Case and Khanna, 1981; Fischer, 1980; Isaac and O'Connor, 1975; Siegler, 1978; Wallon, 1970). Children acquire the ability to perform many tasks that involve coordinating two or more ideas. For example, they can take elementary perspective-taking, in which they relate a representation of someone else's perceptual viewpoint with a representation of their own (Flavell, 1977; Gelman, 1978). Similarly, they can relate two social categories, e.g., understanding how a doctor relates to a patient or how a mother relates to a father (Fischer et al., in press).

The term representation here follows the usage of Piaget (1936/1952; 1946/1951), not the meaning that is common in information-processing models (e.g., Bobrow and Collins, 1975). Piaget hypothesized that late in the second year children develop representation, which is the capacity to think about a thing that is not present in their immediate experience, such as an object that has disappeared. He suggested that, starting with these initial representations, children show a gradual increase in the complexity of representations throughout the preschool years, culminating in a new stage of equilibrium called "concrete operations" beginning at age 6 or 7.

Research has demonstrated that children acquire more sophisticated abilities during the preschool years than Piaget had originally described (Gelman, 1978), and theorists have hypothesized the emergence of an additional developmental level between ages 2 and 6—one involving simple relations of representations. The major controversy among the various structural theories seems to be whether this level is in fact the beginning of Piagetian concrete operations or a separate reorganization distinct from concrete operations. Many of the structural approaches recasting Piaget's concepts in information-processing terms have treated this level as the beginning of concrete operations (Case, 1980; Halford and Wilson, 1980; Pascual-Leone, 1970).

For Piaget (1970), the second level, that of concrete operations, first appears at age 6–7 in middle-class children. In many of the new structural theories, concrete operations constitute an independent level, not merely an elaboration of the level involving simple relations of representations (Biggs and Collis, 1982; Fischer, 1980; Flavell, 1977). The child comes to be able to deal systematically with the complexities of representations and can understand what Piaget described as the logic of concrete objects and events. For example, conservation of amount of clay first develops at this level. In social cognition the child develops the capacity to deal with complex problems about perspectives (Flavell, 1977) and to coordinate multiple social categories, understanding, for example, role intersections, such as that a man can simultaneously be a doctor and a father to a girl who is both his patient and his daughter (Watson, 1981).

The third level, usually called formal operations (Inhelder and Piaget, 1955/1958), first emerges at age 10–12 in middle-class children in Western cultures. Children develop a new ability to generalize across concrete instances and to handle the complexities of some tasks requiring hypothetical reasoning. Preadolescents, for example, can understand and use a general definition for a concept such as addition or noun (Fischer et al., 1983), and they can construct all possible combinations of four types of colored blocks (Martarano, 1977). Some theories treat this level as the culmination of concrete operations, because it involves generalizations about concrete objects and events (Biggs and Collis, 1982). Others consider it to be the start
of something different—the ability to abstract or to think hypothetically (Case, 1980; Fischer, 1980; Gruber and Voneche, 1976; Halford and Wilson, 1980; Jacques et al., 1978; Richards and Commons, 1983; Selman, 1980).

Recent research indicates that cognitive development does not stop with the level that emerges at age 10–12. Indeed, performance on Piaget’s formal operations tasks even continues to develop throughout adolescence (Martarano, 1977; Neimark, 1975). A number of theorists have suggested that a fourth level develops after the beginning of formal operations—the ability to relate abstractions or hypotheses, emerging at age 14–16 in middle-class Western children (Biggs and Collis, 1982; Case, 1980; Fischer et al., in press; Gruber and Voneche, 1976; Jacques et al., 1978; Richards and Commons, 1983; Selman, 1980; Tomlinson-Keasey, 1982). At this fourth level, adolescents can generate new hypotheses rather than merely test old ones (Arlin, 1975); they can deal with relational concepts, such as liberal and conservative in politics (Adelson, 1975); and they coordinate and combine abstractions in a wide range of domains.

Additional levels may also develop in late adolescence and early adulthood (Biggs and Collis, 1980; Case, 1980; Fischer et al., 1983; Richards and Commons, 1983). At these levels, individuals may be able to deal with complex relations among abstractions and hypotheses and to formulate general principles integrating systems of abstractions.

Unfortunately, criteria for testing the reality of the four school-age levels have not been clearly explicated in most cognitive-developmental investigations. There seem to be little question that some kind of significant qualitative change in behavior occurs during each of the four specified age intervals, but researchers have not generally explicated what sort of qualitative change is substantial enough to be counted as a new level or stage.

Learning a new concept, such as addition, can produce a qualitative change in behavior; but by itself such a qualitative change hardly seems to warrant designation as a level. Thus, clearer specification is required of what counts as a developmental level.

Research on cognitive development in infancy can provide some guidelines in this regard. For infant development, investigators have described several patterns of data that index emergence of a new level. Two of the most promising indexes are (1) a spurt in developmental change measured on some continuous scale (e.g., Emde et al., 1976; Kagan, 1982; Seibert et al., in press; Zelazo and Leonard, 1983) and (2) a transient drop in the stability of behaviors across a sample of tasks (e.g., McCall, 1983). Research on cognitive development in school-age children would be substantially strengthened if investigators specified such patterns for hypothesized developmental levels and tested for them. Available evidence suggests that such patterns may index levels in childhood as well as they do in infancy (see Fischer et al., in press; Kenny, 1983; Peters and Zaidel, 1981; Tabor and Kendler, 1981).

In summary, there seem to be four major developmental reorganizations, commonly called levels, between ages 4 and 18. Apparently, the levels do not exist in a strong form such as that hypothesized by Piaget (1949, 1975) and others (Pinard and Laurendeau, 1969). Consequently, the strong stage hypothesis has been abandoned by many cognitive-developmental researchers, including some Piagetians (e.g., Kohlberg and Colby, 1983). Yet the evidence suggests that developmental levels fitting a weaker concept of stages probably do exist.

Relativity and Universality of Developmental Sequences

One of the best-established facts in cognitive development is that performance does not strictly adhere to stages. On the contrary, developmental stages vary widely with manipulations of virtually every environmental factor studied (Flavell, 1971, 1982b). Developmental unevenness, also called horizontal decalage (Piaget, 1941), seems to be the rule for development in general (Biggs and Collis, 1982; Fischer, 1980). During the school years it may well become even more common than in earlier years. By the time children reach school age they seem to begin to specialize on distinct developmental paths based on their differential abilities and experiences (Gardner, 1983; Horn, 1976; McCall, 1981). Some weak forms of developmental stages—what we have called levels—probably exist, as we have noted, but they occur in the face of wide variations in performance.

Since developmental unevenness has been shown to be pervasive, it seems inevitable that developmental sequences will vary among children and across contexts. Unfortunately, there have been few investigations testing for variations in sequence. Most of the studies documenting the prevalence of decalage are designed in such a way that they can detect only variations in the speed of development on a fixed sequence, not variations in the sequence itself. The dearth of studies testing for individual differences in sequence, apparently arises from the fact that cognitive developmentalists have been searching for commonalities in sequence, not differences.

Nevertheless, a few studies have expressly assessed individual differences, and their results indicate that different children and different situations do in fact produce different sequences (Knight, 1982; McCall et al., 1977; Roberts, 1981). A plausible hypothesis is that developmental sequences are relative, changing with the child, the immediate situation, and the culture.
To examine this hypothesis researchers must face an important hidden issue—the nature and generality of the classifications used to code successive levels or steps of behavioral organization. Indeed, when issues of classification are brought into the analysis, it becomes clear that universality and relativity of sequence are not opposed. With a general mode of analysis, children can all show the same developmental sequence in some domain, while with a more specific mode of analysis they can all demonstrate different sequences in the same domain.

Figure 3-1 helps show why. The arrows and solid boxes depict developmental paths taken by two children, boy X on the left and girl Y on the right. The letters in the boxes indicate the specific content of the behaviors at each step, and the hyphens connecting letters indicate that two contents have been coordinated or related. The word step is used to describe a specific point in a sequence without implying how that step relates to developmental levels such as those described above.

Depending on how these sequences are analyzed, they can demonstrate either commonalities or individual differences—that is, that both children move through the same sequences or that each child moves through a different sequence. When viewed in terms of the specific steps each child traverses, the figure shows different developmental sequences. At step 1, child X can control a skill or behavior F, and at step 2 he can control skills F and M separately but prefers F. Finally he reaches step 3, where he can relate F to M. Child Y at step 1 can control skill M, and at step 2 she can control both M and F but prefers M. Finally she reaches step 3, where she can relate M to F. For example, in social play, F might represent the social category for father, M the social category for mother, F-M an interaction in which the father dominates, controlling what the mother does, and F M an interaction in which the mother dominates, controlling what the father does. Thus, all three steps clearly differ for the two children.

Such plurality would seem to contradict the idea of a universal developmental sequence, since the two children are demonstrating different sequences for similar content. Yet when the specific steps are characterized more generally, it is possible to see these different paths as variations on a common theme. Analysis in terms of the social categories present, for instance, leads to the conclusion that steps 2 and 3 are the same in the two children: At step 2 both children comprehend the two separate categories of mother and father, and at step 3 they both understand how a mother and a father can interact.

In a still more general classification, the steps can be defined in terms of social category structure rather than the particular categories. Then, steps 2 and 3 remain equivalent for the children, and, in addition, step 1 becomes equivalent, since both children control similar structures, a single category (mother or father). In addition, skills that deal with markedly different contents can also be considered equivalent. An interaction between a doctor and a patient is equivalent structurally to the interaction between mother and father at step 3, since both interactions involve a social role relationship between two categories.

When cognitive-developmental theorists posit general developmental levels, they are defining developmental sequences even more abstractly—terms of highly general, structural classes of behaviors. For the levels of concrete operations, for example, the conservation of amount of clay can be considered structurally equivalent to the intersection of social categories (Fischer, 1980). Conservation of clay involves the coordination of two dimensions (length and width) in two balls of clay, and the intersection of categories involves the coordination of two social categories for two people (such as doctor/father with patient/daughter).

These considerations lead to a reconceptualization of the controversy over whether developmental sequences are relative or universal. For highly specific classes of behavior, universality would seem impossible, relativity inevitable. At the extreme, even the social category of mother is not the same for the two children, since the behaviors and characteristics that each child includes in the category undoubtedly differ. As a result of such variation, no two randomly chosen children could be expected to show the same specific developmental sequences. Even identical twins exposed, say, to a common mathematics curriculum would follow developmental paths for mathematics unidimensional.
livered in detail. Thus, a useful analysis must distinguish irrelevant relevant detail and generalize over the latter.

Of course, what counts as relevant detail depends on the researcher's more focused concerns. And care must be taken to avoid trivialization of the issue of relativity in a second way—by using overly general or ill-defined classes. It is important that what counts as an equivalent structure be specified with precision. For example, all instances of two units of something cannot be treated as equivalent unless there is a clear rationale for classifying them as equivalent. With social categories, it would seem unwise to treat someone as structurally equivalent to "corporation president." One of the research tasks in cognitive developmental theories is to devise a system for analysis of structural equivalences across domains (Flavell, 1972, 1982a; Wohlwill, 1973).

Assuming an opposition between relativity and universality, then, is too simple, because at times individual differences may usefully be seen as variables on a common theme. Many of the current disagreements among researchers about universality and relativity in sequences could be clarified by consideration of the nature of the structural classifications being used. Practice, investigators can use a straightforward rule of thumb: They can restrict their classes at an intermediate degree of abstraction—neither so specific as to miss valid generalization nor so general that they serve only the purpose of imposing order.

The controversy about relativity and universality will be resolved in part on whether the structures and processes of developmental relativity can be usefully regarded as similar across different domains of development and across children who differ in their achievements within domains. Can the growth of linguistic skill be usefully described in the same terms as the growth of mathematical skill? Or are there distinct linguistic and mathematical faculties whose development remains fundamentally different in any useful system for classifying sequences (Gardner, 1983)? Is there a difference between a retarded child and a prodigy? A difference in the speed of mastering what can usefully be considered a sequence (Feldman, 1980)? These questions are just beginning to be addressed in a sophisticated manner.

Processes of Development

Many of the questions about the nature of developmental stages, their relativity, and the extent of individual differences would be substantially better understood by a solid analysis of the processes underlying cognitive development. However, the best way to conceptualize the results of the extensive research literature on developmental processes is very much an open question. No emerging consensus is evident here, except perhaps that none of the traditional explanations is adequate. Three main types of models have dominated research to date.

