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STRUCTURE, FUNCTION, AND VARIABILITY IN COGNITIVE DEVELOPMENT: THE PIAGETIAN STAGE DEBATE AND BEYOND*

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Piaget's theory of cognitive development has evoked strong, multivocal responses within the English-speaking community around the world, and over the last 40 years, it has helped to produce a massive reconstruction of approaches to development and mind. In reviewing this literature, we could not possibly provide an exhaustive history or review of these responses, just as we could not possibly review all of Piaget's diverse work. There is one theme, however, that has dominated the Anglophone debate: Piaget's claims that cognitive development occurs in stages. Although Piaget (1983) did not view the stage claims as the most important part of his framework, they became the focus of the large majority of English-language research based on his work. As a result of this sometimes rancorous debate, developmental researchers now find ourselves in a fortunate situation: The decades of empirical challenge and defense of stage theory have provided masses of findings about developmental variability as well as new methods for studying variation and

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change. These findings and methods provide the foundations from which to move forward toward the resolution of the basic psychological and epistemological dilemmas that Piaget grappled with but never fully resolved, despite valiant pioneering efforts.

In his constructivist epistemology Piaget (1947/1950) had sought to overcome the reductionistic and dualistic approaches to mind that Western science had derived from its 17th century roots. His approach was to build a new framework for knowledge; one that moved beyond the false dilemmas of dualism by demonstrating the fundamental psychological unity of dimensions such as thought and action, structure and function, subject and object. The key to his solution was human activity in context: *People build their own minds by acting in the world to construct understandings.*

Yet Piaget's very broad, epistemologically oriented theory, lacked the psychological specificity to carry through this project at the empirical level. A contradiction emerged in theory between his constructivist epistemology, which placed functional activity in context at the center of development, and his abstract structural account of stage-wise development which portrayed developmental change as universal and relatively context free. In his own judgment Piaget's broadly sketched framework did not succeed in fully unifying polar dimensions like structure and function, nor did it resolve this contradiction within his theory (Piaget, 1981-1983/1987). The lack of theoretical and methodological tools for reconciling contextualized activity with the succession of stable structures of cognition led to an intractable debate between researchers who alternatively sought to demonstrate predominance of stable, cross-contextual cognitive structures, or the predominance of variability in cognitive performance across situations and conditions.

Fortunately, the findings and methods emerging from the lengthy debate over Piagetian stage theory provide a basis for the resolution of this contradiction in Piagetian theory, and points the way toward the completion of Piaget's project. Throughout the debate over Piagetian stages, explanation of developmental variability was pushed into the background. Instead of attempting to account systematically for variability, each side of the debate focused on patterns of variability and stability that supported their own position. The task now is to foreground variability in development and build on the wealth of evidence produced by decades of Piagetian research to explain the shapes of cognitive devel-

opment.

In this paper, we present a neo-Piagetian framework that moves beyond the stage debate to deal simultaneously with structure and function, organism and environment, variability and stability. Within this framework, the dilemma underlying the stage debate is shown to be false: Development is *both* continuous and discontinuous, structural and functional. It shows stage-like characteristics under some predictable circumstances, while it shows only continuous change under others. The diverse shapes of development follow from principles of variability arising from concrete activity in real-world contexts.

The paper begins by reviewing Piaget's own quest for structural/functional unity, and the contradictions that arose in his theory. Next, the history of the stage debate is briefly reviewed in order to outline the nature of the positions and findings that serve as a basis for its resolution. It is argued that neither side in the stage debate adequately accounted for the patterns of variability across studies. Finally, a neo-Piagetian framework is advanced that uses constructivist principles to account for both variability and stability in patterns of developmental data, and specific conceptual and methodological tools for the analysis and interpretation of developmental variability are presented.

Piaget's Quest for Structural/Functional Unity

The origins of the Anglophone world's response to Piaget's theory of cognitive development are to be found in the dualistic formulation of the nature of knowledge which the Western world inherited from its 17th century philosophers, especially Rene Descartes (1641/1960). Piaget grew up with this dualistic formulation and sought to transcend it. The Cartesian radical division of mind from body, with its corollary divisions of subject/object and thought/action, set the stage not only for the dramatic technological progress of the West but also for some of the most intractable epistemological debates in the history of philosophy (Bernstein, 1983; Rotman, 1993). The artificial separation of intrinsically related dimensions of reality such as mind and body led philosophers into endless and fruitless debates over which dimension was more real, or more fundamental, or over which dimension caused which. By the end of the 19th century these futile debates had brought epistemology to a virtual

standstill and had gone a long way toward discrediting the whole philosophical enterprise.

In the meanwhile, 19th century science had come into its own with established success in areas such as physics and chemistry and with its newest success, Darwin's evolutionary theory, standing as a symbol of the potential of science to solve humanity's most perplexing questions including the question of our own origins. It was within this intellectual climate that the young Piaget began to formulate his central goals and primary intellectual insights. Rejecting what he later referred to as the "demon" of philosophy (Chapman, 1988, p. 17), Piaget set for himself the goal of resolving the epistemological dilemmas inherited from 17th century philosophy through recourse to the emerging 20th century science of psychology.

Beyond Cartesian Dualism: Construction Coordinates Thought and Experience

Piaget's strategy, as it eventually evolved through his early research, was to re-unify mind and body, subject and object, by uncovering their fundamental relations through an empirical investigation of their development during childhood (Piaget, 1947/1950, 1967/1971, 1968/1970). He recognized that by separating the organization of the mind from its functional activity in context, Western epistemology had created a static conception of mental structure, with no possibility of explaining its origins nor specifying its relationship to the world around it (which remained forever mystified). Piaget argued that this false dichotomy produced two types of accounts of the nature of the mind, "a structuralism without development, and a development without structure." In one of these accounts, called *nativism*, mental organization is frozen into Platonic-type structures such as Kantian categories and Gestalt perceptual structures. Because these structures are viewed as independent of the world they attempt to interpret, they must be projected inward as innate. With mental structures thus predetermined, there is no real conception of mental development. Either cognitive structure is seen as fully formed and waiting to be activated as in the case of Chomsky's (1965) linguistic structures, or it is seen as gradually emerging over a period of time through an equally predetermined process of maturation. In either case, the same mental structures

emerge in every individual regardless of the person's activity or the context of action.

The second type of account, development without structure, is represented by the tradition of British empiricism (Locke, 1690) and American behaviorism (Watson, 1928). This view of the mind shifts the focus from mental structure cut off from experience in the world to experience in the world cut off from mental structure. From the *tabula rasa* perspective of empiricism, the mind and its contents are determined by the gradual accretion of experiences, a process of continuous growth that is dominated by environmental contingencies. In this view, mental development is a chain of experiences that account for the individuality of a person's beliefs and viewpoints, with common mental structures across individuals attributed to commonalities in experience (which are poorly defined). Piaget argued that the empiricist interpretation provides no adequate explanation for such shared forms of mental organization as logic, linguistic universals, or fundamental concepts such as time, space, and matter. Because mental processes are seen as dominated by environmental contingencies, the role of the person or subject is reduced to forming automatic associations, habits, or stimulus-response bonds. In place of nativism's invariant structures, empiricism posed the problem of unconstrained variability across a potentially infinite diversity of environmental contingencies and developmental pathways.

In sum, Piaget argued that the two basic epistemological positions possible within the Cartesian framework formed two irreconcilable and ultimately inadequate views on the nature of mind and knowledge. On the one hand, the invariant mental structures of nativism captured the stable forms of cognition shared across individuals but failed to explain individual variation due to the contingency of environmental experience. On the other hand, the atomistic associations of empiricism captured the gradual build-up of conceptions through engagement with the world but proved incapable of explaining shared forms of cognitive structure, including the logic by which empiricists believed sensations were molded into ideas.

Piaget recognized that he had to step out of the dualistic framework that held the organization of thought apart from lived experience. He argued that the dilemma arose from the failure of both nativism and empiricism to deal with the role of *human agency* in the development of knowledge. Neither the pre-determined structures of nativism nor the

atomistic associations of empiricism provided an adequate role for organizing activity. His constructivist alternative was to view our ways of understanding the world as neither pre-determined genetically nor engraved by the environment, but instead as built from our own self-regulated activity, coordinating thought and experience.

In principle, Piaget's constructivism showed the way to uniting cognitive structure with experience in the world: People actively construct new cognitive structures, reorganizing old structures by using them in the everyday world. The role of activity and the unity of structure and function are seen most clearly in his analysis of this process in early sensorimotor development (Piaget, 1936/1952). Beginning with the newborn's primitive perceptual and motor organization (which itself is actively organized in utero), Piaget showed how stable, shared forms of cognitive organization such as object permanence emerge out of babies' own efforts to make sense of their world. Each step in the construction of object permanence evolves from infants' attempts to act in the world through their current forms of sensorimotor organization, adapting them based on experience to build new forms of action. For example, by coordinating prehension and vision infants cross-index ways of grasping and looking at objects so that they eventually come to interpret objects as having an existence independent of the self.

Subsequently, Piaget and his collaborators (especially Bärbel Inhelder) devised a similar argument for later cognitive development through their well known studies of childhood and adolescent reasoning. The development of intelligence could be explained as steps in the gradual reorganization and extension of internalized action systems. They sought to trace, step by step, the process by which individuals constructed for themselves fundamental forms of cognition including logic (Inhelder & Piaget, 1959/1969), number (Piaget & Szeminska, 1941/1952), space (Piaget & Inhelder, 1948/1967), time (Piaget, 1946/1971), and physical quantity (Piaget & Inhelder, 1941/1974). Through on-going engagement with the world, children gradually integrate early internalized actions to form systems of internalized actions that allow logical thinking, especially through the property of reversibility, the mental undoing of internalized actions.

