CHAPTER 15

The Development of Conceptual Structures

ROBBIE CASE

THREE THEORETICAL TRADITIONS IN THE STUDY OF CONCEPTUAL GROWTH 747
The Empiricist Tradition 747
The Rationalist Tradition 748
The Sociocultural Tradition 750
Comparing the Three Traditions and Clarifying Their Differences 751

DIALOGUE BETWEEN THE EMPIRICIST AND RATIONALIST TRADITIONS 753
Early Empiricist Critiques of Piaget’s Theory 753
Subsequent Developments of the Empiricist Critique 755

NEW MODELS OF CHILDREN’S CONCEPTUAL UNDERSTANDING 755
Conceptual Development as a Local Process, Limited by General Constraints 755
Conceptual Development as a Sequence of Theoretical Revolutions 757
Conceptual Development as the Acquisition of Expertise 759
Conceptual Development as Initiation into a Community of Praxis 761
Comparing the New Models and Abstracting Common Principles 763

TOWARD AN INTEGRATED VIEW OF CHILDREN’S CONCEPTUAL STRUCTURES 764
Young Children’s Understanding of Number 764
Young Children’s Social Understanding and Their Construction of a “Theory of Mind” 766
Young Children’s Understanding of Space 767
Abstracting a Common Pattern of Development across Different Domains 769
Broadening the Search for Commonalities to Other Domains 771

THE PROCESS OF CONCEPTUAL CHANGE 774
Models of Conceptual Change in the Empiricist Tradition 775
Models of Conceptual Change in the Rationalist Tradition 779
Models of Conceptual Change in the Sociocultural Perspective 784
Trends and Convergences among the Three Traditions 786

TOWARD AN INTEGRATED VIEW OF CONCEPTUAL CHANGE 788
Differentiating and Elaborating the Content of Existing Schemas 788
Linking Existing Schemas from Different Modules 789
Reorganizing the Existing Schematic Repertoire 789
Mastering a New (Second-Order) Symbol System 790
Putting the New System to Work 790

SUMMARY AND CONCLUSION 791
REFERENCES 793

Children’s early concepts differ in interesting ways from those of adults; even when they use the same word to describe a particular object (e.g., dog) the conceptual meaning that they attach to this word often differs substantially from the adult one (Anglin, 1993; Clark, 1983). It has also been claimed that the entire structure of children’s conceptual understanding is different from that of adults. When unpacked, this claim may normally be seen to involve one or more of the following propositions: (a) distinctive general patterns may be discerned in children’s conceptual understanding, ones which are present across a wide variety of local exemplars (e.g., mother, father, brother); (b) these patterns reflect a fundamental difference—not just in the content of children’s conceptual knowledge—but in the way that knowledge is organized; and (c) the reason children’s knowledge is organized differently from that of adults is not just because children have had less experience, but because the architecture of their cognitive systems is different in some fundamental way. The foregoing claims, or ones much like them, show up in the earliest writings on children’s cognitive development, and have inspired some of the most controversial work that has been done in the field throughout this century. In the present chapter I review this work, with special attention to the age range for
which the largest body of empirical data has been gathered: namely, 4 to 10 years.

Most previous treatments of this topic have been organized in one of four ways: chronological, substantive, thematic, or theoretical. When adopting the chronological approach, the standard procedure is to review the conceptual structures that have been hypothesized for children at different ages, beginning in infancy and passing on to higher stages; then to evaluate the evidence that has been gathered and the conclusions that have been drawn for each. When adopting the substantive approach, the standard procedure is to lay out the major domains or types of concepts for which structural claims have been made (for example, those having to do with causality, time, and space); then to summarize the structural progression that has been hypothesized within each domain, the studies have been conducted, and the conclusions that have been drawn. The thematic approach is compatible with either of the foregoing forms of organization and is sometimes combined with them. Its distinctive feature is that a general set of issues or questions are presented at the outset: Do general conceptual structures exist at all? What sort of data would we need to gather to support or refute this claim? Are the conceptual structures at different stages of development qualitatively different? Is the transition from one form of structure to the next a gradual or a rapid one? Each of these questions has a long history in the field; accordingly, each can be treated in a separate section. Alternatively, the questions as a group can be used as a leitmotif to provide unity and coherence to the material that is reviewed throughout. The final form of organization is theoretical. Here the strategy is to devote a different section to each of the major theories that has been proposed in the field of cognitive development and to outline the position that each has taken on the structural question; then to attempt some sort of systematic comparison and/or integration of these positions at the chapter's end.

A modified form of this latter organization will be used in the present chapter. The basic thesis that underlies the present review, and that distinguishes it from other reviews on the same topic, is that many of the most enduring issues and controversies in this field are actually epistemological in nature; that is to say, they have to do with background assumptions that their authors make about the fundamental nature of human knowledge, and the process by which that knowledge is acquired. Although investigators have not always stated their background assumptions explicitly, these assumptions have nevertheless had a profound effect, both on the nature of the theories to which they have been attracted, and on the methodologies that they have regarded as most appropriate for investigating these theories. In order to highlight the role that background assumptions of this sort have played in the history of the field, the theories that are covered in the present chapter are organized into three broad epistemological categories. The history of the field is then described as a dialectic one, in which a succession of new and/or improved theories is seen as emerging within each of the three categories, in response to criticisms that were levelled at the previous theory by those subscribing to a rival epistemological position.