The first type of model grows out of Piaget's approach. The developing organization of behavior is said to be based fundamentally in logic (Piaget, 1957, 1975). Developmental change results from the push toward logical consistency. Stages are defined by the occurrence of an equilibrium based on logical reversibility, and two such equilibria develop during the school years—one at concrete operations and one at formal operations.

Tests of this process model have proved to be remarkably unsuccessful. The primary empirical requirement of the model is that, when a logical equilibrium is reached, individuals must demonstrate high synchrony across domains. The prediction of synchrony arises from the fact that at equilibrium a logical structure of the whole (structure d'ensemble) emerges and quickly pervades the mind, catalyzing change in most or all of the child's schemes. Consequently, when a 6-year-old girl develops her first concrete operational scheme, such as conservation of number, the logical structure of concrete operations should pervade her intelligence in a short time, according to Piaget's model. Her other schemes should quickly be transformed into concrete operations.

Such synchrony across diverse domains has never been found. Instead, synchrony is typically low, even for closely related schemes such as different types of conservation (e.g., number, amount of clay, and length). Even if one allows that several concrete operational schemes might have to be constructed before the rapid transformation occurs, the evidence does not support the predicted synchrony (Biggs and Collis, 1982; Fischer and Bulluck, 1981; Flavell, 1982b).

Attempts to study other implications of the logic model also have failed to support it (e.g., Braine and Rumin, 1983; Ennis, 1976; Osherson, 1974). Several attempts have been made to build alternative models based on some different kind of logic (e.g., Halford and Wilson, 1980; Jacques et al., 1978). But thus far there have been only a few studies testing these models, and it is therefore not yet possible to evaluate their success.

The second type of process model in cognitive-developmental theories is based on the information-processing approach. The child is analyzed as an information-processing system with a limited short-term memory capacity. In general, the numbers of items that can be maintained in short-term memory are hypothesized to increase with age, thereby enabling construction of more complex skills. The exact form of the capacity limitation is a matter of controversy, but in all existing models it involves an increase in the...
number of items that can be processed in short-term or working memory. An increase is conceptualized as a monotonic numerical increment from 1 to 2, and so forth, until some upper limit is reached.

This memory model has been influential and has generated a large amount of interesting research, although it has not yet produced any consensus about the exact form of the hypothesized memory process (Dempster, 1981; Siegler, 1978, 1983). One of the primary problems with the model seems to be the difficulty of using changes in the number of items in short-term memory to explain changes in the organization of complex behavior. Although analysis of behavioral organization is always difficult, the distance between the minimal structure in short-term memory and the complex structure of a behavior is as conservation or perspective-taking seems to be particularly difficult. How can a linear numerical growth in memory be transformed to a change from, for example, concrete operational to formal operational perspective-taking skills (Elkind, 1974)? Although such a transformation may be possible, its nature has not proved to be transparent or simple (Flavell, 1984).

Moreover, how to conceptualize working memory is itself a controversial issue. Various investigators have challenged the traditional conceptualization at there is an increase in the size of the short-term memory store (Chi, 1978; Dempster, 1981; see also Grossberg, 1982: chs. 11 and 13). Fortunately, ever richer developmental models involving ideas about working memory capacity have continued to appear since Pascual-Leone's (1970) groundbreaking work (see Case, 1980; Halford and Wilson, 1980), and it is hoped that one of these will be successful in overcoming the problems mentioned.

The third common type of model assumes that development involves continuous change instead of general reorganizations of behavior like those elicited by the logic and limited-memory models. The fundamental nature of intelligence is laid down early in life, and development involves the cumulation of more and more learning experiences. Behaviorist analyses of cognitive development constitute one of the best-known forms of this reactionist model. A small set of processes defines learning capacity, such as conditioning and observational learning, and all skills—ranging from the flexes of the newborn infant to the creative problem solving of the artist, scientist, or statesman—are said to arise from these same processes (Bandura and Walters, 1963; Skinner, 1969). Any behavioral reorganizations that might occur are local, involving the learning of a new skill that happens to be useful in several contexts.

Some information-processing approaches also assume that the nature of intelligence is laid down early and that development results from a continuous accumulation of many learning experiences: The child builds and revises a large number of cognitive "programs," often called production systems (Gelman and Baillargeon, 1983; Klahr and Wallace, 1976). Children construct many such systems, such as one for conservation of amount of clay and one for conservation of amount of water in a beaker. At times they can combine several systems into a more general one, as when conservation of clay and conservation of water are combined to form a system for conservation of continuous quantities. These reorganizations remain local, however. There are no general levels or stages in cognitive development—no all-encompassing logical reorganizations and no general increments in working memory capacity.

Researchers who believe in the continuous-change model tend to investigate the effects of specific types of processes or content domains on the development of particular skills. One of the processes emphasized within the continuous change framework has been automatization, the movement from laborious execution of a skill or production system to execution that is smooth and without deliberation. Several studies have demonstrated that automatization can produce what seem to be developmental anomalies. When school-age children are experts in some domain, such as chess, they can perform better than adults who are not experts (Chi, 1978). More generally, many types of tasks produce no differences between the performances of children and adults (Brown et al., 1983; Goodman, 1980).

In research on specific content domains, the general question is typically how the nature of a domain affects a range of developing behaviors. For example, the nature of language, mathematics, or morality is said to produce "constraints" on the form of development in relevant behaviors (Keil, 1981; Turiel, 1977). Development in domains that involve self-monitoring, such as knowledge about one's own memory processes (metamemory), is hypothesized to have general effects on many aspects of cognitive development (Brown et al., 1983; Flavell and Wellman, 1977).

Within the continuous-change, functionalist framework, investigators often assume that there is some intrinsic incompatibility between general cognitive-developmental reorganizations and effects of specific domains or processes. Yet it is far from obvious that any such incompatibility exists. The process of automatization can have powerful effects on developing behaviors, and at the same time children can show general reorganizations in those behaviors (Case, 1980). The domain of mathematics can produce constraints on the types of behaviors children can demonstrate, and at the same time those behaviors can be affected by general reorganizations. The reason for the assumption of incompatibility seems to be that developmentalists view the logic and limited-memory models as incompatible with the continuous-change model.
assumption of incompatibility between reorganization and continuous
to stem from the fundamental starting points of the models:
logic and short-term memory models focus primarily on the organism
focus of developmental change, whereas the continuous models focus
environmental factors. Several recent theoretical efforts have sought to
beyond this limit of the three standard models by providing a more
sensory interactional analysis, with major roles for both organismic and
In particular, approaches that explicitly include both organism and envi-
the working constructs for explaining developmental processes
provide the most promise for future research.

THE CENTRAL ISSUES IN THE FIELD TODAY
differences among the traditional approaches to development are
ant to understand, but they seem much less significant today than
aid 10 years ago. A pervasive change in orientation seems to be taking
among behavioral scientists—a shift away from emphases on competing
is toward integrating whatever tools are available to explain behavior
whole person, in all of his or her complexity. The present era seems
a time of integrating rather than splitting. Structuralism and func-
ism, for example, are seen not as competing approaches but as com-
ponentary ones, emphasizing different aspects of behavior and development.
An orientation is evident throughout this volume.

ne study of cognitive development, this change in the field appears
associated with attempts to go beyond certain fundamental limitations
ous approaches and to move toward a more comprehensive framework
acterizing and explaining cognitive development. At least three basic
ns have arisen as part of this movement toward a new, integrative
rk. All three involve efforts to avoid conceptual orientations that
oved problematic in past research. The most fundamental of the
questions is: How do child and environment jointly contribute to
development? The other two questions involve elaborations of
ston: How do developing behaviors in different contexts and do-
ate to each other? What methods are appropriate for analyzing
development? In a general way the answers to these questions
development at any age, but the answers apply in particular ways
age children.

The Collaboration of Child and Environment
entral unresolved issue in the study of cognitive development today
be the manner in which child and environment collaborate in
development. As a result of the cognitive revolution, it is generally accepted
that the child is an active organism striving to control his or her world. But
this emphasis on the active child often seems to lead to a neglect of the
environment. Contrary to the structural approaches of such theorists as
Piaget (1975) and Chomsky (1965), it appears to be impossible to explain
developing behavior without giving a central role to the specific contexts
of the child's action, including those in the school environment (see Scribner

Giving context a central role does not mean merely demonstrating once
again that environmental factors affect assessments of developmental steps.
Researchers have documented these effects in thousands of studies, thus
pointing out the inadequacies of the Piagetian approach to explaining the
unevenness of development. Surely Piaget, Kohlberg (1969, 1978), and
other traditional structural theorists have failed to deal adequately with the
environment. It is also true, however, that the functionalists have not
produced a satisfactory alternative—an approach that both deals with the
environment's roles in development and treats children as active contributors
to their own development (Lerner and Busch-Rossnagel, 1981). An analysis
of the collaboration of child and environment in development is just as
unlikely to arise from a functionalist emphasis on the environment as from
a structuralist emphasis on the child.

A Diagnosis

Why has the study of cognitive development repeatedly fallen back on
approaches that focus primarily on either the child or the environment?
Why have developmentalists failed to build approaches based on the col-
laboration of child with environment?

Historically, developmental psychology has been plagued by repeated fail-
ures to accept what should be one of its central tasks: to explain the emer-
gence of new organization or structure. These failures have most commonly
taken either of two complementary forms. In one form, nativism, the
structures evident in the adult are seen as already preformed in the infant. These
structures need only be expressed when they are somehow stimulated or
nourished at the appropriate time in development. In the second form,
environmentalism, the structures in the adult are treated as already preformed
in the environment. These structures need only be internalized by some
acquisition process, such as conditioning or imitation. Typically, structuralist
approaches assume some form of nativism, and functionalist approaches
assume some type of environmentalism.

Although it is common to focus on the difference between nativism and
environmentalism, there is a fundamental similarity, a common preformism.
h approaches reduce the phenomena of development to the realization of preformed structures. The mechanisms by which the structures are realized clearly differ, but in both cases the structures are present somewhere in the start—either in the child or in the world (Feffer, 1982; Fischer, 1984; Sameroff, 1975; Silvern, 1984; Westerman, 1980).

A mature developmental theory, we believe, must move beyond explanation by reduction to preexisting forms. It must build constructs that explain child and environment collaborate in development, and one of the many tasks of such constructs must be to explain how new structures emerge in development (Bullock, 1981; Dennett, 1975; Haroutunian, 1983). If the future is not to be a reenactment of the past, it is important to ask if it has been so difficult to avoid drifting toward one or another type of preformism. Why has no well-articulated, compelling alternative to preformism been devised? Any compelling alternative to preformism must describe how child and environment collaborate to produce new structures during development. Constructing such a framework is an immensely difficult task. Fortunately, even approaches that have explicitly attempted to move beyond preformist views have typically failed to do so. Piaget provides a case in point. He set out expressly to build an interactionist position, an approach that would deal with both child and environment and thus avoid the pitfalls of reductionism, which environmentalism (Piaget, 1947/1950). Yet the theory he eventually built placed most of its explanatory power on the child and neglected the environment.

Consider, for example, his famous digestive metaphor for cognitive development. Just as the digestive system assimilates food to the body and modifies the characteristics of the particular type of food, so children assimilate an object or event to one of their schemes and accommodate the new to the object or event. Piaget seems to have chosen this metaphor as a device to avoid preformist thinking, yet he still drifted back toward preformism. In practice, the focus for applications of the metaphor was assimilation of experience to preexisting schemes. The other side of the metaphor—accommodation to experience—was systematically neglected. For example, Piaget (1936/1952, 1975) differentiated many different assimilations but generally spoke of accommodation in only global, general terms. Similarly, the structures behind Piaget's developmental stages—concrete operations and formal operations in school-age children—were treated as characteristics of the child. The environment was granted an ill-defined role in supporting the emergence of the structures, but the structures themselves were treated as if they came to be fixed characteristics of the child's mind (Piaget and Inhelder, 1966/1969). In a genuinely interactionist position, these structures would have been attributed to the collaboration of the mind with particular contexts. Piaget's neglect of the environment became particularly evident when he was faced with a host of environmentally induced cases of developmental unevenness (termed horizontal decalage). His response was that it was simply impossible to explain them (Piaget, 1971:11). Because of Piaget's neglect of the environment, even supporters of his position have argued that it is essentially nativist (Beilin, 1971; Broughton, 1981; Flavell, 1971).

Toward a Remedy

If the foregoing diagnosis is accurate, any remedy must explicitly counteract the tendency to drift toward attributing cognitive structures to either the child or the environment. What is needed seems to be a framework providing constructs and methods that researchers can use to explicitly deal with both child and environment when they characterize how new structures emerge in development.