The Ambiguity of Stage Theory

Piaget was in principle able to point the way toward unifying the Cartesian dichotomies in conceptions of thought, but in practice his theory and research represented only the first halting steps toward that goal. On the theoretical level, Piaget preferred to characterize cognitive organization in terms of global structured wholes (*structures d'ensemble*), providing an extremely generalized account of the emergence of such structures that ignored the particulars of structures and the contextual dimension of development (Bidell, 1988). As his research on intellectual development continued, Piaget increasingly described development in terms of pervasive, cross-domain systems of thought, feeling that a broad-based integration or equilibrium of action systems — the structured whole — was required to account for the consistency of logical thinking across so many contents, circumstances, and people. Although Piaget recognized age gaps, called *decalage*, between the same type of structural acquisition in different domains and between people (Chapman, 1988; Gelman & Baillargeon, 1983), he persisted in describing development of thought in terms of emergence of a pervasive logic that implied relatively tight temporal synchrony in operational acquisitions across domains (Broughton, 1981; Fischer & Bullock, 1981). Moreover, this domain-general view was reinforced by a cognitive universalism. Piaget's work increasingly focused on properties of action systems general to the person across contexts and systematically de-emphasized the effects of particular contexts, even while he maintained that social factors are indispensable in explaining cognitive development (Piaget, 1947/1960).

This emphasis on domain-general knowledge and cultural universalism led to a fundamental ambiguity in Piaget's theory, captured by the contrast between his model of universal stage structures and his core epistemological position that knowledge is constructed from actions in the real world. Constructive activities must take place in specific contexts with particular tasks and goals, and so both overt and internalized actions should naturally reflect the variable particulars of specific contexts, tasks, and goals (Fischer, 1980; Rogoff & Lave, 1984; Rogoff, 1990; Zimmerman, 1989). Yet Piaget's theory contains no theoretical tools to account for this natural variability in cognitive organization or to explain effects of culture, immediate context, personal history, state, social support, or other sources of individual and group variation. The existence of *deca-*

lage is acknowledged, but no tools or concepts are provided to explain and predict when and how variations occur. Such diverse forms of sophisticated reasoning as Puluwat islander's navigational system (Gladwin, 1970) and Western scientists' paradigm of isolation of variables are reduced to a single stage of formal operations. Even the specifics of Piaget's characterizations of the logic of concrete and formal operations are not related to variation and diversity in knowledge (Inhelder & Piaget, 1955/1958, 1959/1969). Although the description of operational thought may succeed in capturing some of what is common to these forms of reasoning, ironically it loses the ways that the forms differ through adaptation to their specific contexts, despite Piaget's intent to use adaptation to the world as the central mechanism in his theory.

Toward the end of his life, Piaget did address this conflict between the implied context-specificity of constructivism and the domain-general universalism of his stage structures, turning his attention to the functional processes of problem solving and meaning construction (Inhelder & Piaget, 1980; Piaget, 1974/1976, 1974/1978, 1981-83/1987). However, he never offered a revised framework, reconciling these new functionally oriented ideas with conceptions of structural cognitive change. As a result, although Piaget always insisted on the centrality of construction in his theory, his failure to link construction to everyday activity in his theory became a major obstacle to the growth of constructivism. The notion of logical cognitive structure as the organization of living mental activities was too easily assimilated to conceptions of static forms of logic isolated from the world. Without an account of the ways in which everyday activity in context contributes to cognitive growth, the concept of stage became the default category for argument.

As a result, the concept of stage gradually emerged as the center of research attention. In most of the English-speaking world, Piaget's constructivism was greeted enthusiastically in the 1950s and 1960s as a key contribution to the cognitive revolution that ended behaviorism's domination of psychological theory and research. The essence of the revolution was the reassertion of the centrality of human meaning and self-regulated activity (Bruner, 1982; Fischer & Bullock, 1984; Gardner, 1985; Kagan, 1982). Piaget's constructivism was welcomed as a powerful ally to refocus the field on activity and meaning through one of the few systematic psychological models of mental organization.

For a while, the notion of the construction of stages was accepted

rather uncritically, with researchers from very different traditions each projecting their own interpretations onto the theory. Responses to Piaget's work fell into two main groups. On the one hand were functional psychologists, many of them newly converted cognitive psychologists who sought to use parts of Piaget's work to build new descriptions of mental functioning and its organization to replace behaviorist associationist descriptions (e.g., Boden, 1980; Donaldson, 1978; Mandler, 1963; Miller, Gallanter, & Pribram, 1960; Schank & Abelson, 1977). On the other hand, a growing group of structuralists accepted Piaget's constructivist epistemological stance as their starting point for describing the mind. Many of this latter group adopted the stage model in part because they were influenced by a maturationist trend from earlier developmental research, in which development was seen as a series of genetically determined milestones (Hall, 1904; Gesell, 1928). Another important influence was Werner's (1957) developmental version of Gestalt psychology, which projected a gradual differentiation and articulation of symbolic and logical functions without clear specification of the organization of those functions.

The Stage Debate and the Discovery of Developmental Variability

These two general responses to Piaget's work grew into an empirical debate over the validity and generality of the concept of cognitive stage, which dominated the English-language research literature on Piagetian theory until the mid-1980's. In general, the debate fell along traditional lines of structuralism versus functionalism. With the traditional dominance of functionalism in English-language research, scholars launched an extensive and multifaceted research program emphasizing environmental influences and challenging the idea of stage in all its aspects (Fischer & Silvern, 1985). Are the stages Piaget described really universal? Do they cut across domains of knowledge as the structured whole seems to imply? Do the various cognitive abilities associated with the stages emerge at the ages Piaget reported? Are the developmental sequences he described invariant across individuals and cultures? Among supporters of Piaget's stage theory, research efforts centered on attempts to validate Piaget's concept of stages, especially his descriptions of developmental sequences and age norms.

Not surprisingly, the debate over the validity and interpretation of stages produced two apparently contradictory sets of findings. For every study challenging predictions about the order, age of acquisition, or generality of Piaget's stages, another study offered evidence in support. One large volume of research offered evidence contradictory to predictions of stage theory, showing earlier (or later) ages of acquisition, different sequences of development, differences across cultures, or failure of cross-domain transfer (Fischer, 1980; Flavell, 1982a; Gelman & Baillargeon, 1983). On the other hand, another large volume of research supported Piaget's general descriptions, substantiating the approximate ages, the general developmental sequences, and the patterns of errors and solutions in particular tasks (Case, 1985; Halford, 1989).

This outcome could be viewed as depressing. Thirty years of research seemed to have led back to Piaget's starting point: an intractable debate between empiricists and nativists, between those who view knowledge as a variable function of environmental contingencies and those who consider it as a product of invariant structures that receive and organize experience. However, the study of development is in a much more attractive position than when Piaget began his work, precisely because of the rich empirical data base produced by the debate over cognitive stages.

The Way to a Constructivist Solution

Patterns in this data base point the way to solution of the task Piaget set himself: building a theory that moved beyond Cartesian dualism by grounding the mind in people's constructive activities. Piaget's challengers and the defenders have both been partly right, and the solution needs to combine their arguments just as Piaget wanted to combine mind and world through activity. Indeed, general developments from pre-operational to concrete and then to formal or abstract thinking have been remarkably replicable, showing the approximate sequences and ages reported by Piaget. On the other hand, people show much more variation in development than Piaget's theory either predicts or explains. The evidence therefore supports neither a conception of invariant stage structures, nor an unconstrained variation across situational contexts.

In the following sections we will review the research literature emerging from the debate over Piaget's stage theory and summarize patterns

of developmental variability and stability emerging from those data. Next we will describe a set of conceptual and methodological tools that help to systematically measure and describe the developmental patterns. Finally, we will outline an interpretation of development that starts with a person acting in context and thus explains both variability and stability in development.

In the stage debate researchers manipulated a number of environmental factors, including assessment condition, learning history, and cultural background. Not surprisingly, children's cognitive development varied in several ways as a function of these factors: variation in *age* of acquisition of specific skills, in *relative synchrony* of acquisitions in different domains, and in developmental *sequence* of a given set of acquisitions. In each of these three categories, conditions similar to those used by Piaget usually produce results similar to his, but conditions substantially different from his usually produce divergent results. The following sections examine this pattern of variability in representative research from each of the three categories.

Variability in Age of Acquisition and the Limitations of Age-Only Analysis

Piaget argued that cognitive structures must be built hierarchically, in stages, and therefore must appear at periodic intervals during development. Specifically, he predicted three major transitions during childhood: from sensorimotor intelligence to preoperational representational abilities at about 18 months, from pre-operations to concrete operations at about 7 years, and from concrete operations to formal operations at around 12 years. He recognized that these ages were approximate, that individuals would vary from group norms, and that decalage or time gaps occurred between acquisitions in differing domains that seemed structurally similar.

Despite all these qualifications, Piaget's research relied on mean age of acquisition to index development, and he typically assessed mean age through differences between groups of children of differing ages. When children of different ages were given a task such as conservation of orange juice, on average responded pre-operationally to a task like conservation of substance at age 5 and then concrete operationally at age 7, these data were taken as evidence that individual children acquire concrete operations after pre-operations in these tasks. The problems he

recognized should have led him instead to construct direct tests of within-individual stage sequences with longitudinal designs or Guttman-scale techniques (Fischer & Bullock, 1981; Wohlwill, 1973).

Piaget's reliance on mean age has encouraged acceptance of this questionable tendency among other cognitive-developmental researchers, even those questioning his theory. For example, researchers demonstrate substantial variation in age of acquisition (usually downward to younger ages) and then conclude that Piaget's stage sequence has been disconfirmed. The tacit acceptance of the indirect age criterion over more direct tests of developmental sequence has led to a prolific and, at times, confusing debate about ages of acquisition. By manipulating factors such as task structure, familiarity of task materials, practice, and social support, researchers have demonstrated wide variability in the age of acquisition for a number of Piagetian tasks (Fischer & Bidell, 1991; Flavell, 1982a). Some manipulations have produced older ages of acquisition, some younger, and some ages that approximate Piaget's results. The most widely cited studies of age variation have been those in which age of acquisition has been moved downward (e.g., Bryant & Trabasso, 1971; Donaldson, 1978; Gelman & Gallistel, 1978). Typical is Gelman's (1972) study of number conservation, in which she manipulated task complexity to achieve conservation judgement from children much younger than expected. The standard number conservation task involves two parallel rows of 8 to 10 objects placed in one-to-one correspondence. One row is then transformed, usually by extending the items to make it longer. To show conservation, the child must indicate that the rows remain equal in number and justify that conclusion in terms of logical necessity—the rows *must* remain equal. Piaget and Szeminska (1941/1952) reported this skill at about 6 to 7 years of age.