This chapter is organized in six sections. In the first, I provide a brief description of the major epistemological positions that have influenced the field, and the background assumptions that they entail about human knowledge. In subsequent sections, I describe (a) the view of children's conceptual structures that has been proposed in each tradition; (b) the dialogue that has taken place among the traditions, as the relative merits of the different positions have been debated and their points of disagreement clarified; (c) the work that has been done in each of the traditions in the last decade in response to the most recent round in this debate; and (d) several new lines of investigation: ones that suggest a way in which work in the three traditions may possibly be integrated. Finally, in the last two sections, I consider the question of how to conceptualize the process of structural change. After a brief review of the mechanisms that have been proposed in each of the three traditions, I conclude by suggesting a way in which these different proposals may be integrated.

For readers who are new to the topic of conceptual structures, my hope is that the present chapter will constitute a good introduction. All the classic positions on the topic are covered, as are the different substantive domains for which these positions have been developed, the data that have been gathered and the issues that have emerged. For readers who are already sophisticated students in this field, or active contributors to it, my hope is that my treatment of the history of the field will be of some interest as well. The assignment of theories to groups is somewhat different from the one that we have become accustomed to, as is the treatment of certain of the classic controversies. My hope is that the reader will find these differences to be productive, both in terms of the light that they cast on past work in the field, and the promise that they offer for the future.
THREE THEORETICAL TRADITIONS IN THE
STUDY OF CONCEPTUAL GROWTH

Research on children’s conceptual structures has been conducted within several different epistemological frameworks. Although a number of schemes have been proposed for classifying these frameworks (Bellin, 1983; Overton, 1984, 1990, 1996), the scheme that will be used in this chapter is one that distinguishes three traditions: each with its own pioneers, its own methods, and its own tradition of progressive inquiry.

The Empiricist Tradition

The epistemological roots of the first tradition lie in British empiricism, as articulated by Locke and Hume (1755/1748). According to the empiricist position, knowledge of the world is acquired by a process in which the sensory organs first detect stimuli in the external world, and the mind then detects the customary patterns or “conjunctions” in these stimuli. Developmental psychologists who accept this view have tended to view the goals of psychology as being to describe (a) the process by which new stimuli are discriminated and encoded (perceptual learning); (b) the way in which correlations or associations among these stimuli are detected (cognitive learning); and (c) the process by which new knowledge is accessed, tested, and/or used in other contexts (transfer). The general method that has been favored includes the following three steps:

1. Make detailed empirical observations of children’s learning, in a fashion that can be replicated with reliability.
2. Generate explanations for these observations that are clear and testable.
3. Conduct carefully controlled experiments to test these hypotheses: ones that rule out any rival hypotheses.

In the field of child development, early attempts to apply this perspective led to two main kinds of investigation. The first was directed toward clarifying the nature of the perceptual stimuli that infants could detect at birth, and documenting the forms of learning that were possible (Lipsitt, 1967). The second was directed to clarifying the sort of higher order learning that children could engage in at older ages, once they could make the required perceptual discriminations. Of particular interest was the learning of verbal concepts. To study this latter type of learning, children were presented with pairs of sensory stimuli that varied along a number of dimensions (e.g., form, color, pattern), and then asked to play a game where they had to figure out which stimulus feature was associated with receipt of a small reward (e.g., square stimulus on top of container = raisin inside container; circular stimulus on top = nothing inside). On each trial children were allowed one guess as to which stimulus would be rewarded. When they had succeeded in picking the correct stimulus on some predetermined number of trials (typically 9 out of 10), they were said to have acquired the concept. At that point, a different attribute was selected, and a fresh sequence of experimental trials was initiated.

The results that were obtained from these studies were as follows. Although preschool children could learn to select a stimulus on the basis of its shape, color, or pattern by the age of 3 to 4 years, and could also learn to change the basis for their selection when the criterion was changed, they did so in a rather slow and laborious manner, with the result that their learning curves looked much like those exhibited by lower primates (Kendler, Kendler, & Wells, 1960). By the age of 5 to 6 years, children’s original learning became much more rapid. They also became capable of relearning much more rapidly, typically within one or two trials (Kendler & Kendler, 1962). However, this was true only if the new criterion was one that required attention to the same general stimulus dimension (e.g., shape). If they were required to shift to a different dimension, particularly one that was perceptually less salient than the first dimension, the capability for rapid relearning did not emerge until the age of 7 to 10 years of age (Mumbauer & Odom, 1967; Osler & Kofsky, 1966).