What might such a framework look like? Many would recommend general systems theory, because it views the child as an active component in a large-scale dynamic system that includes the environment. To date, however, systems theory does not seem to have been successful in promoting research explicating the interaction between child and environment in development. Many investigators appear simply to have learned the vocabulary of the approach without changing the way they study development. Apparently, the concepts of systems theory lack the definiteness needed to guide empirical research in cognitive development toward a new interactional paradigm. A few provocative approaches based on general systems concepts have begun to appear in the developmental literature (e.g., Sameroff, 1983; Silvern, 1984), but they seem to bring to bear additional tools that specifically promote interactional analyses.

It is in such practical tools that the proposed remedy lies. To promote interactional analyses, a framework needs to affect the actual practice of cognitive-developmental research. We would like to suggest that the concept of collaboration may provide the basis for such a framework.

The Collaborative Cycle

Human beings are social creatures, who commonly work together for shared goals. That is, people collaborate. Often when two people collaborate
solve a problem, neither one possesses all the elements that will eventually 
be in the solution. During their collaboration, a social system (Kaye, 
1982) emerges in which each person’s behavior supports the other’s behavior 
thought in directions that would not have been taken by the individual 
without collaboration. Indeed, even after the structure has developed, the individuals 
are able to access it only by reconstituting the collaboration. Of course, 
ies having the same two people collaborate again, it is also possible for 
them to collaborate with a different partner (Bereiter and Scardamalia, 
Brown et al., 1983; Maccoby and Hartup, in this volume).

Figure 3-2 shows this developmental process as a collaborative cycle. The 
left circles represent, respectively, structures that are external and in-

to an individual. Consider a girl engaged in solving a puzzle with her 
father. The father provides external structures to support or scaffold her 
solving by stating the goal of the task, lining up a puzzle piece to 
light how it fits in its particular place, providing verbal hints, and so 
(Brown, 1980; Kaye, 1982; Wertsch, 1979; Wood, 1980). The child’s 
ledge and skills for solving the puzzle constitute the core of the de-
ing internal structures.

The collaboration of external and internal structures produces the be-

tal episodes represented in the right circle. The girl and her father 
at solving the puzzle, and, as a result of the collaboration, she can 
ve a scaffolded mental state, which she could not achieve by herself 
ically or in the same form.

The feedback arrows running from the right circle to the left ones in 
3-2 show the dependence of developmental change on collaboration. 
forming the task in a scaffolded interaction, the girl learns the goal 
puzzle and how to go about solving it without her father’s help. She 
ops more sophisticated internal structures so that she is less dependent 
complex external structures provided by her father. Of course, 
ment of this ability takes many steps: The father constantly updates 
affording to fit the child’s present knowledge and skill. In this way, 
mental change occurs both inside the child and outside her—an 
overlooked fact to which we will return.

Such human behavior there is indeed a collaboration between two or 
individuals. Recent socially oriented analyses of development have 
ized this process. Sometimes the emphasis is on the joint contribu-
of collaborating individuals, and the process is called coregulation or 
thing similar (see Feldman, 1980; Markus and Nurius, Maccoby, and 
er, in this volume; Westerman and Fischman-Havstad, 1982). Some-
times the emphasis is on the role of the parent or older child in supporting 
and advancing the child’s behavior, and the process is called scaffolding or 
something similar, as in Figure 3-2 (Bruner, 1982; Kaye, 1982; Laboratory 

Even when a child is acting alone, collaboration can occur because the 
nonpersonal environment can play the role of collaborator. Because envi-
ronments have structures, every environment supports some behaviors more 
than others. For example, a tree that has strong branches far down on its 
trunk provides strong support for climbing, a tree with only high branches 
provides less support, and a pole with no branches provides little support.
If course, much about human environments is socially constructed. Consequently, the collaboration between child and environment often involves people even when no other person is immediately present, because people have constructed the physical environment to correspond with mental structures that organize their activity. Good examples include a library with spatial/topical organization of its many books and a classroom with its schedules, chalkboards, and wall displays all designed to facilitate the types of interactions needed for schooling.

**Implications for Research**

Although the collaboration approach has not yet been fully articulated, it already seems to have straightforward implications for research practice. Child and environment are always collaborating to produce a behavior, and explanations of that behavior must invoke characteristics of both. As a practical procedure to encourage such explanations, investigators can use research designs that vary important characteristics of both the child and environment. With such designs, variations in both child and environment are likely to affect behavior (Fischer et al., in press; Hand, 1981).

A series of studies on the development of understanding social categories illustrates how this type of research design can lead to analyses of the collaboration between child and environment in cognitive development (Hand, 82; Van Parys, 1983; Watson and Fischer, 1977, 1980). The studies were designed to test several predicted sequences for the development of social categories such as the social roles of doctor and patient and the social interaction categories of “nice” and “mean.” Each study was designed to include variations in both the child and the environment.

The main variable involving child characteristics was age. A wide age range was included in each study to ensure substantial variation in children’s activities to understand the social categories. Ages ranged from 1 to 12 and included the relevant periods for the major developmental reorganizations in preadolescent school-age children.

To determine the contribution of environmental characteristics, behavior assessed under three different conditions, which were designed to provide varying degrees of support for advanced performance. In a structured condition—the elicited-imitation assessment—a separate task was administered for each predicted step in the developmental sequence. The subject was given a story embodying the skill required for that step and was asked to out the story. Thus this condition provided high environmental support for performance at every step. The other two conditions provided less support and thus assessed more spontaneous behavior. In the free-play condition, each child played alone with the toys, acting out his or her own stories. In the best-story condition the experimenter returned to the testing room and asked the child to make up the best story he or she could.

The results showed a systematic effect of environmental support on the child’s performance, but the effect varied as a function of the developmental level of the child’s best performance. For the first several steps in the developmental sequence, virtually all children showed the same highest step in all three conditions. However, a major change occurred beginning with the first step testing the developmental level of simple relations of representations (which typically emerges at approximately age 4). At this step most children performed at a higher step in the structured assessment than in the two more spontaneous conditions, and that gap grew systematically in the later steps in the sequence. Figure 3-3 shows these results for the studies of the social roles of doctor and patient, and parallel results were

![Figure 3-3](image)
ained in studies of the social interaction categories of nice and mean (ind., 1982), and the self-related categories of gender and age (Van Parys, 3).

A similar design and method was used to test for an analogous phenomenon in adolescents. The developmental sequence involved the moral concepts of intention and responsibility. It was predicted that at the cognitive-developmental level of formal operations (also called “single abstractions”) the highest development would show the same highest step in a structured assessment and spontaneous condition. However, when they became capable of performing at the next developmental level, relations of abstractions, a major would appear between performance in the structured and spontaneous conditions. The prediction was supported. Once again, the highest developmental step that the individual demonstrated varied systematically as a function of both the individual’s capacity and the environmental condition (Sher et al., 1983).

Analyzing results of this sort, a proponent of a noncollaborative approach would ask which condition provides the best assessment of the child’s true competence. The collaboration theorist replies, “You’ve missed the point. Competence as traditionally assessed is a joint function of child and environment.” The child does not have any true competence independent of cultural environmental conditions. Competence varies with degree of supervision for an individual child research can be designed to investigate variables in both the child and the environment. Cole and Traupman (1983), for example, assessed a learning disabled child’s capabilities using a range of cognitive tests and examined his performance in settings outside the home. They found that, in settings involving social interactions with people, his disabilities were hardly noticeable because he used his skills to compensate for them. Thus, the portrait of the child in a real-life testing situation was vastly different from the portrait in a real-life setting. It is surprising how few cognitive-developmental studies have systematically varied characteristics of both child and environment. Typically, studies note either changes with age and ability or changes resulting from environmental factors. In the infrequent studies that include variations in both and environment, the interpretations often neglect the interaction stead focus on the child and the environment separately. For example, studies criticizing Piaget’s work demonstrate that variations in environmental conditions produce developmental unevenness (decalage), but sometimes deal with the variations as a function of children’s age or sex. Fortunately, there are a growing number of exceptions to this characterization—studies that seriously consider the effects of both child and environment on performance. The results of these studies are already beginning to transform explanations of cognitive development (see O’Brien and Overton, 1982; Rubin et al., 1983; Tabor and Kendler, 1981).

The Transformation of Concepts of Ability and Competence

As these research examples illustrate, analyzing development as a collaborative process leads to a reconceptualization of many basic cognitive-developmental concepts. Since every behavior can be seen to depend on a collaboration between child and environment, it becomes impossible to analyze any behavior without including both organismic and environmental factors.

Cognitive developmentalists and psychometricians commonly speak of children’s ability, or capacity, or competence, as if a child possessed a set of static characteristics that could be defined independently of any context: One child has the ability to understand conservation of water, and another child does not. As soon as the collaborative role of the environment is introduced, these concepts must be radically changed. Competence is not a fixed characteristic of the child but an emergent characteristic of the child in a specific context. It is not enough to make a distinction between competence and performance, because in standard usage this distinction begs the question. The assumption is made that children really do possess a set of competences, but they are somehow prevented from demonstrating them in their performance (Overton and Newman, 1982). If concepts such as ability and competence are to be consonant with a collaboration approach, they must be redefined in terms of the interaction of child with environment.

Within a collaboration approach, concepts of ability and competence retain their utility, because the child is part of the analysis, too. In certain contexts, children perform up to a certain level of complexity and not beyond it, thus demonstrating a certain competence for those contexts. At times children show partial knowledge of what is needed for a particular task (Brown et al., 1983; Feffer, 1982) and so demonstrate the competence for collaboration with a more knowledgeable partner. Also, children evidence large individual differences in the facility with which they can generalize an ability to new contexts, thus demonstrating variations in the competence to generalize. Upon the emergence of formal operation, for example, very bright children seem to be able to use their new capacity quickly in a wide range of tasks, whereas children of normal intelligence take much longer to extend the capacity to many tasks (Fischer and Pipp, 1984; Webb, 1974).
The collaboration orientation poses many new questions for the study of cognitive development. It is not enough to ask questions such as: How does a child's behavior change with age, or how does the child's behavior change as a function of experience? Instead, questions like the following need to be asked: Why do children often perform below capacity? How does context support or fail to support high-level performances that are known to be within the child's reach? How do specific collaborative systems support the acquisition of particular skills in different ways at different developmental levels? How is the nature of the child's experience jointly regulated by the child and by resources (human and other) available in the child's environment? Later, we examine several lines of research that show promise of contributing answers to such questions.

Integrating Across Traditional Research Categories

In the same way that scholars are coming to treat child and environment collaborators in development they are recognizing the need to integrate traditional categories for categorizing behavior. Cognition and emotion, for example, are not separate in the developing child. There seem to be at least three reasons for this changing orientation.

First, after decades of research, developmentalists have found that a child's behavior does not fit neatly into separate boxes labeled cognition, emotion, motivation, social skills, personality, and physical development (see, for example, Harter, 1982, 1983; Selman, 1980). Indeed, even behavior in the restricted, intuitively appealing categories such as perspective taking and social interaction does not fit together coherently (see Hooper et al., 1971; Uzgiris, 1964). Behavioral development has not proved to obey the "obvious" categories devised by developmentalists.

Second, the general movement toward integrating diverse approaches and studies of child development is leading to an emphasis on the collaboration of child and environment and also to the consideration of relations between behaviors in the traditional categories: How does emotional development relate to cognitive development? How does social development relate to cognitive development? Instead of one set of researchers studying cognitive development, while another set studies a social child, and still another studies an emotional child, the field is moving toward viewing the child whole—a cognitive, social, emotional, motivated, personal, biological whole—during the last 20 years the cognitive-developmental orientation has become a dominant influence in the study of development, and it has provided a major impetus toward integration. The central questions in the study of cognitive development involve the organization of behavior and processes underlying behavioral change. Because these questions are so general and fundamental, their applicability is not limited to the traditional domain of cognitive development—increments in knowledge about "cold" topics, such as objects, space, and scientific principles. All behavior, including that involving "hot" topics, such as emotions and social interaction, is organized in some way and undergoes developmental change.

The movement toward integration across behavioral categories has been promising, and many interesting results have come from research in this new tradition. But thus far progress has been limited by several conceptual difficulties.

Overcoming the Obstacles

One of the central conceptual problems has been the tendency to reify the traditional behavioral categories despite the lack of evidence that children's behavior fits the categories. Thus, the most common hypotheses about the relationship between, for example, cognitive development and social development have assumed the validity of cognition and social skills as separate categories. This assumption is especially clear when cognitive development is postulated as a prerequisite for social development.