In Gelman's (1972) study, task complexity was manipulated in two ways. First, the number of counters in each row was reduced to as few as two or three. Second, the method of assessing conservation was altered substantially. After children initially judged the two rows to be equal, one row was transformed surreptitiously either by adding more counters or by simply rearranging the counters already there. Then, children who showed more surprise at viewing the enlarged set than the transformed set were scored as number conservers; there was no need for explicit judgment and justification. Under these conditions children as young as 3 years were coded as conserving number.

Following up on Gelman's and similar studies, other researchers have shown that changes in task complexity can move age of acquisition upward again, even with tasks like Gelman's (Cooper, 1984; Fischer & Canfield, 1986). For instance, Silverman and Briga (1981) argued that children in Gelman's study might simply be counting rather than applying conservation reasoning. When they altered the task to preclude counting, by covering part of the transformed array, 3-year-old children no longer showed conservation-like responses. Similarly, Halford and Boyle (1985) used a number conservation task in which the transformed array was configured in ways that were difficult to count. Under these circumstances too, 3-year-olds failed to conserve number; but 6 to 7-year-olds did show conservation.

Age of acquisition has also been adjusted downward by manipulating the amount of practice or training children have with conservation tasks (for reviews see Beilin, 1978; Field, 1987; Halford, 1982). Various techniques have been used to teach conservation responses to children who fail to demonstrate them in pretests; children were then retested on a new conservation problem. In a number of studies, children as young as 4 or even 3 years have been trained to produce appropriate conservation responses under some circumstances (Halford, 1989).

At the same time, effectiveness of training is constrained by various factors that require explanation, including task complexity, content, the complexity of the training, the age of the child, and the developmental status of the child. Some sort of developmental explanation seems to be required by findings that training is more effective if the children are older (Beilin, 1965; Murray, 1968), have higher mental ages (Sigel, Roeper, & Hooper, 1966), or already show some progress in concrete operations (Inhelder, Sinclair, and Bovet, 1974).

Age of acquisition varies similarly in other types of tasks (Gelman & Baillargeon, 1983; Halford, 1989). In class inclusion, children must simultaneously consider (1) relations among subclasses (e.g., daisies and tulips) and (2) relations between subclasses and the superordinate class (e.g., daisies and flowers) (Halford, 1982; Winer, 1980). Pre-operational children who can handle only one set of these relations at a time typically focus on the subclass comparison alone and cannot understand that there must be more flowers than either daisies or tulips—missing the part-whole relation of inclusion.

Again, age of acquisition varies both upward and downward depen-

ding on assessment conditions. Researchers using tasks similar to Piaget's have reported approximately similar ages of acquisition (Elkind, 1964; Wohlwill, 1968). Winer's (1980) review reported more studies showing later than earlier ages. Yet challenges to Piaget's stage of concrete operations have come mainly from those citing earlier ages of acquisition (Donaldson, 1978; Gelman & Baillargeon, 1983; Markman, 1978; Smith, 1979) associated with conditions such as high socioeconomic status of the children, weakening of scoring criteria, and reduction of task complexity (Halford, 1989).

Most of the dramatic reductions in age of acquisition come from reductions in task complexity. In a typical study McGarrigle, Grieve, and Hughes (1978) attempted to use a familiar situation and in doing so, greatly reduced task complexity. They showed children a picture in which a teddy bear had to climb a set of six steps, four red and two white. Cues marked the two groups: a chair at the end of the red steps and a table at the end of the white ones. The investigators asked the children, "Are there more red steps to go to the chair, or more steps to go to the table?" Under these conditions a majority of the 4-year-old subjects gave class-inclusion responses. By providing cues (the chair and table) to support the representation of the aspects of the problem and by using everyday terminology, the authors seem to have reduced the complexity of the task. An important question to be considered is whether such reductions in task complexity fundamentally change the nature of the task, thereby requiring a different, developmentally earlier skill (Halford, 1989).

In short, Piaget's ages for abilities at each of his stages represent rough central tendencies in a range of both upward and downward variation, not fixed landmarks. The variation around these central tendencies is not random but is closely related to both organismic and environmental factors, including task complexity, content, experience, type of training, and emotional state, all of which often have a powerful effect on age of acquisition.

Variability in Synchrony of Acquisitions Across Contexts and Domains

Another focus of the debate over Piaget's structural theory involves the stability of cognitive stages across contexts and domains. As noted above, Piaget's conception of the structured whole implies a system of logic that

pervades the entire mind at each stage. Many researchers have taken this so-called "hard stage" version of the theory (Kohlberg, Levine, & Hewer, 1983) to mean that children should perform at precisely the same logical stage on each task they encounter, regardless of the situational context or the content domain of the task.

Such strong synchrony is seldom empirically supported. The research literature shows a high degree of variability in the cognitive stage an individual exhibits on structurally equivalent tasks from one context to another, across domains, and even from moment to moment (Feldman, 1980; Fischer, 1980; Flavell, 1982a; Granott, 1993a). For both context and domain, variation in cognitive stage appears to be affected by a range of environmental and organismic variables, in the same way that age of acquisition is affected. We prefer to use the term *level* rather than *stage* to reflect this fact of variation.

In terms of moment-to-moment variation, an individual's cognitive level varies widely depending on the degree of contextual support immediately available (Rogoff, 1982). When the context provides support for high-level functioning, including familiarity of settings and materials and especially modelling or prompting of key components, individuals exhibit much higher levels of cognitive performance than under less supportive circumstances (Fischer, Bullock, Rotenberg, & Raya, 1993). A given child's cognitive level will vary from high to low over a period of a few minutes depending upon the degree of support. Children, adolescents, and young adults have all shown consistently higher developmental levels under high-support conditions than they showed spontaneously for the same content domain. Domains in which this has been shown include concepts of social roles like nice and mean (Fischer, Hand, Watson, Van Parys, & Tucker, 1984), classification of blocks (Fischer, Bullock, Rotenberg, & Raya, 1993), reflective judgment (Kitchener & Fischer, 1990), and concepts of honesty and kindness (Fischer & Lamborn, 1989).

Similar variation is found across content domains. Numerous studies covering a wide range of Piagetian tasks have consistently produced notoriously low correlations either among Piagetian tasks or between those tasks and other cognitive measures such as school achievement (Gelman & Baillargeon, 1983; Jamison, 1977). In general there is a high degree of variability and a low degree of synchrony across theoretically equivalent tasks in different domains. The high degree of variability across both contexts and domains clearly disconfirms the strong version

of the structural-whole hypothesis as described above. A common alternative view among contemporary theorists is that cognitive structure is organized within specific domains rather than as a system-wide logic (Feldman, 1980; Flavell, 1982b; Gardner, 1983).

Other theorists have argued that the existence of variability does not indicate the absence of broader organizing principles: More limited, local forms of cross-contextual or cross-domain organization can be detected if the proper methods are used (Case, 1991). Fischer and Bullock (1981) have argued that while "point synchrony" (same-level acquisitions occurring at exactly the same time) is almost never found, there is good evidence for "interval synchrony" (same level acquisitions occurring within a narrow time frame), especially when the degree of contextual support is controlled. When support is not controlled, the factors producing variability in performance lead naturally to widely variable performance. When degree of support is held constant, the upper limit on children's performance across some contexts or domains can show substantial consistency.

A reasonable interpretation of the evidence seems to be that neither absolute structure nor absolute variability reigns over cognitive development. While Piaget's structured whole clearly does not exist in the strong sense, some cross-domain organization seems to exist, as evidenced in the human ability to sometimes think and act consistently from one situation to another. Instead of being imposed by an underlying abstract logic, such organization seems to be constructed by a specific real-time process of generalization from one context to another (Fischer & Farrar, 1987; Rogoff, 1990).

Variability in Sequence of Acquisitions

Even more basic than the question of synchrony across sequences is the question of whether Piaget's developmental sequences remain invariant across individuals and groups, as well as across conditions within individuals. Once again, the evidence gives rise to conflicting interpretations. On one side, evidence of variation in specific developmental sequences has been taken as evidence against the notion of hierarchically constructed stages (Gelman & Baillargeon, 1983; Brainerd, 1978). On the other side, a large number of studies have supported general predictions

of long-term Piagetian stage sequences (Case, 1985; Fischer, 1980; Halford, 1989).

An examination of the evidence shows a familiar pattern: There is high variability in developmental sequences, but this variability is neither random nor absolute. The number and order of steps in developmental sequences tends to vary as a function of factors like learning history, cultural background, content domain, and probably emotional state. In addition, the variability in steps appears to be contingent upon the level of analysis at which the sequence is examined.

Developmental sequences tend to appear mainly at two levels of analysis: (1) large-scale, broad sequences covering several years between steps, relatively independent of domain, and (2) small-scale, detailed sequences found within particular domains (Fischer & Bullock, 1984; Flavell, 1972). Large-scale sequences appear to be relatively invariant. Children do not, for instance, exhibit concrete operational performances across a wide range of tasks, and then years later begin to exhibit preoperational performance on related tasks. On the other hand, small-scale sequences have often been found to vary dramatically (Dodwell, 1960; Kofsky, 1966; Lunzer, 1960).

Typically, variation in small-scale sequences is associated with variation in task, context, or assessment conditions. For instance, Kofsky (1966) constructed an eleven-step developmental sequence for classification based on Inhelder and Piaget's (1959/1969) research on concrete-operational thinking and tested it using scalogram analysis. Kofky's predicted sequence, while following a logical progression, drew on an assortment of different tasks and materials to evaluate each step. The results showed weak scalability with several non-standard mini-sequences.

Other sources of variation in small-scale sequences include cultural background, learning history, learning style, and affect. Price-Williams, Gordon, and Ramierez (1969), for instance, examined the order of acquisition of conservation of number and substance, in two Mexican villages. The villages were comparable in most ways except that in one village the children participated in pottery-making at an early age. Children of the pottery-making families tended to acquire conservation of substance (tested with clay) before conservation of number, while non-pottery-making children showed the opposite tendency. Affective state can also powerfully affect developmental sequences (Fischer & Ayoub, 1994). For example, shy, inhibited children seem to show different sequences in

representing positive and negative social interactions, and extreme emotional experiences such as child abuse lead to different developmental sequences for representing self and others in relationships.