When these phenomena were first observed, the change in children’s learning on such tasks was hypothesized to be part of a larger pattern, which White (1967) referred to as the “5 to 7 shift.” In keeping with the learning theories of the time, Kendler and Kendler (1962) proposed that the pattern was caused by a shift from unmediated to verbally mediated learning. The notion was that children under the age of 5, like lower primates, can learn to differentiate objects that are associated with reward from other objects. However, since they do not covertly label each object using dimensional terms (e.g., square), they have to learn about each object in a rather local fashion. By contrast, since older children and adults do engage in this sort of covert verbal labelling, they are capable of much more rapid initial learning; they are also capable of much more rapid re-learning, since all they have to do is substitute one
dimensional term for another, not learn a whole new set of associations. This same change, that is, the change from unmediated to verbally mediated learning, was believed to have a wide variety of other consequences for children’s cognition, especially the sort that is required in school (Kendler & Kendler, 1967; Rohwer, 1970).

In interpreting the data in this fashion, investigators in this tradition were subscribing to the first two classical hypotheses that were stated at the outset, namely (a) that a distinctive pattern may be discerned in young children’s conceptual understanding, which is present across a wide variety of different local exemplars and (b) that this pattern reflects a fundamental difference, not just in the content of children’s conceptual knowledge, but in the way that knowledge is organized. The third hypothesis that was mentioned—namely, that this difference does not derive from experience, but from a fundamental difference in the architecture of children’s cognitive systems—was not necessarily subscribed to. Indeed, a good deal of work was devoted to showing that children could encode the relationship to be learned in the required fashion with a little instruction, but did not do so spontaneously (Kendler & Kendler, 1967). This latter datum was interpreted as indicating a “performance” rather than a “structural” deficiency in children’s verbal mediation.

In retrospect, what can be said about the early work on children’s concept formation in this tradition? From a theoretical point of view, the harvest was relatively meager. Although the notion of verbal mediation continued to play some role in other epistemological traditions (see below), it was by and large abandoned in the empiricist tradition, because it did not fit the overall pattern that emerged, as further training and transfer studies were conducted. (See Stevenson, 1972; Ch. 9 for a review.) From a methodological point of view, the harvest was not as rich as it might have been, either. For a variety of reasons that will be described below, subsequent investigators decided that this sort of perceptually-based learning paradigm was not the best one to use during this age range, in order to reveal the full conceptual understanding of which children are capable.

To say that the harvest from these early studies was relatively meager is not to say that there was no harvest at all, however. First, the data that were gathered were extremely reliable and formed a lasting part of the general corpus that subsequent investigators felt obliged to explain, in building a model of the change that takes place in children’s cognition in this age range (Case, 1985; Gholson, 1985). Second, the general paradigm embodied a number of methodological canons that proved enduring. Of particular importance were:

1. There is much to be learned, in studying any complex conceptual structure, by examining the manner in which children encode its constituent elements.
2. There is also much to be gained by selecting a carefully circumscribed task, and varying its parameters.
3. Finally, there is much to be learned by examining the performance of different age groups, in a multiple-trial task where learning can be observed directly.

All three of these features have been preserved (or rather reintroduced) by subsequent investigators in this tradition (Siegler, 1978, 1996).

The Rationalist Tradition

The second theoretical tradition in which children’s conceptual structures have been studied drew its inspiration from Continental rationalism rather than British Empiricism. In reaction to British empiricists, philosophers such as Kant (1791/1796) suggested that knowledge is acquired by a process in which order is imposed by the human mind on the data that the senses provide, not merely detected in these data. Examples of concepts that played this foundational role in Kant’s system were space, time, causality, and number. Without some pre-existing concept in each of these categories, Kant argued that it would be impossible to make any sense of the data of sensory experience: to see events as taking place in space, for example, as unfolding through time, or as exerting a causal influence on each other. For this reason he believed that these categories must exist in some a priori form rather than being induced from experience.

Developmental psychologists who were influenced by Kant’s view tended to see the study of children’s cognitive development in a different fashion from those who were influenced by empiricists. They thought that one should begin by exploring the foundational concepts with which children come equipped at birth; then go on to document any change that may take place in these concepts with age. The first developmental theorist to apply this approach was Baldwin (1968/1894). According to Baldwin, children’s conceptual schema progress through a sequence of four universal stages, which he termed the stages of “sensorimotor,” “quasilogical,” “logical,” and “hyper-logical”
thought, respectively. In any given stage, Baldwin believed that new experience is "assimilated" to the existing set of schemata, much in the manner that the body assimilates food. He saw transition from one form of thought to the next as driven by "accommodation," a process by which existing schemata are broken down and then reorganized into new and more adaptive patterns. Finally—and in this he was attempting to go beyond Kant—he saw children's conceptual understanding in each of Kant's categories as something that they construct, not something that is inborn. The only primitive elements with which he saw children being endowed at birth were entities that he called "circular reactions." He called for subsequent generations to explore these reactions, and to chart the process by which they are assembled into higher order schemata.

Although Baldwin was the first to articulate a general theory of conceptual development, it was Piaget's (1960, 1970) acceptance of Baldwin's challenge, and his reworking of Baldwin's theory, that had the greatest impact on the field. The most important feature that Piaget added to Baldwin's theory was the notion of a "logical structure," that is, a coherent set of logical operations that can be applied to any domain of human activity, and to which any cognitive task in the domain must ultimately be assimilated. Piaget hypothesized that the form of children's structures is different at different stages of their development, and that it is this difference that gives the thought of young children its unique character. To highlight the importance of these structures, he relabelled Baldwin's second and third stages of development, calling them the stages of "pre-operational" and "operational" thought, respectively. He also divided the stage of operational thought into the "concrete" and "formal" periods.