One such hypothesis that has received much attention involves the relationship between cognition and morality: Cognitive development is hypothesized to be a prerequisite for moral development (see Kohlberg, 1969). In practice, this proposition has been taken to mean that performance on Piagetian tasks is a prerequisite for performance on Kohlberg's moral dilemmas. Why should conservation of amount of clay, for instance, be a prerequisite for moral reasoning based on normative concepts of good and bad (Kohlberg's stage 3)? Is there any sense in which conservation is included in the concepts of good and bad? Or is there any way that conservation is more fundamental to mental functioning than concepts of good and bad? Isn't it just as reasonable (or unreasonable) to suggest that concepts of good and bad may be a prerequisite for conservation? If evidence does not support the division of behavior into separate categories of cognition about science problems and moral reasoning, it cannot be meaningful to suggest that such cognition is a prerequisite for moral reasoning (Rest, 1979, 1983).

A similar problem arises when investigators assume that the behaviors captured by the traditional categories are totally separate, showing no relation to each other at all. One of the most neglected topics for school-age children is emotional development, which is sometimes treated as if it is...
Cognitive development during middle childhood

Implications for Research

Since the traditional categories for categorizing behavior do not seem to make sense to analyze development across categories. More generally, concern for explaining development in the whole child and for building on the knowledge of the collaboration of child and environment means that researchers assess behavior in multiple contexts and with various methods. In doing such research, however, developmentalists need to avoid allowing the categories to limit their thinking, as when coldness is considered to be a prerequisite for moral reasoning, and to avoid assuming that a single variable will provide a valid index of overall behavior, as when head growth is treated as if it directly reflects cognitive changes.

Practice, doing research on development across traditional categories closely related to doing research on the collaboration of child and environment in development. In both cases a number of variables must be measured in several settings, and the investigator must analyze not only each variable itself but also the relations among variables. Consider, for example, research on the effects of divorce on the school-age child. It would appear to be wise to assess (1) the child's understanding of family roles and the effects of divorce on that understanding, (2) the child's emotional reactions to the divorce, (3) the types of social interactions between parents and child and the changes in those interactions that resulted from the divorce, (4) the child's attitudes toward the parents, and so forth. On the basis of the collaboration argument, it may also be important to measure each of these factors under several different degrees of environmental support. Obviously, such research is difficult because it can quickly become unmanageably complex.

Despite this complexity it is possible to do research on patterns of development across categories without either being overwhelmed by complexity or becoming entangled in the conceptual problems that have plagued much past research. At least two helpful guidelines can be articulated: First, development should be analyzed in what promises to be a coherent domain of personal functioning. For example, an investigator might study the mastery of early skills involved in learning to read words (for example, Knight, 1982) or the relationship of divorce to a child's understanding and use of social roles in the family. Within such domains the investigator can examine development in different contexts while still keeping the project within a manageable scope. In addition, the coherence of the domain itself will often provide environmental support to guide the investigator's efforts.

Second, the researcher needs to use methods and measures appropriate to the questions being addressed. Of course, this admonition has been made often. In cognitive-developmental research, however, inadequate methods have been used repeatedly even when appropriate methods were available. In addition, recent innovations in developmental methodology have provided powerful methods for studying many fundamental developmental issues, including relationships between development in different contexts.

Methods of Assessing Development Change and Continuity

Cognitive-developmental research has not generally been distinguished by the sophistication of its methodology. One of the primary reasons has been that the traditional methods used in the behavioral sciences are not appropriate for studying such issues as developmental change and continuity (Wohlwill, 1973). Analysis of variance, for example, was originally constructed to test whether one or more factors made a difference in the outcomes of independent, equivalent groups. It was not constructed to examine...
questions about cognitive-developmental issues such as changes in the organization of behavior.

Children almost invariably become smarter as they grow older, and so it has been a simple matter in cognitive-developmental research to use analysis of variance to demonstrate differences between age groups and to use correlations to demonstrate relations between development and age. By themselves, such differences and relations can be uninteresting unless they help answer important questions such as the following: Do children show a systematic developmental sequence in a given domain? Does that sequence demonstrate reorganization of behavior? Are there differences in the speed of developmental change at different times in that domain? Across domains or contexts, are there systematic relations among sequences, reorganizations, changes in speed, or other developmental patterns?

Fortunately, there has recently been substantial progress in constructing designs, measures, and statistics for asking developmental questions (Applebaum and McCall, 1983; Bart and Krus, 1973; Coombs and Smith, 1973; Fischer et al., in press; Krus, 1977; Siegler, 1981; Wohlwill, 1973). Although we do not review all these methods here, we do sketch some of the important concepts behind them.

**Developmental Sequences**

Systematic change is clearly one of the fundamental concerns of developmental science in general. In cognitive development the tool used most often to describe and analyze systematic change has been the developmental sequence—a series of steps, levels, or stages that portray how behavior gradually changes from some starting point to some endpoint (Flavell, 1972). As a descriptive tool the sequence has been at the center of cognitive-developmental research, providing the core set of observations on which most cognitive-developmental theories are based, ranging from classical approaches (for example, Piaget and Inhelder, 1966/1969; Werner, 1957) to more recent ones (for example, Case, 1980; Siegler, 1981).

Developmental sequences demonstrate not only developmental change but also a form of developmental continuity. They describe how one type of behavior gradually changes into another, and scales based on sequences can be used to examine when change is relatively gradual and continuous and when it is relatively abrupt and discontinuous.

Since the developmental sequence is so important to the study of cognitive development, scaling should clearly be a central concern in research. Documenting that a description of a series of steps in fact forms a scale would seem to be integral to the research enterprise, yet very few investigations of cognitive development in school-age children demonstrate a basic concern with scaling.

The most common type of study in published cognitive-developmental research fits the following description. Children from a few different age groups are tested on several tasks. For example, 5-, 8-, and 11-year-olds are tested on three tasks: one task for conservation of number of plastic chips, one for conservation of amount of clay in a ball, and one for conservation of amount of water in a beaker. Performance on each task is scored on a three-step hypothesized sequence. Step 1 reflects a clear nonconservation response, such as a statement that the amount changes when the array is transformed. Step 2 indicates a transitional or ambiguous response, as when a child states that the amount stays the same but gives no satisfactory elaboration or explanation. Step 3 indicates an answer showing full conservation. An analysis of variance is then performed on the results, which demonstrate that, for each of the three tasks, performance improved across the three age groups and that performance for one or two tasks was significantly better than that for the other tasks. For example, children had significantly more advanced scores for conservation of number than for the other two tasks.

These analyses clearly demonstrate that the older groups performed better than the younger ones—hardly a surprise. The results document little else of interest, failing even to test directly for any developmental sequences. They do not adequately test the hypothesized three-step sequence, nor do they demonstrate that the three conservation tasks form a two-step sequence, with conservation of number developing before the other two.

To test a developmental sequence an independent assessment is required of each step in the hypothesized scale (Fischer and Bullock, 1981). With such an assessment it is possible to test directly whether one step comes consistently before or after another. Performance on the independent assessments should form a Guttman (1944) scale, in which every child passes all the steps prior to his or her highest step passed (and fails all the steps after the lowest step failed). Table 3-1 shows the possible performance profiles that are consistent with a simple eight-step Guttman scale. Scales can also be more complex, with two or more tasks at a single step, as for step 2 in Table 3-2. Indeed, methods are available for tracing highly complex scales, such as those that branch into multiple parallel paths (Bart and Krus, 1973; Coombs and Smith, 1973; Krus, 1977).

The design of the hypothetical study of conservation allows only one such direct test for sequence. Because of the independent assessment of the three types of conservation, a sequence involving those types can be tested. For example, consider a two-step sequence in which the first step is full un-
predicted order. From one testing to the next, children should either move to a higher step or remain at the same step. This design has been used very effectively in research on moral development to demonstrate that the stages hypothesized by Kohlberg do in fact form a developmental sequence (Colby et al., 1983; Kuhn, 1976; Rest, 1983). The use of scalogram assessments in longitudinal research would provide even greater power and precision, however. With separate tasks to assess each step, individual children's development could be traced in detail. We know of no studies of cognitive development in school-age children using scalograms with a longitudinal design.

Of course, longitudinal research is not needed to test a developmental sequence. With a cross-sectional design, powerful methods are available for rigorously testing a predicted developmental sequence, as suggested by Tables 3-1 and 3-2. Scalogram statistics can be used to test how well the data fit the predicted scale (Green, 1956), and measures approximating a developmental scale can be devised when a specific sequence cannot be predicted. A strong scalogram measure, in which a different task is constructed a priori to assess each predicted step in a sequence, can be especially useful because the theoretical interpretation of each task can be specified unambiguously. For the most part, however, researchers have not taken advantage of the obvious virtues of scalogram methods for testing sequences or other hypotheses about development.

In most published studies, scalability tests are not reported even when the design allows them. The apparent reason for the neglect of scalogram methods is that, when they were used to test some of the detailed developmental sequences inferred by Piaget from mean age differences between tasks, the scalability of the sequences was poor (Hooper et al., 1979; Kofsky, 1966; Wohlwill and Lowe, 1962). Instead of concluding that Piaget's sequences were incorrect, developmentalists seem to have shot the messenger that brought the bad news: They discarded scalogram methods, for the most part. Fortunately, this unwarranted neglect of a powerful method appears to be coming to an end.

The cognitive-developmental issues that can be addressed with scalogram methods include the following: (1) With independent assessments of each step, the parallels and differences between developments in different contexts can be traced precisely (Corrigan, 1983). (2) Individual differences in developmental sequences can be directly tested, especially when separate assessments are used to detect hypothesized differences (Knight, 1982). (3) Changes in the speed of development can be detected.

The particular method will vary with the hypothesis, of course. For instance, to test for changes in the speed of development, such as spurts and

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**TABLE 3-1** Strong Scalogram Method: Profiles for an 8-Step Developmental Sequence

<table>
<thead>
<tr>
<th>Developmental Step</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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</tbody>
</table>

*NOTE: Correct performance of a task is indicated by +.*

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**TABLE 3-2** Profiles for a Measure With Two Tasks at Step 2

<table>
<thead>
<tr>
<th>Developmental Step</th>
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<th>K</th>
<th>L</th>
<th>M</th>
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</table>

*NOTE: Correct performance of a task is indicated by +.*
ateaus, it is essential that subjects be sampled such that their ages are distributed evenly (Fischer et al., in press). If a developmental spurt is elicited at age 10, for example, it is necessary to sample children evenly throughout the age range between 9 and 11. If all children tested are at a restricted ages, such as within a few months of age 9 or 11, it will be possible to determine whether a difference between 9- and 11-year-olds reflects a developmental spurt, since the distribution of ages alone will produce a bunching of subjects at certain steps in the scale.

Several studies using appropriate designs to assess speed of development have found that speed does seem to accelerate at certain ages during the toddler years and to slow down at other ages (Jacques et al., 1978; Kenny, 1983; Tabor and Kendler, 1981). That is, there may be periods of discontinuity and periods of continuity as assessed by speed of development. Current studies are consistent with the hypothesis that spurts are associated with the ge-scaling methods that approximate a Guttman scale, McCall et al. (1977) produced a developmental spurt, since the distribution of ages alone will produce a bunching of subjects at certain steps in the scale.

Rule-Assessment Methods

developmental sequences are a central concern in cognitive research, but emphasis on the relations of behavior across contexts highlights the fullness of the logic of rule assessment and focuses on school-age children (as does most rule-assessment research).

Typically, “rule” refers to a mental procedure whose operation affects performance on many problems within a task domain. Virtually all of the various approaches to specifying rules derive from the theory of production systems (Newell and Simon, 1972), which analyzes human behavior in terms of systems of rules for generating actions. A rule is defined in terms of a condition-action pair, in which the condition for taking some action is specified abstractly. For example, in simple arithmetic tasks involving division, such as 13 divided by 3, a sequence of rules can be used to describe the division procedure. After an estimate has been made of the whole number required in the quotient, a rule applies for dealing with what is left over, the remainder: If the remainder is less than the divisor, a fraction is made, with the remainder as the numerator and the divisor as the denominator. The “if” clause specifies the condition, and the “then” clause gives the action to be followed. For 13 divided by 3 the estimated whole number is 4. Application of the rule leads to the following procedure: The remainder of 1 is less than the divisor of 3, and therefore the remainder is made into a fraction of 1/3.