Furthermore, apparent failures to show clearcut developmental sequences can mask variations in sequence as a function of factors such as learning style or culture. That is, task sequences that seem to scale poorly can sometimes be resolved into alternative, group-specific sequences that scale well. For example, a sequence of six reading-related tasks scaled badly when tested on a sample of poor readers in first to third grade (Fischer, Knight, & Van Parys, 1993; Knight & Fischer, 1992). But use of a scaling technique for detecting alternative sequences showed that subsamples of poor readers showed different, well-ordered sequences that reflected their reading difficulties. Research methods should allow detection of alternative sequences instead of forcing all children to either fit or not fit one sequence. Even research on synchrony benefits from more careful testing of sequences: A recent study of development of perspective-taking found that careful assessment of sequences showed much more synchrony across perspective-taking domains than had been found in previous research (Rose, 1990).

These patterns of variation in developmental sequences suggest that both sides of the debate over Piagetian theory are partly right. Very large-scale, long-term developmental sequences are mostly invariant, as Piaget indicated, while small-scale sequences vary strongly as a function of such factors as domain, cultural background, learning style, and affect.

Conclusion: The Centrality of Variation

Perhaps the most important lesson from the debate over Piaget's stage theory is the central role of variability itself in cognitive development. In each area we have reviewed—age of acquisitions, synchrony of acquisitions, and sequence of acquisitions—researchers embroiled in the stage debate have used instances of developmental variability to argue for or against Piaget's propositions. Yet both sides of the debate have mostly treated variability as a background issue rather than recognizing its centrality for their arguments. They have focused on some particular variation relevant to their own psoition and ignored the broad scope of developmental variation that forms the basis of the stage debate. In so doing,

they have ignored the central phenomenon itself—variability that follows naturally from the basis of intelligence in contextualized action. A focus on variability in activity in context can lead the way out of the Cartesian dilemma that Piaget sought. Along the way it can help resolve the stage debate as well.

The Dilemma of Developmental Variation

The backgrounding of developmental variation in the stage debate has formed the basis for the lack of resolution of the stage debate. Because each debater has focused on only a small part of the relevant variability, none of the competing frameworks have been able to adequately interpret all the data. The debate over stage theory has shown the failure of all involved to account systematically for the central phenomenon of the field: developmental variability.

Meaningful comparisons among studies of development require attempts to systematically manipulate major factors related to developmental patterns. As long as the manipulation of these key factors is not systematic, each piece of research remains self-contained and incommensurable with other pieces that manipulate the factors in different ways or manipulate entirely different factors. For example, a study that simplifies a task and then finds a lower age of acquisition has manipulated task complexity in only one direction. To conclude that Piagetian predictions are disconfirmed is misleading because the manipulation of task complexity has been left implicit. Whenever a given manipulation produces an early age of acquisition in one study, another study with a new manipulation can counter with a later age. The result is a perpetual see-saw.

If this methodological shortcoming is not recognized, it leads to a number of intractable problems for researchers trying to make sense of development. For instance, if differing degrees of social-contextual support produce different cognitive levels, ages of acquisition, or developmental sequences, what degree of support is "right" to evaluate these phenomena? One is forced to ask which is the right cultural context producing the right developmental sequence, or which is the right degree of practice or training or contextual support to determine cognitive level or age of acquisition (Fischer & Bidell, 1991).

A good example of this problem is the study by McGarrigle and

others (1978) version of the class inclusion task described earlier. The researchers hoped to facilitate children's performance by posing the part-whole problem in terms of the familiar context of climbing two sections (the parts) of a stairway (the whole) and by providing visual cues to which children could refer. But the alteration of the task made it unclear whether class inclusion was being assessed at all. Since the part-whole comparison was framed in terms of the relative distance involved in climbing the stairs, the early age of acquisition found in the study may have been due to children solving the task by a simple length comparison instead of by the more complex class-inclusion comparison (Halford, 1989). Children may have treated the stairway as a class inclusion problem, or they may have treated it as a length comparison, or perhaps some took it each way. Because only one task manipulation was used, it is impossible to determine the source of the effect.

Instead of clarifying the question, such evidence only continues a debate that cannot be resolved unless the terms of the argument are changed. Focus on a particular variation or a unidirectional description of variability will perpetuate the see-saw effect in the debate. Without a systematic approach to developmental variability, which grows naturally from a focus on the basis of intelligence in contextualized action, researchers inadvertently sustain an irreconcilable debate over the meaning of developmental phenomena.

Beyond the Dilemma: Foregrounding Developmental Variation

If researchers are to address the problem of developmental variability, they must foreground the phenomenon for direct analysis and devise theoretical and methodological tools adequate to describing, measuring, and controlling it. Only by analyzing the dimensions of developmental variability will it be possible to construct a comprehensive theory of development. The dynamic hypothesis that cognition is formed from actions in contexts leads naturally toward a focus on variation, and it has led us to the use and construction of methods specifically designed to detect variation (Fischer, 1980; Fischer, Knight, & Van Parys, 1993; Fischer & Rose, 1994; Fogel & Thelen, 1987; van der Maas & Molenaar, 1992; van Geert, 1991). Three of the most useful methodological tools for analyzing variation are developmental scaling, the develop-

mental range, and maps of alternative developmental pathways.

Developmental Scaling: Building Rulers

One of the main methodological problems contributing to a non-systematic approach to variability is the inadequate, extremely gross scales of measurement that have traditionally been used to gauge developmental change. Good measurement requires a good ruler, and most developmental research has used extremely ineffective rulers. To get an idea of the nature of this problem, imagine trying to measure the weekly changes in the depth of snow in your backyard during the winter, using a meter stick with no centimeter markings but only meters. The depth of the snow could vary tremendously—say from 0 to 70 cm—but a graph of your results measured in meters would show only a flat line. The crudeness of the scale would force you to lump all the change into one static category: less than a meter.

A similar problem exists with traditional Piagetian stages. Piaget's stages mark off the course of cognitive development in the crudest fashion, dividing the reorganization into units that cover two to six years per stage. In practice, Piaget described a few smaller substages for each of the large stages of preoperational, concrete operational, and formal operational intelligence, but these substages were not done consistently from one study to the next, and there was no clear basis for defining them (Droz & Rahmy, 1974). It was difficult to use them as part of a measuring instrument.

A crude measuring instrument makes it hard to detect variability and encourages misinterpretations of the variability that comes to light. For instance, if the only measure of change during the childhood period is the distinction between preoperational and concrete operational thinking, then factors like contextual support or task complexity have to move performance a whole stage—the equivalent of about five years—if their effects are to be detected. Even when manipulations produce a large effect, the use of only two huge categories can obscure the phenomenon of variability, just as variation in snow depth can be obscured by measuring it in categorical terms (less than or more than a meter). In the face of such a static description of development, it is highly tempting to conclude that an individual simply is concrete operational and that any variations

TABLE 1

Piagetian Stages Compared with a Skill Theory Sequence in Social Interactions

Piagetian Stage	Skill Level	Step	Skill
Preoperations	Rpl: Single Representational Skills	1	*Active agent*: A person performs at least one behavior fitting a social-interaction category of mean or nice.
		2	*Behavioral category*: A person performs at least two behaviors fitting a category of mean or nice.
		3	*Shifting behavioral categories*: One person performs at least two behaviors fitting the category nice, as in Step 2, and then a second person performs at least two behaviors fitting the category mean.
	Rp2: Representational Mappings	4a*	*Combination of opposite categories in a single person*: One person performs concurrent behaviors fitting two categories, such as nice and mean.
		4b*	*One-dimensional social influence*: The mean behaviors of one person produce reciprocal mean behaviors in a second person. The same contingency can occur for nice behaviors.
		5	*One-dimensional social influence with three people behaving in similar ways*: Same as Step 4b, but with three people interacting reciprocally in a mean way (or a nice way).

* Steps 4a and 4b are distinct structures but were not predicted to emerge in sequence.

		6	*Shifting ondimensional social influence*: The nice behaviors of one person produce reciprocal nice behaviors in a second person. Then, in a separate story, the mean behaviors of a thrid person produce reciprocal mean behaviors in the second person. (Or a reciprocal nice interaction).
		7	*One-dimensional social influence with three people behaving in opposite ways*: The nice behaviors of one person and the mean behaviors of a second person produce reciprocal nice and mean behaviors in a third person
Concrete operations	Rp3: Representational Systems	8	*Two-dimensional social influence:* Two people interact in ways fitting opposite categories,
		9	*Two-dimensional social influence with three people*: Same as Step 8 but with three people interacting reciprocally according to opposite categories.
Formal operations	Rp4/A1: Single Abstract Skills	10	*Single abstract control structure integrating opposite social behaviors*: Two interactions involving opposite behaviors (as in Step 8) coordinated in terms of an abstract control structure, such as that intention matter more than actions.
		11	*Shifting abstract control structures, each integrating opposite social behaviors*: First, two interactions involving opposite behaviors are coordinated in terms of one control structure, such as intention (as in Step 10). Then two interactions involving opposite behaviors are responsibility: What matters is whether people take responsibility for the harm they do.

detected are due to either measurement error or performance limitations unrelated to the true underlying competence. As a result, researchers ignore the flexibility in behavior that occurs under a range of differing organismic and environmental conditions.

For these reasons it is important to devise more sensitive scales for measuring changes in developmental performance and to use them to measure developmental variation. A focus on actions in contexts, with its concomitant emphasis on variability, has led us to use more sensitive scales (Fischer & Canfield, 1986). Some other neo-Piagetian researcher-shave also been devising such scales, especially Case (1985), Siegler (1981), and van Geert (1991). Table 1 contrasts a scale designed to measure developmental changes in middle-class American children's understanding of mean and nice social interactions based on neo-Piagetian skill theory with the traditional Piagetian stages that would apply to the same period of development (Fischer, Shaver, & Carnochan, 1990).