Together with his collaborators at the University of Geneva, Piaget conducted a vast number of studies that were designed to reveal the details of children's conceptual understanding in each of Kant's categories, and the process by which this understanding is arrived at. The basic procedure was to present children with a wide variety of simple problems or tasks, in order to see how they would respond to them; then to interview them in order to determine the reasoning on which these responses were based. A final step was to look for a common pattern in children's reasoning at different ages, and to treat this pattern as a clue regarding the underlying logical structure that was present.

The conservation task is perhaps the most famous of Piaget's problems (Piaget, 1952). A precursor to this task had actually been studied by Binet (1900), who asked children to judge which of two objects was bigger under a variety of illusory conditions. Binet and his colleagues had shown that preschool children could not perform successfully on such tasks, that is to say, they could not overcome the perceptual illusion that the stimulus situation presents. By contrast, school-aged children were able to overcome the illusion, and to make an accurate judgment of quantity (Binet & Simon, 1905). Piaget modified this task so that children of all ages would have a more certain, logical basis for making a judgment about relative quantity. First, he presented children with a pair of objects whose quantity was equal, under perceptual conditions that were not illusory, and asked them if they thought the two objects were equal in quantity (typically children decided that they were). Next, he transformed one of the two objects, in full view, so that it looked bigger or smaller than the other object. If dealing with two lumps of plasticene, for example, he might pull one of the two lumps into a long, loglike shape. After the transformation was complete, Piaget's final step was to ask the children if they still thought the quantities were equal, or if one was now bigger (or contained more) than the other. Once they had answered, he asked them to explain why they thought this was the case.

The results are by now well-known. Notwithstanding the fact that "logic" argued that the two quantities must still be equal, preschool children were misled by the evidence of their senses into concluding that one of the two arrays contained more than the other. By contrast, older children concluded that the amount in each array must still be the same. At the age of 7 to 8, the most frequent explanation was that nothing had been added to, or taken away from, the original array. Justifications that were sometimes added at a later age included the argument that—while one array does look bigger now along one dimension (e.g., length)—it looks smaller along another (e.g., width).

Piaget's explanation for the change in children's justifications was that they had acquired a new logical structure: one in which the illusions of the sensory world can be compensated for by a set of internal, logico-mathematical operations. He further asserted that these operations were systemwide in their applicability, and signalled a major change in the architecture of their cognitive systems. Note that—while Piaget's interpretation included all three of the components that were mentioned at the outset of the chapter—it was quite different from the interpretation that had been advanced by empiricists, in order to explain the change that they had observed during the same time period. Rather than seeing children as learning to recognize and
label the basic dimensions of the empirical world, as a result of experience with it, Piaget saw them as constructing a powerful new form of logic, one which enabled them to overcome the illusions to which empirical experience would otherwise subject them.

In this particular case, the logical structure that Piaget presumed children had to assemble was one in which compensation plays a vital role, and that can be symbolized by the following formula:

\[ A_1 \times B_1 = A_2 \times B_2 \]

where \( A_1 \) stands for the value of the first dimension at time 1, \( B_1 \) stands for the value of the second dimension at time 1, \( A_2 \) stands for the value of the first dimension at time 2, and \( B_2 \) stands for the value of the second dimension at time 2.

As Piaget became interested in logical structures of this sort, he devised a number of tasks that he hoped would document their existence more directly (Inhelder & Piaget, 1958, 1964). Included among these was another task that became a classic: namely, the task of class inclusion. In this problem, children are shown an array of shapes (say, a set of square and round shapes). They are then asked to compare the set comprised of all the shapes with the larger of the two subordinate sets, and say which set is bigger. Once again, the result is by now well known: Prior to the age of 7, most children assert that the subordinate set (e.g., square shapes) is larger than the superordinate set (all shapes). They then justify their response by comparing the two subordinate sets. By the age of 7 to 10, most children reverse their earlier decision and conclude that the superordinate set is larger. Moreover, they appear to experience this fact as a "logical necessity." For Piaget, the switch to the correct response, coupled with the feeling of logical necessity, provided further evidence that children were acquiring a new set of logico-mathematical structures.

As it happens, the class inclusion task is rather similar to the concept learning task in certain respects. Both tasks present children with a simple set of shapes that can be classified in a number of different ways (by shape, color, etc.). Both tasks require children to overcome their "natural" or "habitual" way of classifying a set of stimuli. Both tasks require children to sustain a focus on subordinate stimulus values, without losing sight of a superordinate classification. Finally, both tasks are passed for the first time during the same general age range: 7 to 10 years. The form of interpretation that the two groups of theorists developed to explain the developmental change, however, was quite different. For learning theorists, the switch to a new form of response was seen as the result of applying a learned set of labels to stimuli, and forming associations among them; in short, it was seen as the result of a verbally mediated learning process. For Piaget and those who followed him, the switch was seen as the result of acquiring a new logical structure: one in which superordinate and subordinate categories were differentiated and integrated. This structure, in turn, was seen as emerging from an internal process of reflection, not from a process in which exposure to empirical experience played the major role.