To use this rule across division problems, the child must check the current situation to see whether it meets the condition specified in the rule. Such checking can be done only if the rule is represented in some general format. To start with, the child must be able to distinguish which number is currently serving as remainder and which as divisor. Neither remainder nor divisor can be specified in the rule in terms of particular numerical values, such as 1 and 3, respectively, because across problems all numbers can be in both categories.

Researchers can determine whether a child is using such a rule in some set of problems by testing him or her on a number of division problems. The child is said to be using the rule whenever the pattern of behaviors (answers or methods of solution) on some set of the problems fits the rule. The child does not have to state the rule explicitly.

Though the concept of “rule” was controversial two decades ago, today it provides a basis for one of the most promising approaches for exact specification of the cognitive structures underlying child performance. Indeed, it also promises more generally to provide a powerful tool for describing change and continuity in cognitive organization.

In practice, research based on the rule-assessment approach has been characterized by two prominent features. First, it has provided highly differentiated models of regularities in behavior across contexts, including not
correct performances but also errors. This research has articulated the hypothesis that errors form coherent patterns that derive from immature procedures (see Roberts, 1981; Siegler, 1981). Thus, both errors and correct performances can serve as indexes of a child’s rule system for a particular task domain.

The rule-assessment approach has fostered what might be called a “bundle of rules.” Some researchers who use rule-assessment techniques might criticize for depicting the mind as a bundle of rules. Although such an approach avoids the postulation of global, vague cognitive metamorphoses, there is a danger of treating the child too narrowly—as merely a solver of problems, for example. The pull toward the particular seems to be necessary if researchers are to understand the effects of specific environments, but there is no need to stop at the particular. In some work in this tradition, children’s goals figure prominently in the definition of every rule, and these goals can apply across situations. However, the idea of a rule system seems to have within it the seeds of an approach that combines the particular with the general, because rules must interact with one another in such a system (Anderson, 1982; Siegler and Robinson, 1982) and because the construction of rules must be determined in the general nature of the child’s information-processing system.

EXAMPLES OF PROMISING NEW DIRECTIONS

Three central issues in the study of cognitive development—the relation of child and environment, the relationship of development in research categories, and the methods necessary to investigate general questions—lead naturally to a reorientation of research. In going reorientation, as we see it, the study of knowledge defined narrowly is deemphasized, and the study of the organization of behavior in general becomes the focus of developmental inquiry. The analysis of behavioral organization requires topics and methods that directly involve the collaboration of child and environment in development. A number of topics could potentially fit this criterion, but four especially promising new directions that deal with school-age children seem to us to merit the attention of cognitive-developmental researchers: (1) emotional development and its relation to cognitive development; (2) the relation of brain changes to cognitive development; (3) the role of social interaction, especially informal teaching, in cognitive development; and (4) the nature of schooling and literacy and their effects on cognitive development.

Cognitive Development and Emotional Dynamics

Emotion is becoming a central research topic, not only in the study of development but also in behavioral science more generally. From the 1940s until the mid-1970s, so little research was done on emotional development that it was fair to say that emotions had virtually disappeared from developmental science. In the last 10 years, interest in emotional development has clearly been stirred, and much of the resulting research has dwelt on the relationship between cognition and emotion in development. Researchers on infancy have led the way, with arguments that emotions show major developmental reorganizations that are closely related to cognitive changes (Campos et al., 1978; Emde et al., 1976), and now research on cognition-emotion relationships in childhood is beginning to appear.

Children’s Conceptions of Emotions

The research that seems to have advanced farthest involves the development of conceptions of emotions in school-age children. During the school years, several major changes take place, as children become able to understand that a person can experience two distinct emotions at the same time and then to integrate emotions into abstract categories for interpreting behavior.

To study how children think about their emotions, Harter (1982) devised a series of interview tasks ingeniously adapted to avoid the usual problems that arise with interviewing young children. Her research demonstrated systematic changes in the organization of children’s thinking about emotions in themselves and in other people. One of the central changes was that children gradually became able to conceive of themselves as experiencing
In the adolescent years, children begin to describe themselves and other people in terms like those of personality theories. They use trait names, such as responsible, introspective, and nonconformist, and eventually they even begin to use ideas similar to the Freudian notion of internal psychological conflict.

In general, then, substantial progress has been made toward describing the development of school-age children's conceptions of emotions and related social and personality categories. As valuable as this progress is, there is much more to emotional development than conceptions of emotions.

**Emotional Reorganizations**

One of the most straightforward implications of the organization approach to cognitive development is that each major reorganization or level of development should produce a significant change in emotions. This hypothesis has been pursued most explicitly in infancy, for which data and theory have suggested reliable emotional concomitants of general behavioral reorganizations (Campos et al., 1978; Emde et al., 1976; McCall et al., 1977;
analysis of the Oedipus conflict may well be a part of Freud's (1909/1962) psychoanalytic literature suggests many possible examples of such reorganizations involving emotions. In the development of simple relations of representations at approximately age 4, there appears to be a surge of new emotions accompanying the emergence of social roles in the family. The emotions described in the Oedipus conflict may well be a part of such reorganization (Fischer and Watson, 1981). The understanding of social roles may also lead to a change in the nature of friendships, since the will now be able to understand the role relations in friendship (see Ch. 10, 1982; Hartup, 1983). Any such change in important social relationships would seem almost inevitably to have emotional consequences.

The development of concrete operations at age 6–7, a number of changes have been suggested by Freud and others. At this point, children appear to develop a clear-cut conscience, with an accompanying guilt (Freud, 1924/1961, 1933/1965). They develop the capacity for social comparison, so they can compare and contrast their own behavior with that of other people (Rubin, 1983). Presumably, this capacity can lead to both anxiety and pride about one's relative social standing. Component of this new ability for social comparison may also be a spurt in the development of concrete operations at age 6–7, a number of changes have been suggested by Freud and others. At this point, children appear to develop a clear-cut conscience, with an accompanying conscience. Thus, children can construct new, general concepts about themselves and other people, but they remain unable to compare one such abstraction with another. Consequently, they have difficulty thinking clearly about social roles, because the person could begin to relate an abstraction about his or her own personality to an abstraction about the personality of a loved one (Fischer, 1980).

Freudian Processes

It is no accident that hypotheses suggested by Freud appear repeatedly in the section on emotional reorganizations. Psychoanalysis remains one of the most fertile sources of hypotheses about emotional development. Although researchers have generally neglected psychoanalytic ideas about emotional development, especially for the school-age child, a resurgence of interest is evident.

In fact, there are signs that a major conceptual breakthrough may be in progress. For years many scholars have been dissatisfied with Freud's model of the mind (Hartmann, 1939; Holt, 1976; Schafer, 1976). Repeatedly the suggestion has been made that the cognitive-developmental orientation might provide the framework necessary to rebuild the psychoanalytic theory of the mind (Rapaport, 1951; Schimek 1975; Wolff, 1967). A group of neo-Freudians has been working to construct a position called "object relations" theory that makes significant steps toward integrating the cognitive-developmental and psychoanalytic orientations (for example, Kernberg, 1976; Winnicott, 1971). More recently, Feffer (1982) has suggested a recasting of the distoritions of primary process in cognitive-developmental terms.

These integrations of psychoanalysis and cognitive development have already led to a large number of interesting empirical claims. For example, it has been hypothesized that mechanisms of defense follow a developmental progression (A. Freud, 1966; Fischer and Pipp, in press; Haan, 1977; Vaillant, 1977). Repression appears to first develop at age 3–4, which is the approximate age of emergence of the ability to relate representations.
sophisticated mechanisms of defense, such as sublimation, suppression, and mature humor, do not seem to emerge until after age 11 or 12, when formal operations are beginning. These are only a few of the many interesting hypotheses in the literature about emotional development in school-age children.

Despite the easy access of such hypotheses, there have been few studies testing them. Mahler et al. (1975) assessed the development of mother-child relationships in infants and preschool children, which supported several object-relations hypotheses about the early development of self. With school-age children it is difficult to find any systematic research. Clearly, this is another promising direction.

**Research on Emotions**

One of the reasons for the lack of research on emotional reorganizations and Freudian processes has been that it has proved to be difficult to determine how to investigate them. Research with seriously disturbed children is particularly difficult to do, and the induction of strong emotions in children for research purposes is unethical. As a result, scholars interested in pursuing these important questions have often had to approach them indirectly—studying, for example, the development of children's conceptions of defense mechanisms in other people (Chandler et al., 1978).

A straightforward solution to this dilemma may be available. Many issues in children's everyday lives naturally evoke emotions of various degrees and types. Such issues seem to provide natural avenues for studying the organization of behavior in a way that brings together cognition and emotion.

One set of candidates includes virtually any topic involving the self—identification, identity, self-control, attributions about one's successes and failures. Kernberg (1976) has suggested that one of the primary dimensions around which the psyche is organized is whether events are perceived as threatening to the self or as supportive of the self, and much social-psychological research with adults generally supports this hypothesis (Greenwald, 1980). The development of self in children and its relation to the organization of behavior is a promising avenue for studying cognition-emotion relations.

Another set of issues of special relevance to school-age children is family relations, including the emotional climate in the family. The Oedipus conflict is merely the most discussed of a wide-ranging set of family phenomena that are emotion laden.

Consider, for example, divorce. The proportion of children growing up in divorced families has risen sharply, and some projections place it at 40–50 percent in coming years. The experience of divorce is clearly emotional for many children, and systematic relations seem to exist between emotional problems in adulthood (such as loneliness and depression) and the ages of individuals when their parents were divorced (Shaver and Rubenstein, 1980). In addition, young children seem to seriously misunderstand the causes of their parents' divorce, often blaming themselves for the breakup (Longfellow, 1979; Wallerstein and Kelly, 1980). Research on how children understand and deal with divorce would seem a natural avenue for studying the development of emotion and cognition. How children understand what happened and how they conceive of the relationships in their family will probably relate in interesting ways to how they feel about themselves and their parents.

Children's reactions to illness provide another promising topic for the study of emotion-cognition relations. Virtually all children experience illnesses several times during the school years, and a substantial number of children suffer from chronic illnesses (Shonkoff, in this volume). Research on how children understand what happens during an illness and how they cope with it promises to illuminate cognition-emotion relations in development. Indeed, it would be surprising if mechanisms of defense and other emotional organizations could not be investigated in connection with divorce and illness.

A note about emotional development is in order. In our analysis we have focused on promising areas for study of how emotion relates to cognitive development. In doing so we have not differentiated the many components of emotions, including triggering, expression, suppression, interpretation, and communication. Clearly, a full analysis of emotional development will require study of these components (Campos et al., 1983).

**Relations Between Brain Changes and Cognitive Development**

It is a truism in developmental science that changes in the brain must be central to cognitive development, yet researchers have mostly neglected investigation of the relationship between brain and cognition in development. Recent research on development in animals has begun to illuminate relevant topics, such as the processes by which experience affects the development of the visual system in mammals (Movshon and Van Sluyters, 1981) and the mechanisms by which the brain adjusts to early damage (Goldman-Rakic et al., 1983).

Of course, the methods used to study brain development in animals cannot be applied to human beings, but the paucity of research on the relationship between brain changes and cognitive development in children is nevertheless remarkable. One reason for neglect of this topic seems to be that previous investigations searching for such relationships did not meet with much success. Another reason may be that scientists shy away from the topic because
findings have sometimes led to a simplistic form of reductionist thinking, which any brain changes are assumed to have direct correlates in behavioral development.

Few investigators have studied the relationship between certain global changes in the brain and the cognitive-developmental levels occurring during school years. They have uncovered evidence that brain or head growth spurts on the average at ages 4—5, 6—7, 10—12, and 14—16 (Eichorn Bayley, 1962; Epstein, 1974, 1980; Fischer and Pipp, 1984; Nellhaus, 1981). The primary data involve growth in head circumference and change in certain waves of the electroencephalogram. The data for head circumference tend to support the occurrence of spurts at the expected ages, but there is substantial inconsistency across studies (McQueen, 1982). Fewer studies exist on the electroencephalogram, but extant data appear to be more sestant across samples. For brain-wave characteristics that show consistent increases or decreases with age, children show spurts during the four predicted periods.