A comparison of these two scales shows that where the Piagetian stage framework divides the entire period of childhood into only two giant reorganizations, the skill theory framework distinguishes four large-scale levels and eleven smaller-scale steps across those levels in the construction of representations of social interactions during this period. Each step in the sequence involves only a small reorganization of the skills needed to understand mean and nice social interactions. In addition, the theory and method allow discrimination of even more steps when a more detailed scale is needed. The result is a fine-grained measuring tool sensitive to small variations in children's behavior.

The use of a scale sensitive to small developmental steps helps to move research in cognitive development beyond the dilemma created by stage theory by reframing the debate in terms of *processes* instead of categories. Instead of asking whether or not children have "really" reached the concrete operational stage in the domain of mean and nice interaction, researchers can ask more analytic questions: What are the particular sequences of reorganizations children go through in this domain? How do children move from one step to another? Do different children show different pathways, different orderings of the tasks used to assess the sequence? Similarly, instead of debating which of the many possible assessment conditions is the "right" one for measuring concrete operational performance, the debate can focus on *how* changes in environmental conditions affect the level of children's cognitive skills.

For example, in McGarrigle's classification study cited above, the structure of the task was changed in order to achieve a better assessment of the logical ability to classify. An alternative approach would be to use developmental scaling to understand the place that McGarrigle's task (as well as Piaget's) fits in a developmental sequence of classification skills. Fischer & Roberts (1989), for instance, have constructed a 12-step sequence of classification skills for the period between 1 and 7 years of age: Each step represents a small reorganization of classification skills moving toward the skill of classifying objects in a three-dimensional matrix. McGarrigle's task could be analyzed in a similar manner. Then, instead of debating whether or not this particular task variation is the best assessment of classification skills, researchers could ask what specific kind of classification skill this particular task demands and what its relation might be to earlier and later classification skills.

The Developmental Range and the Appearance and Disappearance of Stages

The use of good rulers to measure development makes possible another important tool for describing and analyzing developmental variation, the developmental range (Lamborn & Fischer, 1988). Because developmental level varies from moment to moment, an individual child's cognitive level is not simply a point on a developmental scale, even for a narrowly defined domain. An individual's cognitive skills for a given task actually span a potentially wide interval of levels. The developmental range is a tool for describing this span of abilities and the variation which an individual can show within this span in relation to specific environmental conditions.

As noted above, if cognitive abilities are viewed only in the long term they can seem to be fixed categories of thought that are imposed upon various types of contents. On the other hand, if they are viewed as actions adapted to specific contexts—a more short-term view—attention is directed to the concrete processes by which cognitive skills are used and formed. From this shorter-term perspective, the level of organization of cognitive skills is flexibly affected by the many environmental and organismic factors indicated earlier, including the class of factors that we have called contextual support. Children and adults show systematic

TABLE 2

Developmental Range of a Skill Under Varying Social Support Conditions

Developmental Sequence (Step)	Performance Levels	Social Support
1		
2		
3		
4	Functional	None
5		
6	Optimal	Modelling, Instruction, etc.
7		
8	Scaffolded	Direct Participation
9		
10		
11		
12		

variation in cognitive levels under differing degrees of support, and because this variation is highly systematic, it is called the developmental range. It is similar to Vygotsky's (1978; Wertsch, 1985) concept of the zone of proximal development, but it offers a specific set of methodological and conceptual tools for measuring and analyzing the effects of contextual support.

Table 2 illustrates the developmental range in relation to a given developmental sequence of skills. Three upper limits on performance can be distinguished for any individual performing a given task, depending on the degree of contextual support available. The *functional* level is the

highest level of performance the child exhibits when carrying out a task spontaneously, with no special help from other people. Many behaviors will be at lower steps than the functional level (the earliest steps in Table 2) because it is an upper bound, the limit of performance under spontaneous conditions. When children receive support, such as modeling, instruction, or priming of the task, they can move to a higher level of performance called the *optimal* level, which is the upper limit on performance they can sustain in that domain with social-contextual support. The gap between functional and optimal level is typically large, as shown in Table 2.

Normally, many activities are naturally social, with several people doing them together (Granott, 1993b). In social interactions performance can move to an even higher level called the *scaffolded* level (Bruner, 1982; Wood, 1980). Here the degree of social support goes beyond modeling or instruction to actual co-participation in the task by an adult or more knowledgeable peer. With another person performing part of the task, the duo can produce a level much higher than the child can sustain even at his or her optimal level; but of course the child cannot yet sustain this level in the absence of the direct participation of the other person.

Like developmental scaling, the developmental range can help to reframe the debate over Piagetian stage theory by refocusing attention away from fixed stages and toward developmental variability. The fact that the same child, adolescent, or adult shows consistently different levels for the same tasks under different support conditions makes it necessary to stop treating the individual as having a single stage of knowledge and to begin to analyze the effects of social-contextual support on the construction and use of cognitive skills. If the person's level varies so routinely, then surely variation must be included in research. Indeed, even the existence of stage-like change itself varies as a function of developmental range, as shown in Figure 1. Optimal level typically shows true stage-like jumps in performance, whereas functional level typically shows continuous or disorderly changes in performance (Fischer & Rose, 1994; Kitchener, Lynch, Fischer, & Wood, 1993).

Maps of Alternative Developmental Pathways: Developmental Webs

Another form of variation is developmental pathway: People develop

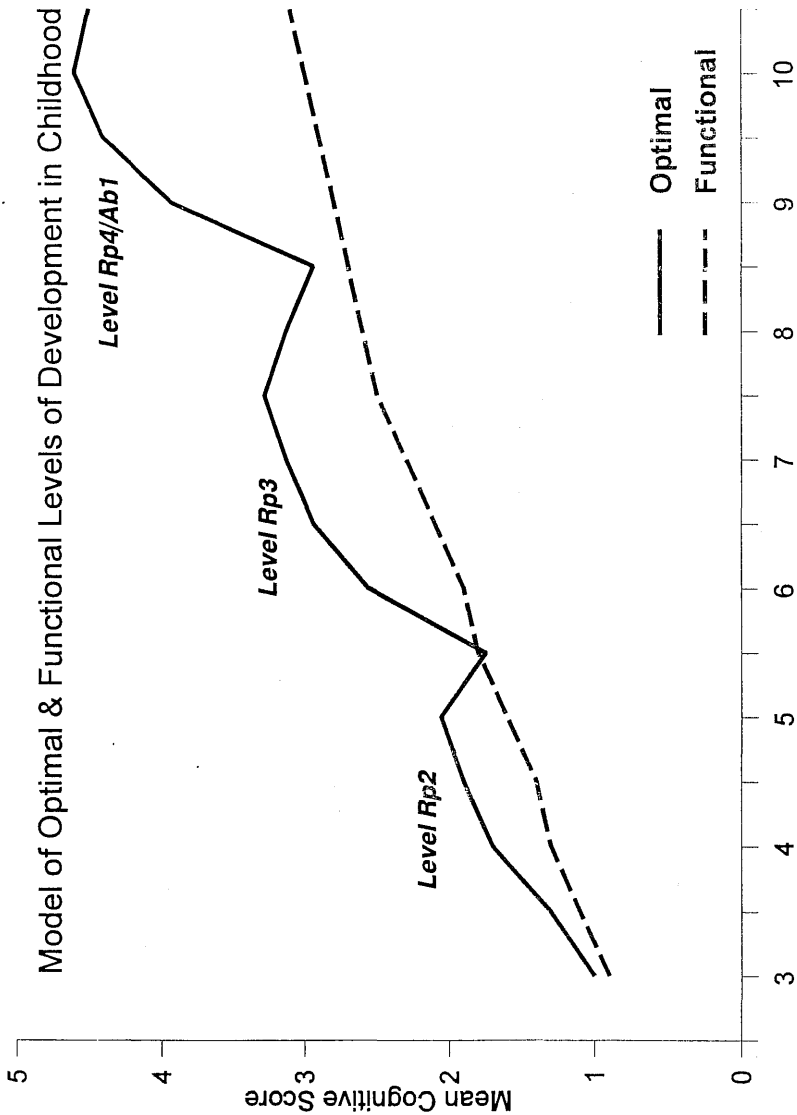

Figure 1. Both Stage-Like and Continuous Change in Cognitive Development

along diverse pathways, not along one, univocal sequence. An individual's developmental pathway for a given domain is the particular sequence of skills he or she acquires for that domain in the environmental context where he or she lives, especially the social context. Different people can show different pathways, and one individual can show distinct pathways in different domains (Fischer, Knight, & Van Parys, 1993; Fischer & Ayoub, 1994). If researchers are to incorporate variability into their explanatory frameworks, they must devise tools for characterizing differences in developmental pathways as a function of contextual differences. One such tool is the map of developmental pathways.

Perhaps because Piaget described the course of cognitive development in very abstract terms, focusing on only a few general stages, he did not deal much with even the most obvious differences in pathways, such as cross-cultural variability. For him there seemed to be a single, universal pathway culminating in the formal abstraction of the Western scientist (Gardner, 1973). Although Piaget (1967) eventually acknowledged this shortcoming and suggested that other cultures may have different developmental outcomes (Piaget, 1972; Greenfield, 1976), he never specifically adjusted his theory to take such alternatives into account. Of course, cultural differences in pathway are only one part of the picture. The activity-in-context framework implies a rich diversity of developmental pathways related to all kinds of factors in addition to culture.

The map of developmental pathways is a tool for detecting and describing variations in the number, kind, and sequence of skills. In Figure 2 the traditional Piagetian model of the developmental pathway is depicted in terms of its underlying metaphor—a ladder. In contrast, the context-sensitive model of diverse pathways is depicted in terms of a *web* of constructive generalizations.