The difference between the two groups in their view of children's developing cognitive competencies was paralleled by a difference in their view of the methods that were most appropriate for studying these processes. The approach favored by empiricists was to focus on a single task that involved some form of empirical learning, then to systematically vary its parameters. By contrast, the approach favored by Piaget and his colleagues was to focus on children's understanding across a broad range of tasks, in which the results of empirical learning had to be overcome in some fashion. The form of response that the two groups analyzed was also different. Empiricists offered children a choice between two clear cut alternatives, then examined their success rate and the strategies that led to it. By contrast, Piaget and his colleagues gave a much higher weight to children's explanations, probing the reasoning that lay behind these explanations in a clinical manner. Like the differences in their theories, these differences in methodology were a function of differences in epistemology.

The Sociohistoric Tradition

A third epistemological tradition within which children's conceptual understanding has been studied has its roots in the sociohistoric epistemology of Hegel, Marx, and the modern continental philosophers (Kaufmann, 1980). According to the sociohistoric view, conceptual knowledge does not have its primary origin in the structure of the objective world (as empiricist philosophers suggested). Nor does it have its origin in the structure of the subject and his spontaneous cogitation (as rationalist philosophers suggested). It does not even have its primary origin in the interaction of between the structure of the subject and the structure of the objective world (as Baldwin and Piaget maintained). Rather, it has its primary origin in the social and material history of the culture of which the subject is a member, and the tools,
concepts, and symbol systems that the culture has developed for interacting with its environment.

Developmental psychologists who adopted the sociohistoric perspective viewed the study of children's conceptual understanding in a different fashion from empiricists or rationalists. They believed that one should begin one's study of children's thought by analyzing the social, cultural, and physical contexts in which human cultures find themselves, and the social, linguistic, and material tools that they have developed over the years for coping with these contexts. One should then proceed to examine the way in which these intellectual and physical tools are passed on from one generation to the next, in different cultures and at different time periods.

The best known of the early sociohistoric theories was Vygotsky's (1962). According to Vygotsky, children's thought must be seen in a context that includes both its biological and its cultural evolution. Three of the most important features of human beings as a species are: (a) that they have developed language; (b) that they fashion their own tools; and (c) that they transmit the discoveries and inventions of one generation to the next. From the perspective of Vygotsky's theory, the most important milestone in children's early development is the acquisition of language, not the construction of some logical structure, or exposure to a set of universal stimuli and labels. Children first master language for social (interpersonal) purposes. Next, they internalize this language and use it for intra-personal (self-regulatory) purposes. Finally, as this change takes place, their culture recognizes their new capabilities, and begins an initiation process that includes an introduction to the forms of social practice in which they will have to engage as adults. In modern literate societies this initiation process normally includes the teaching of skills such as reading, writing, and enumeration in primary school, followed by such subjects as science and formal mathematics in secondary school. Followers of Vygotsky often saw the acquisition of the first set of skills as being causally related to the appearance of the concrete logical competencies that children develop in middle childhood, and the second set as being causally linked to the emergence of the more formal competencies that appear in adolescence.

Early research in the sociohistoric tradition led to a number of interesting new findings. One of the most provocative was that adults in a traditional agricultural culture, especially ones who have not attended school, tend to score at a much lower level than adults who have attended school, on tests of mnemonic and formal logical capabilities such as syllogisms (Luria, 1976; Vygotsky, 1962). To Vygotsky, this finding indicated that modern schooling, not some universal process of reflexive abstraction, is the major instrument of cognitive growth. This inference has not gone unchallenged in recent years. Nevertheless, the datum was an important one, and one that has led to many further studies. In most of the early studies, strong schooling effects were found, not just on the sort of tasks that Luria and Vygotsky had used, but on tasks that had been used in the other two traditions as well. (Cole, Gny, Glick, & Sharp, 1971; Goodnow, 1962; Greenfield, Reich, & Oliver, 1966).

Although the results differed somewhat from study to study, the general pattern was that children moved through the 5 to 7 shift at a considerably later age if they did not attend school; very often, too, they failed to show the teenage shift to a more abstract or "formal" type of response. Instead, the shift that they showed was one that could only be understood by studying their culture, its beliefs, and its socialization practices (Bruner, 1964; Greenfield, 1966).

As this tradition developed, ethnographic and historical methods were utilized with increasing frequency in order to place children's reasoning in context. Use of these methods further differentiated the sociohistoric tradition from the empiricist and rationalist traditions.

Comparing the Three Traditions and Clarifying Their Differences

Before proceeding, it is worthwhile to review the differences among the three traditions, and the challenge that these differences posed to subsequent investigators. The first difference was in the data that were collected on children's conceptual growth. Studies in the empiricist tradition demonstrated that, during the early years of schooling, children show a change in the strategies that they employ on tests where some novel association must be learned (e.g., square = correct; circle = wrong). They also showed that these strategies can be manipulated by instruction, at least to some extent. Studies in the rationalist tradition demonstrated that, during the same age range, a change takes place children's understanding of fundamental properties of the world: properties such as quantity, time, and space. They also showed that a change was present in children's tendency to use their response on the structure of the perceptual world, rather than the structure suggested by reasoning or "logic." Finally, studies in the sociohistoric tradition demonstrated that the emergence of a "logical" (and supposedly universal) pattern of responding during
this age range is affected by variables such as culture and schooling. Indeed, for certain formal tasks (e.g., syllogistic reasoning) the pattern that emerges does not appear to be universal at all.