Unfortunately, these data have been used to support unjustified conclusions about the nature of cognitive development and learning at various ages during the school years. Children can learn new skills during periods of growth spurts, it has been claimed, but they cannot learn during periods of slow growth (Epstein, 1978, 1980; Toepfer, 1979). Thus, for example, children between ages 12 and 14 are said to be unable to learn new skills, use brain growth shows a plateau rather than a spurt during that period. The conclusions have been based almost entirely on the brain growth data, virtually no assessment of actual learning, despite the limitations of the data, some school systems have begun to portions of their curricula on these unwarranted conclusions. Efforts being made, for example, to build middle-school curricula around the notion that children of middle-school age cannot learn very much because their brains are not undergoing a growth spurt. Clearly, no conclusions about learning ability or recommendations about educational practices can be supported by data on brain growth alone.

Several recent studies have tested the hypothesis that children undergo cognitive spurts when they show head-growth spurts and cognitive growth when they show head-growth plateaus (McCall et al., 1983; Pennington and Cavrell, in press). The results are clear: There was no correlation between head growth and cognitive growth. The most reasonable conclusion is point seems to be that head growth and cognitive-developmental changes are related for large samples but not for individual children. Similar problems have arisen in research on the development of brain lateralization (Kinsbourne and Hiscock, 1983). From a few early findings differences between the right and left hemispheres, some investigators have jumped to broad generalizations about the different natures of intelligence in the two hemispheres. Journalists and educators have gone further and drawn sweeping, unjustified conclusions about the nature of intelligence in general and cognitive development in particular. There seems to be an unfortunate tendency for people to repeatedly make the same unjustified leap from data on brain growth to conclusions about behavior.

This leap is apparently predicated on the assumption that brain developments appear before behavioral changes and then have an immediate, measurable impact on behavior. Based on research on the relationships between developments in other domains, the most reasonable hypothesis is that the relationship between brain changes and cognitive development will be highly complex. Indeed, behavioral changes are probably just as likely to precede brain changes as to follow them. For both head circumference and the electroencephalogram, for example, brain growth shows a spurt one to three years after the first cognitive changes reflecting concrete operations: Concrete-operational skills are first evident as early as age 5.5—6, but brain spurts do not usually appear until age 7—9. One reasonable hypothesis is that small behavioral changes typically precede any global brain changes of the type measured by head circumference and the electroencephalogram.

Some animal research supports the argument that behavioral changes can precede major brain changes (Greenough and Schwarcz, in press).

The findings of correlations between brain growth and cognitive development may eventually lead researchers to examine seriously brain-behavior relationships in development. The research topic is both legitimate and important, and eventually it is likely to produce important scientific breakthroughs. However, the complexity of the topic means that legitimate applications leading to the solution of practical problems almost certainly will not be available for a long time (Shonkoff, in this volume).

Cognitive Development and Modes of Social Interaction

A third promising direction in the study of cognitive development addresses the question of how social interaction dynamically constitutes a favorable climate for the growth of the mind. In the past, psychologists' answers to related questions have often over- or underestimated the contribution of social interaction to normal cognitive development. Recently, renewed interest in the problem has produced a burst of naturalistic and seminaturalistic studies of parent-child and teacher-student interactions.

This new research has begun to chart a middle course between two extreme views of the role of social interaction in cognitive development. The first of these extremes can be called the social learning straw man. It holds that...
Cognitive development is a result of imitation, which is construed as mimicry rather than cognitive reconstruction. The second extreme views cognitive development as a result of autonomous inventions, cognitive reconstructions in which social interaction plays no formative role. Both of these views are caricatures of human development. A minimal task for cognitive developmentalists is to portray the role of social interaction without resorting to either caricature.

The words that best depict the middle-course alternative emerging from recent research are guided reinvention (Lock, 1980; see also Karplus, 1981; Rick, 1976), which acknowledges the social learning theorists' insistence that social guidance is ubiquitous, both within and outside the classroom. They also acknowledge, however, the Piagetian insight that to understand is to reconstruct. Thus, the guided reinvention perspective elaborates the notion that normal cognitive development must be understood as a collaborative phenomenon.

Classical writings on cognitive development, Vygotsky (1934/1962, 4/1978) seems to have best anticipated the guided reinvention perspective. For Vygotsky, an analysis of modes of social interaction is essential for aiding cognitive development. In addition, he argued that an explanation of guided reinvention must use the historical-reconstructive method, which is similar to what Piaget called the "genetic" method. For Vygotsky, the "to understand is to reconstruct" was as apt a summary of the essential theorist's efforts as it was a summary of the child's efforts. Vygotsky believed that developmentalists need to study the dynamics of the developmental process directly, rather than continuing merely to draw inferences from the process from structural analyses of the products of development.

What would a reconstructive understanding of social interaction involve? Of Vygotsky's central tenets was that social interaction is organized on a number of planes and that each successive plane is associated with greater cognitive powers. One way of conceiving these planes is schematized in Table 3-3, adapted from a convergence rate hierarchy proposed in Bullock (1983), which synthesizes social learning theorists' observations about the effects of modeling on learning rate (Bandura, 1971) and Vygotsky's observations about the hierarchically layered nature of social interaction (see also Dennett, 1973; Premack, 1973).

The entire hierarchy might be taken as a schematic for assembling a system for guided reinvention. In this regard, special note should be made of levels 5 and 6, because they mark the crystallization of two complementary roles, i.e., child as reinventor and parent as guide. The words constructive imitation, which describe the social innovation at level 5, are meant to be a reminder of the reconstructive nature of imitation noted by all major students of imitation since Baldwin (1895; Bandura, 1971, 1977; Guillaume, 1926/1971; Kaye, 1982; Piaget, 1946/1951). Many imitative achievements are not mere mimicry; instead, they involve persistent reconstructive efforts on the part of the imitator. These efforts are a major source of developmental organizations, especially when complemented by the purposive teaching spontaneously provided by parents. Also, because constructive imitation engages a wide range of cognitive resources, there is no isolable imitative faculty, as some have supposed.

By hypothesis, constructive imitation by children and purposive teaching by parents are complementary components of an evolved system for guided
the situation of playing a game). Thus, a high degree of social-cognitive coordination requires the achievement of many moments of shared understanding.

Shared understanding is such a critical factor because normal language development is a comprehension-driven process that involves much more than the learning of syntactic patterns (Curtis, 1981; Macnamara, 1972; Nelson, 1973; Wittgenstein, 1953), even though it is sometimes discussed as a pure exercise in pattern learning (Kiss, 1972). Comprehension involves both isolating new patterns and making sense of them by finding a way to articulate them with what is already understood (Clark and Clark, 1977; Schlesinger, 1982). In guided reinvention the child and adult share an understanding of their joint situation, and the adult's speech takes that understanding as a point of departure while heeding developmental and contextual constraints. As a result of this support, the child stands a good chance of being able to comprehend the adult's utterance the first time he or she hears it, even when it contains novel components (Bullock, 1979; Cross, 1977; Wells, 1974).

How do child and adult articulate new patterns with what the child already understands? The child seeks above all to discover the relevance of the adult's contributions to his or her own purposes and goals at the moment. The adult attempts to ensure that his or her acts are relevant to the child's activity in a way that the child is prepared to discover.

How is shared understanding dynamically maintained over long bouts of interaction? Parents of children who exhibit rapid language development actively work to maintain shared understanding over long stretches of interaction. They do this in several ways. They introduce objects to serve as bases for joint activities, and they closely monitor their child's apparent goals or intentions. During most of their interactive turns, they attempt to modulate, correct, or elaborate their child's behavior rather than redirect it. And they construct an internal model of their child's current preferences, skills, and world knowledge, which they continuously update and check (Brown, 1980; Kaye, 1982; Nelson, 1973; Snow, 1977).

**Embedded Teaching and Formal Schooling**

It would certainly be misleading to say that language is not taught, but the type of teaching uncovered in these naturalistic studies of language development is unlike that found in most formal schooling. Under normal conditions it seems that every child receives a steady diet of what might be called embedded teaching—elaborative and corrective acts responsively
bedded by parents in the flow of joint goal-directed activity. As the child
naturally and vigorously works to master a wide range of goals, his or
constructive efforts are constantly guided by the parent's embedded
chaining efforts. Although such efforts do not obviate the need for inventive
inductive efforts by the child (Maratsos, 1983), they appear to be crucial
he child's efforts are to result in a course of development that is recog-
ibly normal.

With preschool and school-age children, research has focused not on
guage learning but on cognitive tasks ranging from puzzle solving to
ical Piagetian tasks such as seriation and conservation. Yet the results
at much the same picture (Heber, 1977; Sonstroem, 1966; Wertsch,
; Wood, 1980). In his survey of this small body of research; Wood
0) concluded that “where instruction is contingent on the child's own
ilities and related to what he is currently trying to do. . . . considerable
gress may be made” (p. 290). His survey also revealed that when instruc-
techniques depart from the embedded teaching mode the child's prog-
is markedly slowed. Finally, in research on the learning cycle or guided
covery approach to the instruction of mathematical reasoning, this embed-
teaching method was very successful in a domain in which many students
with more traditional classroom techniques (Karplus, 1981).

Much more research along these lines is needed, especially with school-
children. We expect that studies of embedded teaching with older chil-
will show it to be superior to “disembedded” teaching, especially in
promotion of lasting changes in cognitive skills. Here, disembedded
thing means any teaching that departs significantly from guided rein-
tion. On the basis of available research, two characteristics of guided
vention seem particularly critical: (1) any new information provided is
vant to furthering the child's current goal-directed activity, and (2)
formation is provided in a way that is immediately responsive and “pro-
tionate” (Wood, 1980) to the child's varying information needs. Note
much classroom instruction departs from guided reinvention in both
sects.

Recently a number of authors have tried to explain the difficulty many
l ready have making the transition to school or the related difficulty they
in becoming engaged in certain school subjects (Bereiter and Scar-
talia, 1982; Cook-Gumperz and Gumperz, 1981; Donaldson, 1978; Pap-
1980). All these analyses support the idea that many children fail not
use of inability but because they are ill prepared for the mode of social
raction encountered in many classrooms. This ill preparedness—or to
the other way, this ill adaptedness of some schooling modes to what
children naturally expect—has two consequences. First, many children
fail to progress at an acceptable rate and fall progressively further behind
their peers. Second, many children become disaffected with the classroom
setting.

Obviously, these two results are closely linked. Failure to progress implies
continual frustration, which leads to global disaffection. But several lines of
research suggest a deeper relationship. In the literature on the development
of affective relationships, responsiveness seems to play a crucial role in
attatchment formation (Ainsworth, 1979). At every level of the convergence
rate hierarchy, the child's development depends on the contributions of
others in immediate social interaction. In parametric research on what makes
educational computer games attractive, contingency on the child's behavior
in essential (Malone, 1981). And in informal research on how to make
mathematics more appealing, Papert (1980) even speaks seriously of the
child's affective relationship to the world of mathematics. Given the human
ability to personify, there is no reason to dismiss Papert's usage as mere
metaphor.

There is ample evidence that several qualities of dyadic social interaction
contribute to a positive attitude toward instructional activities, what Malone
(1981) calls their holding power: in particular, goal-directedness, responsiv-
eness, novelty, and performance-contingent shifts in problem difficulty.
Indeed, a classic study by Bowman (1959) showed that disaffected delin-
quents will regain interest in classroom work and markedly reduce their
disruptive behavior when the classroom mode is restructured around goal-
directed activities. Although Bowman failed to find larger academic gains
in the embedded teaching group than in a control group, the study deserves
replication with more sensitive cognitive outcome measures and with a
better-designed “guided reinvention” curriculum.

We would like to raise another issue, although we cannot pursue it here.
We noted earlier that the disembedded teaching that children encounter in
many classroom settings does not meet their expectations. However, this
statement is too weak because it presents too passive a picture of the student.
We believe that children actively try to structure their interactions such
that the type of teaching they receive is the embedded type. Children
demand involvement as performers rather than as mere observers. (See
Barker and Gump, 1964, for the classic treatment of this distinction.) A
common childhood plea is “I want to be included and help you do it, not
just watch.” In this connection it is also interesting to note a convergence
with Harter's (1978) revision of the concept of competence motivation.
According to her reformulation, the child with high competence motivation
actively resists excessive guidance in joint-task contexts.
Collaboration Not Conservation

As noted in the introduction to this section, history shows that it has been quite difficult to maintain a balanced view of the role of social interaction in cognitive development. Many seem to think of the problem according to the scheme of a "conservation" equation: Child's Contribution + Social Contribution = A Constant Amount of Knowledge. Given this scheme, the laws of algebra demand that if the child's contribution goes up the social contribution must go down, and vice versa. Any theorist who focuses on one factor is led by the scheme to downplay the other. But the scheme itself is plainly inappropriate. Not only is the amount of knowledge not conserved, but the evidence indicates that social factors contribute most when embedded within the child's own ongoing efforts at mastery. As Bullock (1983) noted when proposing the convergence rate hierarchy, higher cognitive potentials seem to arise with specific new types of social interaction. By emphasizing the concept of guided reinvention, we hope to have made it difficult for investigators to continue thinking in terms of the conservation scheme.