The traditional metaphor of the ladder of development suggests a single generalized pathway that everyone must follow. However, the metaphor of the web suggests that instead of being imposed by general structures, developmental pathways are constructed and can be influenced in different directions by both organismic and contextual factors. (Similarly, evolutionary theorist Steven J. Gould [1993] has used a metaphor of a bush to describe the multi-directionality of alternate evolutionary pathways). A web is constructed by first establishing a few strands in some particular place, and then extending those strands to new but nearby

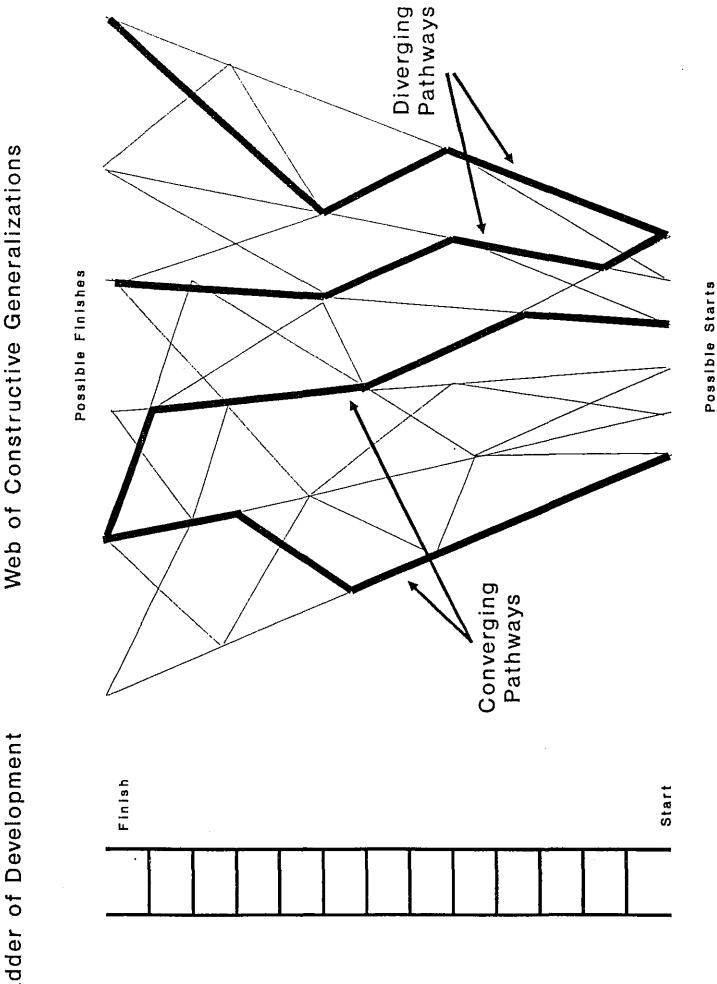

Figure 2. Two Metaphors for Conceptualizing Developmental Pathways

points that offer possible support. The particular direction and ultimate shape of a given pathway within a web is thus a joint function of the constructive activity of the web builder and the type of environment in which it is built.

Figure 2 depicts an idealized version of a web of development, representing many possible pathways in development in different contexts. The darkened lines indicate two kinds of potential relations between developmental pathways: convergent and divergent development. In convergent development a child begins at different points in development—say, two different expectations about schemas for stories (Michaels, 1981). Through constructive activity in similar contexts, such as educational settings, the child winds up at essentially the same point in development for both types of stories, such as his or her culture's prototype for telling a story. In divergent development, on the other hand, a child can begin at the same point and pursue different pathways of development toward differing developmental outcomes, as when a child develops different pathways for understanding and using gender roles for boys and girls (Fischer, Knight, & Van Parys, 1993; Gilligan & Attanucci, 1988).

Besides variations within a child, the web also characterizes differences among children. Different children can begin with different expectations about story schemas and end up with similar prototypic narratives. A boy and a girl can start out showing few differences in dealing with gender roles at 3 years of age and end up years later with large differences in their understanding and relation to gender.

Alternative developmental pathways can often be traced for different groups of children, as illustrated by the study of reading development cited earlier (Knight & Fischer, 1992). Poor readers in first to third grade were found to follow different developmental pathways from normal readers through a set of reading-related skills. When the standard metaphor of the developmental ladder is used, as in Figure 3, children are compared only in terms of relative progress or delay on a single progression from low to high performance on a single task or criterion—in this case, reading production. As long as only a single pathway is considered, there seems to be only one remedial choice: to work to speed up the apparently delayed group.

However, Figure 4 shows an alternative method of comparison based on the constructive web metaphor. In this instance, instead of comparing

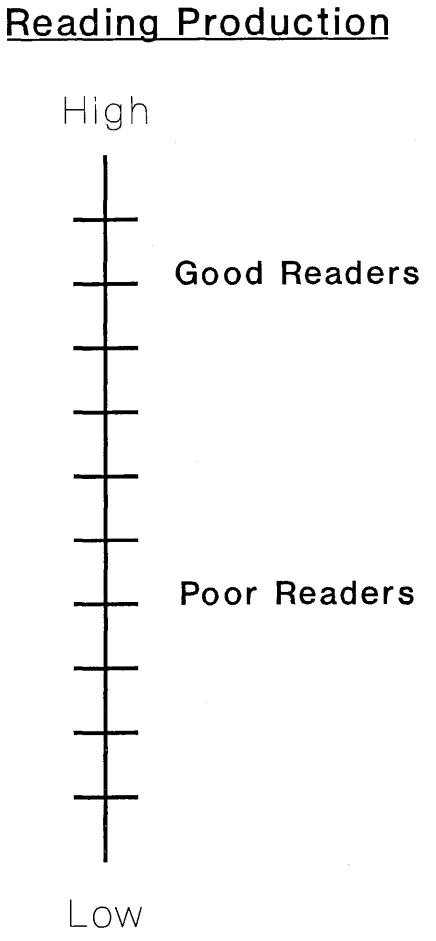

Figure 3. The Conventional Ladder Metaphor Applied to the Assessment of Reading Production Skills

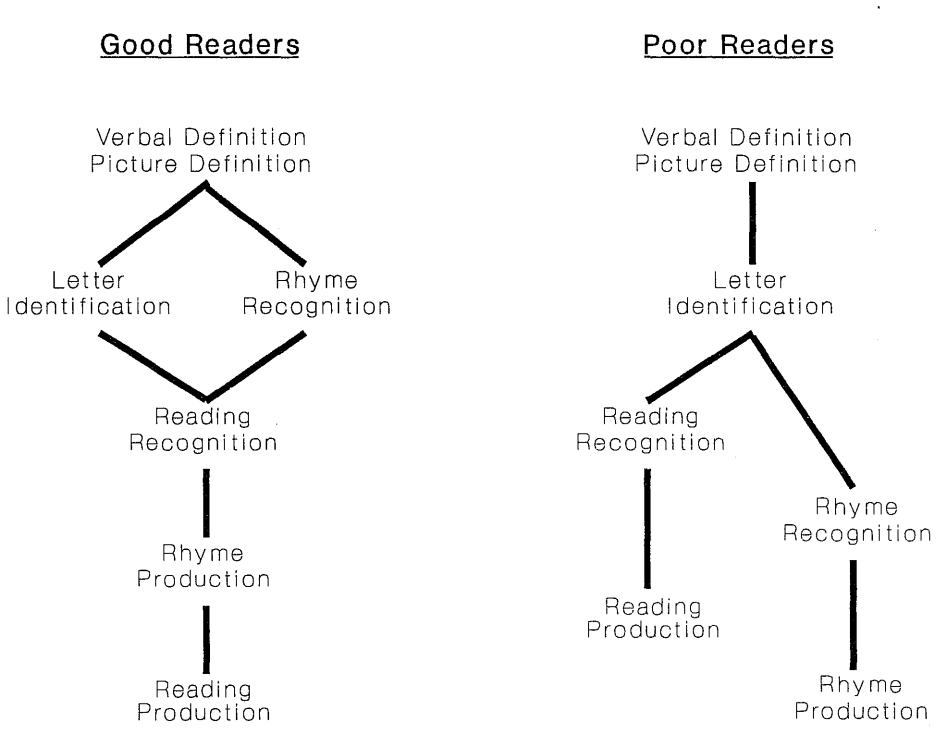

Figure 4. Alternative Developmental Pathway Maps for Reading Skills in Two Diagnostic Groups

each group in terms of achievement on a single task or criterion, the groups are compared in terms of the developmental pathways they take through a series of tasks. For each group, the order of acquisition for six reading tasks was tested using a statistical technique called partially ordering scaling that is based on the logic of Guttman scaling (Fischer, Knight, & Van Parys, 1993; Krus, 1977). In the figure, tasks acquired first are shown at the top of the sequence, and later acquisitions are shown below them. A line between two tasks means that the ordering is statistically reliable, and tasks that are parallel but have no lines between them are acquired at about the same time.

A comparison of the developmental pathways shows that the poor readers are not simply delayed with respect to a universal sequence of acquisitions, but actually follow *different* pathways in acquiring these skills, two of which are shown in the figure. Normal readers all showed one common pathway, but poor readers showed two different pathways, both distinct from the normal one. This map of alternative pathways suggests a different remedial educational strategy from the standard attempt to speed up development in poor readers: Instead, teachers can think in terms of helping to channel children into pathways that converge on the goal of competent reading. Teachers can support development by building bridges from the known to the unknown instead of providing frustrating repetitive encounters with the unknown (Rogoff, 1990).

For example a study of highly successful adult dyslexics, all of whom were strong readers and writers despite their continuing dyslexia, found that in every case mastery of reading came from intense interest in learning about a subject, such as civil war history (Fink, 1992). Because of this interest, the children worked hard to master reading despite their difficulties and gradually became skilled literate adults. In developing literacy, they likely followed distinct pathways as shown in Figure 4 but continued beyond the steps shown there to high levels of skill in reading and writing, always based on their own particular abilities and disabilities rather than the standard pathway to reading followed by most children.

From this perspective, the tool of mapping alternative developmental pathways is especially important for the study of cognitive development among working-class children and children of color. Against the backdrop of a developmental ladder based on white, middle-class norms, children from these social groups are frequently seen as exhibiting "deficits" in development. The developmental web metaphor facilitates analy-

zing developmental differences as alternative pathways instead of deficits. An important direction for future research will be to describe the webs of divergent and convergent developmental pathways in differing sociocultural groups in order to better understand and address the educational needs of diverse segments of human communities (Bidell & Fischer, 1993).

Conclusion: Toward Unity of Structure and Function through Activity in Context

In Piaget's work, there was a tension between his abstract structuralist stage theory and his constructivist view of knowledge as the product of self-regulated functional activity in the real world. From this tension, a seemingly intractable debate ensued focusing on the notion of stages (structured wholes) abstracted from considerations of specific contexts and activities. The research has highlighted the variability of development, although researchers have not always been aware of the degree to which their findings have been grounded in variability. This variability arises naturally from people's constructive activity in context, which was Piaget's original starting point for analyzing development of knowledge. Focusing on the variability does not preclude detection of commonalities and universals, but instead facilitates their detection, because most commonalities can be uncovered only when variability is systematically understood.