The first challenge that these three groups of data posed to subsequent investigators was to fashion a theory that provides a unified account of all three sets of findings. A second challenge had to do with the most appropriate methods to use in exploring such accounts, or trying to decide among them. As indicated above, each group had a natural affinity with a particular set of methods, because it was motivated by a distinctive set of epistemological questions. For this reason, it was not clear how to combine the results of the different methods, or how to weigh the different evidence that each one generated. This task was further complicated by the fact that the different traditions did not just hold different views of children’s conceptual development. As indicated in Table 15.1, they also held different views about such basic constructs as learning, intelligence, and experience. Finally, and perhaps most problematically, the three groups held different views about what constituted “good science.”

Although the activities of scientists are different in a great many respects from those of children, they are similar in that they often share a common goal: namely, the acquisition of knowledge. Because knowledge and its acquisition were viewed so differently in the three traditions, subtle disagreements arose on what constituted good science. From the empiricist perspective, good science was science that focused on a clearly identified empirical phenomenon, that developed explicit and testable causal hypotheses regarding this phenomenon, and that tested these hypotheses in a rigorous fashion. General theories were valued, but the best method for arriving at them was presumed to be a bottom-up one, in which theoretical constructs were induced from specific phenomena.

<table>
<thead>
<tr>
<th>Psychological Constructs</th>
<th>Empiricist</th>
<th>Rationalist</th>
<th>Sociocultural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Repertoire of patterns or problems that one has learned to detect and operations that one can execute on them</td>
<td>Structure created by human mind and evaluated according to rational criteria such as coherence, consistency and parsimony</td>
<td>Creation of a social group, as it engages in its daily interaction and praxis, and both adapts to and transforms the environment around it</td>
</tr>
<tr>
<td>Learning</td>
<td>Process that generates knowledge; begins when one is exposed to a new problem, continues as one learns to respond to that problem and generalize one’s response to other contexts</td>
<td>Process that takes place when the mind applies an existing structure to new experience, in order to understand it</td>
<td>Process of being initiated into the life of a group, so that one can assume a role in its daily praxis</td>
</tr>
<tr>
<td>Development</td>
<td>Cumulative learning</td>
<td>Long-term, transformational change that takes place in the structures to which new experience is assimilated</td>
<td>The emergence and training of the symbolic and tool-using capacities that make social initiation possible</td>
</tr>
<tr>
<td>Intelligence</td>
<td>Individual trait that sets limit on the maximum rate at which cumulative learning takes place</td>
<td>Adaptive capability that all children possess, to apply and modify their existing cognitive structures; this capability grows with age (and is transformed)</td>
<td>Distributed across a group, and intimately tied to the tools, artifacts and symbolic systems that the group develops</td>
</tr>
<tr>
<td>Motivation</td>
<td>Internal state that is subject to external influence, and that affects the deployment of attention</td>
<td>Set of natural tendencies that draw human beings of all ages toward epistemic activity</td>
<td>Identification: i.e., the natural tendency of the young to see themselves as being like their elders and to look forward to the day when they will assume their elders’ role</td>
</tr>
<tr>
<td>Education</td>
<td>Process by which the external conditions that affect children’s learning and motivation are carefully arranged and sequenced so that socially desirable goals may be achieved</td>
<td>Child-centered process: one that involves the provision of an environment that will stimulate children’s natural curiosity and constructive activity, and promote active reflection on the results of that activity</td>
<td>Process by which a community takes charge of its young, and moves them from a peripheral to a central role in its daily practices</td>
</tr>
</tbody>
</table>
and retained a close linkage to them. This meant that the general structure of empiricist theories often resembled a list of "factors," together with a set of operational procedures for measuring the factors in a particular situation, and predicting their combined effect.

From the rationalist perspective, such theories often appeared to be oversimplified, pedestrian, and/or trivial. In the rationalist tradition, good science was seen as involving the articulation of a sophisticated intellectual system, and the exploration of its implications across a wide range of circumstances. Although a theory's power to accommodate new data was acknowledged to be important, theoretical change was seen as equally likely to result from the discussion, clarification, and rationalization of the elements of the system itself. Thus, the theories that emerged in this tradition were more likely to resemble a complex system of interwoven arguments, assertions, and constructs than they were a list of factors, principles, or even general laws. By the same token, the development of new methods of observation, the gathering of more detailed data, and the use of new statistical techniques was not seen as having much scientific import in and of itself. What was seen as being of importance was the extent to which any given method flowed from, or could contribute to, an advance in general theoretical understanding.