Because this treatment stands on the shoulders of Vygotsky's pioneering work and because the next section is devoted to the topic of literacy, it is fitting to round off this section with Vygotsky's (1934/1978:117-118) prescient remarks about the need for embedded teaching of literacy:

"Reading and writing must be something the child needs. Here we have the most vivid example of the basic contradiction that appears in the teaching of writing not only in Fontesser's school but in most other schools as well, namely, that writing is taught as a matter of hand and finger habits but as a really new and complex form of speech."

The Effects of Schooling and Other Literate Practices

One of the most promising new directions for cognitive-developmental research concerns the cognitive effects of literacy and formal schooling (Cole & Bruner, 1971; Cole & Griffin, 1980; Goody, 1977; Luria, 1976; Olson, 76; Ong, 1982; Scribner and Cole, 1981; Vygotsky 1934/1978). This new area has live roots in anthropology, educational theory, historiography, philosophy, linguistics, and developmental and cross-cultural psychology. These roots give the area both a singular vitality and a special promise for promoting communication among relatively isolated academic disciplines (Ong, 1982). Moreover, literacy and schooling relate closely to the emphasis on the interaction between child and environment in cognitive development. The effects of literacy and schooling seem to arise from the environmental supports they provide for advanced cognitive functioning. To understand cognitive development in the child in school, scientists and educators need to understand how the teaching of literacy and schooling relates to the child's natural learning processes and how literacy and schooling affect the child's mind.

Our treatment of literacy effects necessarily begins with the problem of definition, because there are many literacies and each may have distinctive cognitive-developmental effects. The range of literate practices is analyzed in terms of how each functions in mental life. This analysis leads to the specification of appropriate methods for assessing the cognitive effects of literate practices. The approach presented here represents what seems to be an emerging consensus about literacy and schooling.

Defining Literacy

What are the cognitive effects of literacy? According to recent research (Goody, 1977; Scribner and Cole, 1981), answering this question in a scientifically useful manner requires careful specification of what is meant by literacy. All literacies involve both (1) one or more conventionalized systems for external representation of ideas and (2) a set of cultural practices that use the systems. Literacies include all conventionalized representational systems, not just alphabetic writing. Any cognitive consequences can be expected to be determined jointly by the specific nature of a representational system and its associated practices. As a reminder of these points, we use the words literate practices rather than literacy.

Table 3-4 presents some literate practices that span a range from simple labeling (practice 1) to scientific theory construction (practice 9). To illustrate the vastness of this span, we discuss two extreme cases of literate practices: the use of a limited writing system by some men in West Africa and the use of multiple representational systems by modern scientists. The vast differences between these two cases suggest enormous differences in their cognitive consequences.

In the first case, men belonging to the rural Vai people in West Africa are taught a native script (Scribner and Cole, 1981). (Literate practices are virtually absent among Vai women.) The Vai script is a syllabary, a system for representing speech phonetically syllable by syllable. In this system a text consists of a continuous stream of symbols without any segmentation.

Defining Literacy

What are the cognitive effects of literacy? According to recent research (Goody, 1977; Scribner and Cole, 1981), answering this question in a scientifically useful manner requires careful specification of what is meant by literacy. All literacies involve both (1) one or more conventionalized systems for external representation of ideas and (2) a set of cultural practices that use the systems. Literacies include all conventionalized representational systems, not just alphabetic writing. Any cognitive consequences can be expected to be determined jointly by the specific nature of a representational system and its associated practices. As a reminder of these points, we use the words literate practices rather than literacy.

Table 3-4 presents some literate practices that span a range from simple labeling (practice 1) to scientific theory construction (practice 9). To illustrate the vastness of this span, we discuss two extreme cases of literate practices: the use of a limited writing system by some men in West Africa and the use of multiple representational systems by modern scientists. The vast differences between these two cases suggest enormous differences in their cognitive consequences.

In the first case, men belonging to the rural Vai people in West Africa are taught a native script (Scribner and Cole, 1981). (Literate practices are virtually absent among Vai women.) The Vai script is a syllabary, a system for representing speech phonetically syllable by syllable. In this system a text consists of a continuous stream of symbols without any segmentation.
markers such as blanks to indicate word boundaries. Also, homophonic syllables (such as boar and bore in English) are always represented by the same symbol. These characteristics make it virtually impossible to read Vai script rapidly with full comprehension. Because of this limitation as well as competition from other scripts, the Vai script is highly restricted in the range of practices it supports. The script is neither taught nor used in formal school settings, and its major use is letter writing (practice 3 in Table 3-3). Scribner and Cole report that letters written in Vai script are short and limited to expected themes. Because of the difficulty of reading the script, longer texts on novel themes would overwhelm even the most accomplished Vai readers. Not one Vai occupation depends critically on the use of the script.

At the other extreme, consider a modern scientist working at the frontiers of the field of neural modeling of cognitive processes (Grossberg, 1982). A single paper published in this area may draw on a tool kit of conventionalized representations that includes (1) standard written English, including the modern Roman alphabet and numerous other conventions; (2) mathematical equations, including modern number systems and the Greek alphabet; (3) a biochemical symbol system; (4) labeled graphs that are a hybrid of iconic and more arbitrary representational devices; (5) a computer language used to write simulation programs; and (6) models of memory, cognitive development, and other psychological processes. All these resources are being used to compose a new formalism capable of expressing a set of critical theoretical distinctions (practice 9) for characterizing the design principles exhibited by the human brain.

Modern science has institutionalized the practice of inventing such new representational systems. This enterprise is critically dependent for its success on both the evolving representational systems already in the tool kit and the evolving tradition of scientific practices (e.g., techniques for studying nonlinear differential equations, computer simulation techniques, and so forth). Equally important, the whole enterprise would be inconceivable to anyone who was unschooled in similar literacy-based practices. Even for someone who knew some such practices but was not familiar with the specific tool kit, the enterprise would be difficult to conceive with any specificity. The scientific enterprise is thus much farther removed from the preliterate world than is the Vai practice of writing simple status reports or orders.

Consequently, it would be odd to expect the Vai male’s literacy to have the same cognitive effects as the neural modeler’s literacy. In fact, both persons differ in some way from nonliterate because of their shared encounter with an external, representational system in use. Yet that common difference pales in comparison with other intellectual differences arising from the distinctiveness of their literate practices.

A common question in research has been whether some specific cognitive effect should be attributed to literacy or to formal schooling. The definitional problems with such a question are similar to those with questions about the effects of literacy alone. The term formal schooling is just as ill defined as the term literacy. Moreover, posing a dichotomy between literacy and formal schooling obscures the fact that all types of formal schooling are literacy based. Though it is possible to have literate practices without formal schooling, it is not possible to have formal schooling without literate practices. In general, formal schooling and literate practices are closely linked. Many literate practices with distinctive cognitive effects were probably invented in an attempt to improve schooling (Goody, 1977), and many children encounter these practices for the first time in a school setting.

### Characterizing the Range of Literate Practices

The literate practices in Table 3-4 are divided into three groups: amplification, nonlocal integration, and systemic analysis. These labels are meant to capture qualitative differences in how literate practices seem to function in the cognitive life of individuals and to suggest directions for research on literate practices.

In amplification, some human ability already exists in some form, and the literate practices simply magnify that ability (Cole and Bruner, 1971;
and Griffin, 1980). For example, labeling of containers (practice 1) des redundant cues for identifying contents and thus often increases
peed of identification. Listing donations (practice 2) duplicates a pre-
ate mnemonic achievement and supports more accurate recall. The
ng of orders (practice 3) substitutes for speaking them in a way that
's the orders to affect people at greater distances. Note that these are
ntitative (amplifying) effects. They leave the structure of the activity
 unchanged.

Literate practice can do more than amplify. It can induce a qualitatively
cntent (Cole and Griffin, 1980). Though the distinction between
itative and qualitative is sometimes fuzzy, it is useful. Classical writings
itive development describe two pervasive functions of literate prac-
tions: nonlocal integration and systemic analysis shown in Table 3-3 (e.g.,

ny literate practices support nonlocal integration of materials that
otherwise remain separate. Under aliterate conditions, thoughts tend
from one content to the next on the basis of characteristics that are
ervel obvious and that have already been recognized. Contents with
ities, complementarities, or other relationships that have not yet been
ized will rarely be juxtaposed in thought. As a result, the undiscovered
ships between them will rarely be discovered.

hen writing, the writer has a device that supports the juxtaposition of
disparately disparate contents and thus raises the chances of discovering
way of integrating experience. As a result, writing can accelerate the
ceptual innovation, forming the core of new types of cultural
es, including the scientific method. By overcoming a systematic limit
memory, it opens up a new range of human practices. For example,
cting the theory of evolution, Darwin had to put together widely
ite contents. Howard Gruber (1981) wrote of Darwin: "To understand
he had seen, and to construct a theory that would do it new justice,
to re-examine everything incessantly from the varied perspectives
se enterprises" (p. 113, italics added). Darwin wrote down obser-
s and thoughts in a series of logs and notebooks to facilitate this
. Indeed, the experimentalist's practice of keeping a log is a partic-
clear example of how writing can overcome the limitations of memory.
g supports simultaneous consideration of experiments that are tem-
and conceptually remote.

Local integration is certainly not unique to literate practices. Under
conditions it would seem to occur primarily in social interactions
 communicating individuals try to reconcile disparate schemes. It
is probably common in language and cognitive development, when a child
is trying to reconstruct integrative schemes underlying adult usage (Feldman,
1980; Horton and Markman, 1980; Laboratory of Comparative Human Cogni-
tion, 1983; Perret-Clermont, 1980). Among adults it can occur when
individuals confront each others' disparate ways of organizing experience.
At the same time, literacy practices themselves support a heterogeneity of
adult perspectives unheard of in aliterate cultures. After the invention of
literate practices, a language's stock of terms based on nonlocal integration
explodes (Slaughter, 1982). Apparently, literacies support lifelong use of
a type of integration that would otherwise be rarely exploited after the early
years of development.

A third function of literate practices, systemic analysis, occurs whenever
the focus of a thinker's concern is the adequacy of an entire representational
system. Nonlocal integration promotes the building of conventionalized
representational systems, and systemic analysis involves the evaluation of
those systems. It seems that literate practices provide strong support for the
ability to consider such systems and to analyze and compare them.

Consider the following historical examples. The ancient Greeks compared
what is now known as the Greek alphabet with various other writing systems
of the time. It was seen as an improvement over its competitors because it
could represent vowel sounds as well as consonantal sounds (practice 8 in
Table 3-4). Riemannian geometry was an improvement over Euclidean geo-
metry because it provided a better representation of physical space under
relativistic conditions (practice 8). Most behavioral scientists have joined
the enterprise of trying to formulate a new cognitivist theoretical system for
thought and behavior because the old behaviorist system appears to be
inherently unequal to the task of modeling psychological phenomena (prac-
tice 9).

Systemic analysis is fundamental to the modern scientific enterprise. Mod-
ern scientists are acutely aware that at some future date their current systems
for representing reality will probably prove inadequate. They take it as their
task to contribute to a better, but never final, fit between data patterns and
theoretical models (representational systems) (Goody, 1977; Toulmin, 1972).
Such an attitude has led to ferment on many levels. Scholars of many stripes
struggle with the problems of relativism, and school-age children are confused
at the apparent lack of absolute truth in modern knowledge. To understand
this attitude, children seem to require many years of experience, and they
may be able finally to understand it only when they reach the highest levels
of cognitive development (Kitchener, 1983).

This phenomenon seems to be tightly bound up with the development of
literate practices (Goody, 1977; Ong, 1982). It seems to require at least
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four components: (1) possession of the concept of a representational system, (2) appreciation that the belief system accepted in one’s day is one of many possible systems, (3) presumption that today’s belief system will prove less adequate than some alternatives that have not yet been specified, and (4) institutionalized support of practices that have a history of producing improvements in representational systems. The second, third, and fourth components require historical studies and are therefore literacy dependent in a strict sense, because historical studies do not seem to be possible without written histories. The first component, possession of the concept of a representational system, seems at least to be greatly facilitated by literate practices. The development of this concept in school-age children certainly merits study (Feldman, 1980; Gardner, 1983).