Foregrounding developmental variability naturally refocuses research and theory on questions of context and mechanism and away from a search for abstract context-free structures. Elsewhere, we have argued that a useful way of conceptualizing the structural and functional unity of cognitive development is through the concept of *skill* (Bruner, 1982; Fischer, 1980; Fischer & Bidell, 1991). A skill may be defined as a control system for relating variations in activity in a particular pattern or cognitive organization in a specific context. The notion of skill embodies a concept of cognitive structure that simultaneously entails a specific functional purpose in an appropriate context. A skill for tennis, for instance, is not immediately transferable to other sports—even similar ones like racquet ball—without an active reconstruction in the new context (Fischer & Farrar, 1987). On the other hand, skills provide stability and

reproducibility of activity patterns across time and space, beginning with the local contexts in which they are constructed, and gradually extending through reconstruction to form homologous skills across increasingly distant tasks and domains (Bidell & Fischer, 1993).

Alone, neither functional experience nor generalized structure can account for variability in cognitive development. The concept of context-specific cognitive skills provides a framework with which to systematically study the variability that arises in cognitive development. Because skills are constructed in specific contexts by real individuals, they may be understood to differ across persons and situations in definable ways. Yet this same constructive process ensures that cognitive skills do not vary strictly as a function of environmental contingency. Since the individual must build new cognitive skills for a given context out of previously built skills, the individual's developmental history constrains the nature of new cognitive structures.

Through the construction of cognitive skills then, structure is particularized to a given context, and particular experience is generalized by reconstruction in new contexts. In this way, refocusing on activity in context harks back to the origins of Piaget's quest for a resolution to the Cartesian dilemma, makes sense of the voluminous findings in the Anglophone literature on Piaget over the last 50 years, and offers the resolution that Piaget sought. Knowledge is truly collaborative, between person and context as well as among people. Both the particularities and the generalities of knowledge arise from that collaboration and can be understood only when analysis takes the collaboration of person and context as its starting point.

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REFERENCES

Bidell, T.R., & Fischer, K.W. (1992). Cognitive development in educational contexts: Implications of skill theory. In A. Demetriou, M. Shayer, & A. Efklides (Eds.), *Neo-Piagetian theories of cognitive development: Implications and applications for education*. New York: Routledge.

Beilin, H. (1965). Learning and operational convergence in logical thought development. *Journal of Experimental Child Psychology, 2,* 317-339.

Beilin, H. (1978). Inducing conservation through training. In G. Steiner (Ed.), *Psychology of the twentieth century: Piaget and beyond* (Vol. 7). Zurich: Kindler.

Bernstein, R. J. (1983). *Beyond objectivism and relativism: Science, hermeneutics, and praxis.* Philadelphia: University of Pennsylvania Press.

Boden, M. (1980). *Jean Piaget.* New York: Viking Press.

Brainerd, C. J. (1978). The stage question in cognitive development. *The Behavioral and Brain Sciences, 2,* 173-213.

Broughton, J.M. (1981). Piaget's structural developmental psychology, III. Function and the problem of knowledge. *Human Development, 24,* 257-285.

Bruner, J.S. (1982). The organization of action and the nature of adult-infant transaction. In M. Cranach & R. Harre (Eds.), *The analysis of action.* New York: Cambridge University Press.

Bryant, P. E. and Trabasso, T. (1971). Transitive inferences and memory in young children. *Nature, 232,* 78-96.

Case, R. (1985). *Intellectual development: Birth to adulthood.* New York: Academic Press.

Case, R., & others (1991). *The mind's staircase: Exploring the conceptual underpinnings of children's thought and knowledge.* Hillsdale, N.J.: Erlbaum.

Chapman, M. (1988). *Constructive evolution: Origins and development of Piaget's thought.* Cambridge, UK: Cambridge University Press.

Chomsky, N. (1965). *Aspects of the theory of syntax.* Cambridge: M.I.T. Press.

Cooper, R. G., Jr., (1984). Early number development: Discovering number space with addition and subtraction. In C. Sophian (Ed.), *Origins of cognitive skills.* Hillsdale, N.J.: Erlbaum.

Descartes, R. (1960). *Meditations on first philosophy* (L.J. Lafleur, Trans.). New York: Bobbs-Merrill. (Originally published, 1641).

Dodwell, P. C. (1960). Children's understanding of number and related concepts. *Canadian Journal of Psychology, 14,* 191-205.

Donaldson, M. (1978). *Children's Minds.* New York: Norton.

Droz, R., & Rahmy, M. (1974). *Lire Piaget.* Brussels: Psychologie et

Sciences Humaines/Dessart.

Elkind, D. (1964). Discrimination, seriation, and numeration of size and dimensional differences in young children: Piaget replication study VI. *Journal of Genetic Psychology, 104,* 275-296.

Feldman, D. H. (1980). *Beyond universals in cognitive development.* Norwood, NJ: Ablex.

Field, D. (1987). A review of preschool conservation training: An analysis of analyses. *Developmental Review, 7,* 210-251.

Fink, R. P. (1992). *Successful dyslexics' alternative pahways for reading: A developmental study.* Unpublished doctoral dissertation, Harvard University.

Fischer, K.W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review, 87,* 477-531.

Fischer, K.W., & Ayoub, C. (1994). Affective splitting and dissociation in normal and maltreated children: Developmental pathways for self in relationships. In D. Cicchetti & S. Toth (Eds.), *Rochester Symposium on Developmental Psychopathology Vol. 5: The self and its disorders* (pp. 149-222). Rochester, N.Y.: University of Rochester Press.

Fischer, K. W., & Bidell, T. R. (1991). Constraining nativist inferences about cognitive capacities. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition.* Hillsdale, NJ: Erlbaum.

Fischer, K.W., & Bullock, D. (1981). Patterns of data: Sequence, synchrony, and constraint in cognitive development. In K.W. Fischer (Ed.), *Cognitive development.* New Directions for Child Development (no. 12, pp. 69-78). San Francisco: Jossey-Bass.

Fischer, K.W., & Bullock, D. (1984). Cognitive development in school-age children: Conclusions and new directions. In W.A. Collins (Ed.), *The years from six to twelve: Cognitive development during middle childhood* (pp. 70-146). Washington, D.C.: National Academy Press.

Fischer, K. W., Bullock, D., Rotenberg, E. J., & Raya, P. (1993). The dynamics of competence: How context contributes directly to skill. In R. H. Wozniak & K. W. Fischer (Ed.), *Development in context: Acting and thinking in specific environments* (pp. 93-117). Hillsdale, N.J.: Erlbaum.

Fischer, K.W., & Canfield, R.L. (1986). The ambiguity of stage and structure in behavior: Person and environment in the development of psychological structures. In I. Levin (Ed.), *Stage and structure: Reopening the debate* (pp. 246-267). New York: Plenum.

Fischer, K.W., & Farrar, M.J. (1987). Generalizations about generalization: How a theory of skill development explains both generality and specificity. *International Journal of Psychology, 22,* 643-677.

Fischer, K.W., Hand, H.H., Watson, M.W., Van Parys, M., & Tucker, J. (1984). Putting the child into socialization: The development of social categories in preschool children. In L. Katz (Ed.), *Current topics in early childhood education* (vol. 5, pp. 27-72). Norwood, N.J.: Ablex.

Fischer, K. W., Knight, C. C., & Van Parys, M. (1993). Analyzing diversity in developmental pathways: Methods and concepts. In W. Edelstein & R. Case (Ed.), *Constructivist approaches to development. Contributions to Human Development, 23,* 33-56. Basel, Switzerland: S. Karger.

Fischer, K. W., & Lamborn, S. (1989). Mechanisms of variation in developmental levels: Cognitive and emotional transitions during adolescence. In A. de Ribaupierre (Ed.), *Transition mechanisms in child development.* New York: Cambridge University Press. Pp. 33-67.

Fischer, K.W., & Roberts, R.J., Jr. (1989). The development of classification skills in the preschool years: Developmental level and errors. Cambridge, MA: Cognitive Development Laboratory Report, Harvard University.

Fischer, K. W., & Rose, S. P. (1994). Development of coordination of components in brain and behavior: A framework for theory and research. In G. Dawson & K. W. Fischer (Ed.), *Human behavior and the developing brain* (pp. 3-66). New York: Guilford.

Fischer, K.W., Shaver, P., & Carnochan (1990). How emotions develop and how they organize development. *Cognition and Emotion, 4,* 81-127.

Fischer, K.W., & Silvern, L. (1985). Stages and individual differences in cognitive development. *Annual Review of Psychology, 36,* 613--648.

Flavell, J. H. (1963). *The developmental psychology of Jean Piaget.* Princeton, NJ: Van Norstrand.

Flavell, J. H. (1972). An analysis of cognitive developmental sequences. *Genetic Psychology Monographs, 86*, 279-350.

Flavell, J. H. (1982a). On cognitive development. *Child Development, 53*, 1-10.

Flavell, J. H. (1982b). Structures, stages, and sequences in cognitive development. In W. A. Collins (Ed.), *Minnesota Symposium on Child Psychology*. Hillsdale, NJ: Erlbaum.

Fogel, A., & Thelen, E. (1987). Development of early expressive and communicative action: Reinterpreting the evidence from a dynamic systems perspective. *Developmental Psychology, 23*, 747-761.

Gardner, H. (1973). *The quest for mind*. New York: Knopf.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Gardner, H. (1985). *The mind's new science: A history of the cognitive revolution*. New York: Basic Books.

Gelman, R. (1972). Logical capacity of very young children: Number invariance rules. *Child Development, 43*, 75-90.

Gelman, R., & Baillargeon, R. (1983). A review of some Piagetian concepts. In P.H. Mussen (Ed.), *Handbook of child psychology*. Vol. 3: *Cognitive development* (J. H. Flavell & E. M. Markman, Eds., pp. 167-230). New York: Wiley.