Finally, from the third perspective, science was seen first and foremost as a social activity. Like any other social activity, it was viewed as having evolved in a particular cultural and historical context, and as depending on a particular set of intellectual tools and representations. It was also viewed as being practiced by individuals who acquired a particular status because of their practice, and who shared a particular set of biases and beliefs. From this perspective, cross-cultural investigation was seen as a vital tool in building up a general model of any social phenomenon, not just something one could conduct after the fact, in order to explore the possibility of "social influences." At the same time, scientific results of this sort were also seen as being open to distortion, due to the tendency of the members of any one cultural group to take their own views and practices as the standard, against which the practices of all other cultural groups should be measured. In this tradition, then, good science was seen as science that was critically aware of its own social origins, modest in the generality of its claims, and neutral in its evaluation of ultimate developmental outcomes.

This third perspective is worthwhile to keep in mind, in evaluating the strengths and weaknesses of the three traditions. The empiricist tradition was born in England, and had its greatest impact on the conduct of social science in that country, and its former colonies. The rationalist position was born in continental Europe, and had its greatest impact in this sphere of influence. Finally, the social-historic tradition was born in post-revolutionary Russia, and had its main impact, at least in its early years, in the countries of the Soviet bloc. Thus, it should be realized that—to some extent, at least—the early discussion and debate that took place among the three traditions involved a confrontation between different cultures and world views, not just different views of knowledge, of children, or of social science.

**DIALOGUE BETWEEN THE EMPIRICIST AND RATIONALIST TRADITIONS**

**Early Empiricist Critiques of Piaget's Theory**

Up until the late 1950s, North American psychology was dominated by empiricism of a rather extreme form: namely, the school of "logical positivism." Although the influence of this school was rather short lived in philosophy, its hold on North American psychology lasted much longer, and served to justify the radical Behaviorism that developed on that continent. During the late 1950s and early 1960s, however, North American behaviorism began to come under fire from within North America as well as outside it. The most common criticism was that behaviorism failed to do justice to the organization of human behavior, and the complex inner processes that are responsible for generating it (Bruner, Goodnow, & Austin, 1956; Chomsky, 1957; Miller, Galanter, & Pribram, 1960; Newell, Shaw, & Simon, 1958). At the same time as this criticism was being voiced, computers were emerging as a new economic force, and a new discipline was being created whose province was the design of software for them. Eventually, investigators from the newly formed discipline of computer science joined hands with psychologists, linguists, and other social scientists, in an effort to describe the cognitive processes that are necessary to generate and control complex human behavior. This event became known as the "cognitive revolution" and the new discipline became known as "cognitive science" (Gardner, 1985).

Although theories of learning underwent a profound transformation during this time period, the underlying epistemology on which they were based changed relatively
little. By and large, North American investigators still presumed that the ultimate locus of knowledge was the empirical world, and that the acquisition of knowledge by psychologists should follow the traditional canons of empiricist methodology. In the field of cognitive development, the result was an interesting ambivalence. On the one hand, there was a great surge of interest in the sort of work that Piaget had pioneered: When Flavell’s (1963) English language summary of Piaget’s work became available, it was widely read and discussed. Although reactions were varied, by and large Piaget’s theory was seen as offering a far deeper understanding of children’s conceptual understanding than had been possible from the perspective of learning theory, and a wealth of new data. On the other hand, Piaget’s theory was often read with empiricist glasses. Thus, many investigators found the manner in which his theory was formulated to be excessively abstract, vague, and difficult to operationalize. They also found it too impregnated with general philosophical arguments and hence difficult to verify or falsify. They had problems with the substance of the theory, as well: in particular, they thought that the general logical structures Piaget hypothesized probably did not exist, and that such cognitive structures as did exist were more likely to be the result of empirical learning than “reflective abstraction.” Finally, they viewed Piaget’s method of interviewing children as too clinical and subjective, and his methods of sampling and data-analysis as too unsystematic.

The continuing split between the two epistemological traditions, and the ambivalent way in which Piaget’s theory was received in North America as a result, was well reflected in the way in which children’s conceptual development was characterized in the 1970 edition of the present handbook. Four chapters were devoted to this topic. The first was Stevenson’s (1970) description of research on children’s learning, which covered work that had been done in the empiricist tradition. The second was Piaget’s chapter, which described his own theory and research (Piaget, 1970). The third was White’s (1970) look at research in both traditions, and its dependence on epistemological priors. Finally, the fourth was a chapter by Flavell (1970), which was devoted almost exclusively to an evaluation of Piaget’s work, from a perspective that Piaget classified as friendly but foreign, due to his strong empiricist emphasis (Piaget, in Flavell, 1963, p. vii).

For the purpose of the present review, the most interesting of these four chapters is the one written by Flavell, since it provides such a clear view of the different perspectives that the two traditions bring to bear on the task of studying children’s conceptual development, and the difficulties confronting any attempt to build a bridge between them. The first task that Flavell undertook was simply to describe Piaget’s theory in terms that would render it more comprehensible to an audience grounded in detailed empirical research and precise, operational definitions. The second task was to describe, in simple terms, the more specific conceptual changes that Piaget hypothesized in each of Kant’s major conceptual categories. The third task was to describe the measurement instruments that Piaget had devised, and the data he had gathered, to support his model of children’s conceptual growth in each of these areas. The fourth task was to review the empirical data that had been gathered using these instruments. Included in this category were: (a) original data gathered by Piaget; (b) new data gathered by investigators elsewhere, to see if Piaget’s findings could be replicated (by and large the answer to this question was affirmative); (c) data gathered on instruments that had been modified in various ways (here the general pattern was that modifications produced differences in the passing age of tasks, but not the general sequence); and (d) instructional studies that had been done, in an attempt to determine whether the overall sequence could be accelerated (here the answer appeared to be that the effects of the interventions were positive but modest).