Aliterate cultures seem to provide little environmental support for the concept of a representational system (Goody, 1977), but literacy provides open and direct support for the concept. Writing is permanent, and so language becomes subject to extended scrutiny. As a result, people can conceive the nature and shortcomings of the written system for language. For example, all alphabets are small systems that can be understood as a whole and that are manifestly imperfect in their ability to represent speech. They fail to capture even many of the vocal aspects of speech, such as timing and inflection. These limitations make it relatively easy for literate peoples to abstract the concept of a representational system.

Methods for Assessing the Cognitive Effects of Literate Practices

If this characterization of the functioning of literate practices in mental life is correct, most traditional methods for assessing literacy effects will need to be revised. Consider one assessment strategy used often in the past: The researcher constitutes a group with equal numbers of illiterates and literates and tests all of them on some cognitive task, such as recalling a long list of words. All subjects perform the task in the same way, with no access to literate tools such as pencil and paper. After statistically controlling for factors such as intelligence, age, and social background, the researcher assesses whether there is any residual effect of literacy on performance. To date, the results of such traditional studies have been disappointing, typically showing no, or only modest, effects of literacy (Scribner and Cole, 1981).

In hindsight this failure is not surprising because the studies do not assess the right skills. First, subjects performing the tasks are denied access to the literate tool kit during their performance. Unable to use the external tools of literacy, they are denied environmental support for their literate skills, which typically require operations with external representational devices.

As a result, the main effects of literacy are at best severely attenuated. Second, the research addresses basic cognitive abilities such as recall. Literacy effects that do not permanently amplify such basic abilities go undetected. Third, the major comparison treats illiterates and literates as homogeneous classes, ignoring the tremendous differentiation within the class of literates. In particular, many literates have little exposure to the literate skills most critical to the modern knowledge explosion—the practices that institutionalize nonlocal integration and systemic analysis.

Figure 3-4 shows the range of conditions needed to assess the cognitive effects of literate practices in children or adults. Subjects need to be differentiated according to their literacy status, as shown in the top row. Preliterates are members of cultures that lack any literate practices, while illiterates are aliterate members of cultures rich in literate practices. This distinction permits assessment of whether some cognitive effects of literate practices diffuse within a culture to those who have not actually learned enough to be literate. Nominal literates have learned the basics about using an external representational system but not the practices that promote nonlocal integration and systemic analysis, while advanced literates have mastered some of those practices. This distinction allows assessment of the effects of the advanced literacy skills related to the modern knowledge explosion.

Individuals should be tested with or without access to the external tool kit of literacy, as shown in the second row of the figure. Testing both ways is critical so that researchers can determine whether literacy effects depend on the environmental support of the tool kit. Most past assessments of

<table>
<thead>
<tr>
<th>Person’s Literacy Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliterate</td>
</tr>
<tr>
<td>Access to Tools</td>
</tr>
<tr>
<td>Type of Task</td>
</tr>
</tbody>
</table>

FIGURE 3-4 A matrix of contrasts for the assessment of literacy effects.
Literacy effects have denied access to the tools (Scribner and Cole, 1981) and thus have tested only for the residual effects of prior engagement in literate practices. Also, subjects should be tested on a range of types of tasks, shown in the left column. Many of the effects of literate practices will remain obscure if only basic cognitive abilities are assessed.

**An Emerging Consensus**

The approach outlined here represents an emerging consensus about the sets of literacy (Bullock, 1983; Cole and Griffin, 1980; Goody, 1977; Scribner and Cole, 1981; Slaughter, 1982; Tannen, 1982; Vygotsky, 1934/78; Zebrowski, 1982). This consensus includes an appreciation of at least major characteristics of the functioning of literate practices:

- Literate practices are highly diverse.
- The diversity includes differences not only in the tools of literacy but in the cultural practices related to the tools.
- Many literacy effects depend on long exposure to organized use of tool kits, and the most interesting literacy effects are probably not automatic products of learning to read, write, or count. Literate practices affect their effects via a long developmental process beginning in the school and extending into adulthood.
- Different literate practices play different roles in mental life, and some of the most important roles seem to involve providing support for functioning levels of cognitive development that emerge in the late school years and beyond.

Of course, the consensus is not complete. Two of the remaining controversies are especially relevant here. First, do literate practices have a pervasive effect on thinking and consciousness, or are their effects highly specific and localized? Second, are literate practices fundamental to the most advanced forms of human thinking, as Vygotsky (1934/1978) believed, or can advanced skills develop without literacy?

Although firm answers to these questions will not be available until more blank cells in Figure 3.4 are filled in, we hazard two predictions. On theoretical grounds (Fischer, 1980; Fischer and Bullock, 1981), and on the basis of available research on literacy effects (see Scribner and Cole, 1981), we expect that some form of the specificity hypothesis will survive the test of time. But along with specificity there can also be some generality. Literacy is itself a vehicle for partially overcoming the natural tendency for processes to remain localized.

Regarding the role of literate practices in advanced forms of thought, we have already proposed that modern scientific enterprises are literally inconceivable to preliterate children because they involve explicit attempts to revise entire conceptual systems. It remains to be seen whether other examples of such systemic analysis can be found among preliterate children (Goody, 1977).

**Literate Practices and Schooling**

We noted earlier that the mode of teaching in traditional schooling departs substantially from the natural teaching mode children experience in everyday life. Instead of being embedded in the course of joint goal-directed activity, teaching is disembodied and organized around domains of knowledge (Slaughter, 1982).

This property of formal schooling appears to be a product of literate practices. In all likelihood the very idea of a domain of knowledge and the disembodied teaching it encourages are two sides of a coin that could only be minted in a literate culture. Only with literacy are words or statements disembodied from the evanescent stream of human action and given the spatial permanence of things. Only with literacy are large bodies of such statements sorted into separate places that are internally organized according to the taxonomic schemes associated with domains of knowledge.

Based on the concept of domains of knowledge, teaching can be disembodied from the world of human purposes and reconceptualized as the transfer of a body of knowledge from one depository (books) to another (children). As Ong (1982:175—177) suggested, the message transfer model of communication appears to be a distortion based in literate educational practice. Fortunately, teachers can reembed their teaching in several ways and reintroduce the natural strategy of guided reinvention. They can show children how what they learn is relevant to everyday goals, and they can introduce the new goals related to domains of knowledge. Children can learn such goals as adding newly encountered facts to the appropriate domain, trying to fill gaps in existing domains, trying to reorganize or reconceptualize domains of knowledge, and trying to transfer organizational schemes from one domain to another. An important topic for research is how schooling practices can be organized to help children make such practices their own.

Modern science could in some ways serve as a model for such research, since it seems to be the epitome of a collaborative, literacy-based enterprise (Toulmin, 1972). Goody, one of the most insightful theorists of literacy effects, made the following argument (1977:46—47, emphasis added):
weakly stagelike characteristics, however. At specific periods a wide range of children's abilities appear to undergo rapid development. These spurts may be particularly evident in children's best performances.

When the various neo-Piagetian theories are compared, there seems to be a consensus, with substantial empirical support, that four of these large-scale reorganizations occur between ages 4 and 18. At approximately age 4, middle-class children develop the capacity to construct simple relationships of representations, coordinating two or more ideas. The capacity for concrete operations emerges at age 6–7, as children become able to deal with complex problems about concrete objects and events. The first level of formal operations appears at age 10–12, when children can build general categories based on concrete instances and when they can begin to reason hypothetically. Abilities take another leap forward at age 14–16, when children develop the capacity to relate abstractions or hypotheses.

Cognitive developmentalists have often assumed that all children move through the same general developmental sequences, but research suggests that such generality occurs at best only for the most global analytic categories, such as concrete and formal operations. With more specific analyses, it seems that children will demonstrate important differences in developmental sequences. Only with research on these differences will a full portrait of school-age children's capacities be possible.

Little consensus exists on the specific processes underlying the cognitive changes that occur during the school years. Most characterizations of these processes fall into two opposing frameworks: an emphasis on changes in organization, usually conceptualized in terms of either logic or short-term memory capacity, versus an emphasis on continuous accumulation of independent habits or production systems. Progress is not likely to arise from continuation of arguments based on this assumption of opposition. The most promising direction for resolution would seem to lie in attempts to determine when abilities show reorganization and when they show continuous accumulation.

What Is Not Known

The new integrative orientation in cognitive-developmental science has led to wide recognition of the need for framing questions in ways that avoid the traditional oppositions that have typified behavioral science. Most centrally, questions have traditionally been formulated in ways that led to answers focusing on either the child or the environment as the main locus of developmental change. What many researchers are striving for today are ways of building constructs that combine the child and the environment as...
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joint determiners of development. A promising direction for this enterprise is a focus on the collaboration of child and environment. The child is seen as always acting in some particular context that supports his or her behavior to varying degrees. One result of this focus is that concepts of ability, capacity, and competence are radically altered. They are no longer fixed characteristics of a child but emergent characteristics of a child in a context. How to recast these concepts is a major unresolved question in cognitive development.

To do research based on the integrative, collaborative orientation, investigators need to assess behavior in multiple contexts and with various methods. It cannot be assumed that a single variable provides a valid index of overall cognitive functioning in any domain or that behavior is truly divided into neat boxes labeled cognition, social behavior, emotion, and so forth. Within this reorientation toward research, investigations naturally cross traditional category boundaries and examine variations in the child and the environment simultaneously. We have focused on four topics consistent with this reorientation that have been generally neglected in research on cognitive development in school-age children.

Emotion has traditionally been treated as distinct from cognition, but some recent research suggests that in many ways the two may develop hand in hand. Some research has shown that school-age children make major advances in their ability to conceptually integrate diverse emotions. Other topics that demand investigation include emotional reorganizations at appear to accompany the general cognitive reorganizations of the school years and Freudian, psychodynamic processes, which seem to flower during these years. A promising approach to studying emotion-cognition relationships is to choose issues in children's daily lives that naturally evoke strong emotions, such as the self, divorce, and illness.

Brain development is a major topic in the neurosciences today, but there has been little research on the relationships between brain development and cognitive development. Such research is especially difficult to do, and it has an unfortunate history. Preliminary results have often been overgeneralized and distorted, and unjustified claims have been made about practical applications for education or other socially important endeavors. Nevertheless, research on brain growth and cognitive development promises to yield important scientific breakthroughs, even though it will be a long time before legitimate practical applications will be possible.

Social development and cognitive development have typically been treated as distinct categories, and there has been little research on the contributions of social interaction to cognitive development. The few studies in recent years on this topic suggested that social interaction plays a central role in cognitive development in the school years. Much of the course of normal cognitive development seems to involve a process of guided reinvention, in which the child constructs new skills with the help of constant support and guidance from the social environment, especially from dyadic interactions. Analysis of this process has been almost completely neglected in school-age children; despite the fact that many of the failures of school-based education seem to result from the ways that classroom procedures diverge from the norm of guided reinvention.

Schooling and the literate practices associated with it seem to produce major extensions of human intelligence. Not only are basic cognitive abilities amplified, but the scope of intelligence broadens greatly, and a new capacity arises to conceive of representational systems and to analyze them. The scientific revolution appears both to have resulted from these extensions of human intelligence and to be producing further extensions. These effects of schooling and literate practices illustrate the central role of the environment in supporting cognitive growth. Unfortunately, research has been sparse on these effects, especially in school-age children, even though the school years appear to be the period during which these new types of intelligence are built.

The present epoch is an exciting time in the history of developmental science in general and the study of cognitive development in particular. With the new emphasis on relating the parts of the child and on placing the child firmly in a context, we expect to see major advances in the understanding of cognitive development in school-age children.

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Bowman, P. H.

Braine, M. D. S., and Rumain, B.

Broughton, J. M.

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Erikson, W.H.

Feffer, M.H.

Feldman, C.F., and Toulmin, S.

Feldman, D.H.

Fischer, K.W.

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Kuhn, D.

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Lerner, R.M., and Busch-Rossnagel, N.A., eds.

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Maratsos, M.

Martarano, S.C.

McCall, R.


McCall, R.B., Eichorn, D.H., and Hopfay, P.S.

McCall, R.B., Meyer, E.D., Jr., Hartman, J., and Roche A.F.
null
Vesterman, M.

Westerman, M.A., and Fischman-Havstad, L.

Winnicott, D.W.

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Wohlwill, J.F.

Wohlwill, J.F., and Lowe, R.C.

Wolf, M.C.

Wood, D.J.

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