Gelman, R., & Gallistel, C. R. (1978). *The child's understanding of number*. Cambridge, MA: Harvard University Press.

Gesell, A. (1928). *Infancy and human growth*. New York: Macmillan.

Gilligan, C., & Attanucci, J. (1988). Two moral orientations: Gender differences and similarities. *Merrill-Palmer Quarterly*.

Gladwin, T. (1970). *East is a big bird: Navigation and logic on Puluwat atoll*. Cambridge, MA: Harvard University Press.

Gould, S. J. (1993). *Eight little piggies: Reflections in natural history*. New York: W. W. Norton.

Granott, N. (1993a). *Microdevelopment of co-construction of knowledge during problem-solving: Puzzled minds, weird creatures, and wuggles*. Unpublished doctoral dissertation, M.I.T.

Granott, N. (1993b). Patterns of interaction in the co-construction of knowledge: Separate minds, joint effort, and weird creatures. In R. H. Wozniak & K. W. Fischer (Ed.), *Development in context: Acting and thinking in specific environments* (pp. 183-207). Hillsdale, N.J.: Erlbaum.

Greenfield, P. M. (1976). Cross-cultural research and Piagetian theory: Paradox & progress. In, K. Riegel & J. Meacham (Eds.), *The developing individual in a changing world*. The Hague: Mouton.

Halford, G.S. (1982). *The development of thought*. Hillsdale, N.J.: Erlbaum.

Halford, G. S. (1989). Reflections on 25 years of Piagetian cognitive psychology, 1963-1988. *Human Development, 32*, 325-357.

Halford, G. S., & Boyle, F. M. (1985). Do young children understand conservation of number? *Child Development, 56*, 165-176.

Hall, G. S. (1904). *Adolescence: Its psychology and its relations to physiology, anthropology, sociology, sex, crime, religion, and education*. East Norwalk, CN: Appleton-Century-Crofts.

Inhelder, B., & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence* (A. Parsons & S. Seagrim, Trans.). New York: Basic Books. (Originally published, 1955).

Inhelder, B., & Piaget, J. (1969). *The early growth of logic in the child*. (Trans., E. A. Lunzer & D. Papert). New York: Norton. (Originally published 1959).

Inhelder, B. & Piaget, J. (1980). Procedures and structures. In D. R. Olsen (Ed.), *The social foundations of language and thought*. New York: Norton.

Inhelder, B., Sinclair, H., & Bovet, M. (1974). *Learning and the Development of Cognition*. Cambridge, MA: Harvard University Press.

Jamison, W. (1977). Developmental interrelations among concrete operational tasks: An investigation of Piaget's stage concept. *Journal of Experimental Child Psychology, 24*, 235-253.

Kagan, J. (1982). *Psychological research on the human infant: An evaluative summary*. New York: W.T. Grant Foundation.

Kitchener, K.S., & Fischer, K.W. (1990). A skill approach to the development of reflective thinking. In D. Kuhn (Ed.), *Developmental perspectives on teaching and learning thinking skills*. Contributions to Human Development. Basel, Switzerland: S. Karger.

Kitchener, K. S., Lynch, C. L., Fischer, K. W., & Wood, P. K. (1993). Developmental range of reflective judgment: The effect of contextual support and practice on developmental stage. *Developmental Psychology, 29*, 893-906.

Knight, C. C., & Fischer, K. W. (1992). Learning to read words: Individual differences in developmental sequences. *Journal of Applied*

Developmental Psychology, 13, 377-404.

Kofsky, E. (1966). A scalogram study of classificatory development. *Child Development, 37*, 191-204.

Kohlberg, L., Levine, C., & Hewer, A. (1983). *Moral stages: A current formulation and a response to critics*. New York: Karger.

Krus, D. J. (1977). Order analysis: An inferential model of dimensional analysis and scaling. *Educational and Psychological Measurement, 37*, 587-601.

Lamborn, S. D., and Fischer, K. W. (1988). Optimal and Functional levels in cognitive development: The individual's developmental range. *Newsletter of the International Society for the Study of Behavioral Development,* no. 2, serial no. 14, 3-4.

Locke, J. (1690). *An essay concerning human understanding*. London

Lunzer, E. A. (1960). Some points of Piagetian theory in the light of experimental criticism. *Journal of Child Psychology and Psychiatry, 1*, 191-202.

Mandler, G. (1963). From association to structure. *Psychological Review, 69*, 415-427.

Markman, E. M. (1978). Empirical versus logical solutions to part-whole comparison problems concerning classes and collections. *Child Development, 49*, 168-177.

McGarrigle, J., Grieve, R., and Hughes, M. (1978). Interpreting inclusion: A contribution to the study of the child's cognitive and linguistic development. *Journal of Experimental Child Psychology, 28*, 528-550.

Michaels, S. (1981). "Sharing time": Children's narrative styles and differential access to literacy. *Language in Society, 10*, 423-442.

Miller, G. A., Galanter, E., & Pribram, K. (1960). *Plans and the structure of behavior*. New York: Holt, Rinehart & Winston.

Murray, F. B. (1968). Cognitive conflict and reversibility training in the acquisition of length conservation. *Journal of Educational Psychology, 59*, 82-87.

Piaget, J. (1950). *The psychology of intelligence* (M. Piercy & D. E. Berlyne, trans.). New York, N.Y.: Harcourt, Brace (Originally published 1947).

Piaget, J. (1952). *The origins of intelligence in children* (M. Cook, Trans.). New York: International Universities Press. (Originally published, 1936).

Piaget, J. (1967). Review of *Studies in cognitive growth* by J. S. Bruner, R. P. Olver, & P. M. Greenfield. *Contemporary Psychology, 12,* 532-535.

Piaget, J. (1971). *Biology and knowledge: An essay on the relations between organic regulations and cognitive processes* (B. Walsh, Trans.). Chicago: University of Chicago Press. (Originally published, 1967).

Piaget, J. (1970). *Structuralism* (C. Maschler, Trans.). New York: Basic Books. (Originally published, 1968).

Piaget, J. (1971). *The child's conception of time* (A. J. Pomerans, trans.). New York: Ballentine. (Originally published 1946).

Piaget, J. (1972). Intellectual evolution from adolescence to adulthood. *Human Development, 15,* 1-12.

Piaget, J. (1976). *The grasp of consciousness* (S. Wedgewood, trans.). Cambridge: Harvard University Press. (Originally published 1974).

Piaget, J. (1978). *Success and understanding* (A. J. Pomerans, trans.). London: Routledge & Kegan Paul. (Originally published 1974).

Piaget, J. (1983). Piaget's theory. In W. Kessen (Ed.), & P. H. Mussen (Series Ed.), *Handbook of child psychology: Vol. 1. History, theory, and methods* (pp. 103-126). New York: Wiley.

Piaget, J. (1987). *Possibility and necessity* (2 vols., H. Feider, trans.). Minneapolis, MN: University of Minnesota Press. (Originally published 1981 and 1983).

Piaget, J., & Inhelder, B. (1974). *The child's construction of quantities: Conservation and atomism* (A.J. Pomerans, trans.). London: Routledge & Kegan Paul. (Originally published 1941).

Piaget, J., & Inhelder, B. (1967). *The child's conception of space* (F.J. Langdon and J.L. Lunzer, trans.). New York: Norton. (Originally published 1948).

Piaget, J., & Szeminska, A. (1952). *The child's conception of number* (C. Gattegno & F.M. Hodgson, trans.). London: Routledge & Kegan Paul. (Originally published 1941).

Price-Williams, D., Gordon, W., and Ramirez, M., III. (1969). Skill and conservation: A study of pottery making children. *Developmental Psychology, 1,* 769.

Reese, H. W., & Overton, W. F. (1970). Models of development and theories of development. In L. R. Goulet & P. B. Baltes (Eds.), *Life-span developmental psychology: Research and theory.* New York:

Academic Press.

Rogoff, B. (1982). Integrating context and cognitive development. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology* (Vol. 2). Hillsdale, NJ: Erlbaum.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Rogoff, B., & Lave, J. (Eds.) (1984). *Everyday cognition: Its development in social context*. Cambridge, MA: Harvard University Press.

Rose, S.P. (1990). *Levels and variations in measures of perspective-taking*. Unpublished doctoral dissertation, University of Denver, Denver, Colorado.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals, and understanding: An inquiry into human knowledge structures*. Hillsdale, NJ: Erlbaum.

Siegler, R.S. (1981). Developmental sequences within and between concepts. *Monographs of the Society for Research in Child Development, 46*(2, serial no. 189).

Sigel, I., Roeper, A., & Hooper, F. H. (1966). A training procedure for acquisition of Piaget's conservation of quantity: A pilot study and its replication. *British Journal of Educational Psychology, 36*, 301-311.

Silverman, I. W., & Briga, J. (1981). By what process do young children solve small number conservation problems? *Journal of Experimental Child Psychology, 32*, 115-126.

Smith, C. L. (1979). Children's understanding of natural language hierarchies. *Journal of Experimental Child Psychology, 27*, 437-458.

van der Maas, H., & Molenaar, P. (1992). A catastrophe-theoretical approach to cognitive development. *Psychological Review, 99*, 395-417.

van Geert, P. (1991). A dynamic systems model of cognitive and language growth. *Psychological Review, 98*, 3-53.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes* (M. Cole, V. John-Steiner, S. Scribner, & Ellen Souberman, trans.). Cambridge, Massachusetts: Harvard University Press.

Watson, J. B. (1928). *Psychological care of infant and child*. London: Allen & Unwin.

Werner, H. (1957). *Comparative psychology of mental development*. New York: International Universities Press.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind.* Cambridge, MA: Harvard University Press.

Winer, G. A. (1980). Class-inclusion reasoning in children: A review of the empirical literature. *Child Development, 51,* 309-328.

Wood, D. J. (1980). Teaching the young child: Some relationships between social interaction, language, and thought. In D. R. Olsen (Ed.), *The social foundations of language and thought.* New York: Norton.

Wohlwill, J. F. (1968). Response to class-inclusion questions for verbally and pictorially presented items. *Child Development, 39,* 449-465.

Wohlwill, J.F. (1973). *The study of behavioral development.* New York: Academic Press.

Zimmerman, B.J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81,* 329-339.