The mere fact of undertaking these four tasks already represented a major effort at bridging the gap between the two traditions. The final task that Flavell set himself, however, was perhaps the most challenging. This was to tackle the question of how Piaget’s most general theoretical claims could be tested empirically. In particular, how could one test the claims having to do with the existence of general logical structures, the process by which they are formed, and their supposedly stage-like development? One view at the time was that—if Piaget’s stage theory was valid—children should be found to acquire a wide range of logical competencies relatively rapidly, that is, within a relatively tight age range (Brainerd, 1976). Flavell spent a good deal of effort documenting the difficulties that were involved in testing this assertion. Since it is difficult to establish an indisputable operational criterion for determining when, exactly, any logical competence is truly in place to begin with, it is doubly difficult to determine whether two or more such competencies emerge in the same age range, in a synchronous fashion.

In retrospect, Flavell’s most prescient comment was perhaps the one in which he raised the question of whether these were the most appropriate criteria to be using in the first place, in order to document the existence of general conceptual structures. As he put the matter:
I assume that my knowledge of developmental psychology is in some sense a cognitive structure rather than a collection of independent pieces of information. However, it would be factually wrong to argue that this structure emerged at a given point in my adult development—elements, relations, and all—and logically absurd to claim that, since it did not, it could not now be a genuine structure. (Flavell, 1970, p 1039)

Note that, in making this comment, Flavell was separating the question of whether or not conceptual structures exist from several other questions, including (a) whether or not these structures emerge in a saltatory as opposed to continuous fashion, (b) whether or not they are age- or stage-specific, and (c) whether or not they depend on the presence of an underlying logico-mathematical competence. In subsequent years, these distinctions turned out to be crucial.

Subsequent Developments of the Empiricist Critique

During the decade that followed Flavell’s chapter, work on Piaget’s theory in the empiricist tradition continued, and dissatisfaction mounted concerning the theory’s assumptions about the role of logico-mathematical structures in children’s thought. Thus, when Gelman and Baillargeon (1983) reviewed the theory 13 years later, they were able to cite at least five different strands of empirical research—all of which were by now well developed—which called Piaget’s general view of these structures into question. The relevant data were: (a) data on intertask correlations, which were often substantial but which did not assume a pattern that bore any obvious relation to the structures Piaget had hypothesized; (b) data on the sequence of cognitive development, which rarely showed logico-mathematical structures emerging before the conceptual competencies they were supposed to generate; (c) data on preschool cognition, which often demonstrated the presence of logical competencies years before many Piagetians would have predicted; (d) data on the training of concrete operational concepts, which likewise indicated that they could often be acquired during the pre-operational period; and (e) data on logical competencies in adolescence and adulthood, which often demonstrated the absence of logical competencies at an age when they would have been long since been expected.

In suggesting which aspects of Piaget’s theory were likely to prove lasting, Gelman and Baillargeon cited his emphasis on the active nature of children’s cognitive processes, his suggestion that these processes were organized into coherent (though not necessarily logical) structures, and his elucidation of concepts such as assimilation and accommodation. Elsewhere, Gelman (1979) also mentioned the many tasks that Piaget’s group had created, and the provocative data that they had generated, as significant and enduring contributions. The aspects of Piaget’s theory that were seen as having received no support, however, and being unlikely to last, were (a) his view of the role played by children’s logico-mathematical structures in their cognitive development; and (b) his view of the stagelike nature of children’s cognitive growth.

This general evaluation was a pervasive one among empiricists in the late 1970s and early 1980s. (For a dissenting view, see Chapman, 1988.) The dilemma with which it left investigators, however, was a perplexing one. How could one create an account of children’s development that would eliminate the weaknesses of Piaget’s theory, without also eliminating its strengths? How could one characterize the development of children’s conceptual understanding in a fashion that captured its specificity, without also eliminating any ability to capture its overall shape? How could one create a weaker and less logic-bound characterization of children’s conceptual structures, which would not also weaken the powerful heuristic utility that Piaget’s account had shown?

NEW MODELS OF CHILDREN’S CONCEPTUAL UNDERSTANDING

Several different lines of inquiry have been pursued since the publication of the last Handbook, in response to this dilemma. In the present section I consider four of these. The first (often referred to as neo-Piagetian theory) had its origins in an attempt to integrate the core assumptions of the empiricist and rationalist traditions. The other three had their origins in attempts to re-think the core assumptions of one of the three classic traditions, in the light of the criticisms that had been levelled at it from other quarters, or new developments that had taken place within the tradition itself.

Conceptual Development as a Local Process, Limited by General Constraints

The first line of theoretical inquiry to emerge was one that became known as “neo-Piagetian” theory. This theoretical enterprise involved a direct attempt to build a bridge between the assumptions and methods that had underpinned