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Cognitive Development beyond Childhood

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CHAPTER 19

Cognitive Development beyond Childhood

David Moshman

Concluding this volume on children's cognition, this chapter addresses developmental changes in cognition that extend beyond childhood. I will not trace cognitive change across the entire span of adulthood (for lifespan accounts, see Cerella, Rybash, Hoyer, & Commons, 1993; Commons, Richards, & Armon, 1984; Craik & Salthouse, 1993; Holliday & Chandler, 1986; Hoyer & Rybash, 1994; Kausler, 1994; Lachman & Burack, 1993; Miller & Cook-Greuter, 1994; Rybash, Hoyer, & Roodin, 1986; Sinnott & Cavanaugh, 1991). Rather, I highlight changes associated with the second (and to a lesser extent the third) decade of life. The research reviewed suggests that developmental changes in cognition, at least in some individuals, continue at least through adolescence and early adulthood.

In the opening sections of the chapter, I address a variety of historical, theoretical, and methodological considerations regarding advanced cognitive development. I then argue that the central locus of developmental change in cognition beyond childhood is in reasoning—that is, in the deliberate application of epistemic constraints to one's own thinking. Three forms of reasoning—case-based, law-based, and dialectical—are distinguished and developmental research relevant to each is reviewed. Finally, I attempt to explain advanced cognitive development by proposing a metacognitive, constructivist, and pluralist conception of human rationality.

HISTORICAL CONCEPTIONS OF ADVANCED COGNITION

Formal Reasoning

Explicit conceptions about the nature of sophisticated reasoning and logic date back at least to Plato and Aristotle. The psychological study of advanced cognitive development can be traced to James Mark Baldwin (1895), who postulated a "hyper-logical" stage of mental development in which

> syllogistic forms come to have an independent or a priori force, and pure thought emerges—thought, that is, which thinks of anything or nothing. The subject of thought has fallen out, leaving the shell of form. (1930, p. 23; cited in Cairns, 1983)

In a similar vein, Piaget (1924/1972) presented early evidence that "formal reasoning" begins to be seen about the age of 11 or 12. By formal reasoning, Piaget meant "formal deduction," which

> consists in drawing conclusions, not from a fact given in immediate observation, nor from a judgment which one holds to be true without any qualifications (and thus incorporates into reality such as one conceives it), but in a judgment which one simply assumes, i.e. which one admits without believing it, just to see what it will lead to. (p. 69)

Piaget was clear that logical deduction could be seen in children as young as age 7 or 8, but insisted that such deduction "bears only upon the beliefs which the child has adopted himself" (p. 67). It is only at age 11 or 12, he suggested, that reasoning becomes "hypothetico-deductive" (p. 69). Formal reasoning, in Piaget's conception, enables the adolescent to reason strictly about hypotheses in a constructed realm of possibility that is explicitly distinguished from empirical reality. "To be formal," he proposed, "deduction must detach itself from reality and take up its stand upon the plane of the purely possible, which is by definition the domain of hypothesis" (p. 71).

Baldwin's theory and the early work of Piaget notwithstanding, the study of cognitive development beyond childhood remained relatively sparse and atheoretical. When Horrocks (1954) wrote what was intended as a comprehensive chapter on "The Adolescent" for the second edition of the present handbook, he devoted barely one page to "Intellectual Growth and Development." Drawing on a quantitative conception of intelligence associated with the psychometric tradition, Horrocks' review of adolescent cognitive development focused exclusively on the "rate of mental growth" and the age at which such growth ceased. His conclusion was that mental growth slows dramatically over the course of adolescence and that "in terms of mental ability or power the adolescent is nearing his peak" (p. 719).

Piaget's Theory of Formal Operations

The year after Horrocks' review, Inhelder and Piaget (1955/1958) published their classic *The Growth of Logical Thinking from Childhood to Adolescence,* the first full-length treatment of cognitive development beyond childhood. The book presented detailed accounts of performance by children and adolescents on a variety of ingenious tasks designed and administered by Inhelder and her associates; as well as an ambitious theoretical effort by Piaget to characterize and explain the observed developmental changes.

Methodologically, the 15 studies reported in *The Growth of Logical Thinking* each involved some sort of physical apparatus—flexible rods, a pendulum, an inclined plane, communicating vessels, a hydraulic press, or a balance scale. Children ranging in age from 5 through 16 were encouraged to manipulate the materials and to construct an understanding of the associated physical phenomena—for example, the effect of potentially relevant variables on the relative flexibility of the rods or on the rate of oscillation of the pendulum. They were interviewed individually about their experiments and conclusions. As in both prior (e.g., Piaget & Inhelder, 1951/1975) and subsequent (e.g., Piaget, 1987) research, responses were interpreted as revealing patterns of thinking that were common among adolescents, but rarely or never seen prior to age 11.

In many respects, Piaget's account of these results was continuous with his earliest theorizing about adolescent cognition. Formal thinking, he argued

> is essentially hypothetico-deductive. By this we mean that the deduction no longer refers directly to perceived realities but to hypothetical statements—i.e., it refers to propositions which are formulations of hypotheses or which postulate facts or events independently of whether or not they actually occur. (p. 251)

The emphasis on the hypothetical involves a radical reconstruction of the perceived relation between realities and possibilities. That is,

> in formal thought, there is a reversal of the direction of thinking between *reality* and *possibility* in the subjects' method of approach. *Possibility* no longer appears merely as an extension of an empirical situation or of actions actually performed. Instead, it is *reality* that is now secondary to *possibility*. (p. 251, emphases in original)

Thus, Piaget continued to emphasize the importance of formal or hypothetico-deductive reasoning in adolescence. Such reasoning, he argued, is central to formulating a logically coherent realm of possibilities. The formulation of such a realm, in turn, was seen as central to a sophisticated understanding of reality. That is, reality can best be understood within the context of possibility. Formal understanding, moreover, involves "reflective thinking" (p. 342), including critical analysis of one's own thinking and the deliberate construction of theories that systematize one's ideas.

By 1955, however, Piaget was consolidating the most structural phase of his career. Having proposed a set of operational structures to explain the reasoning of middle childhood, he now saw the transition to adolescence as involving the construction of second-order, or formal, operations involving transformations of first-order, or concrete, operations. At a still more technical level, formal operations were characterized as an *ensemble des parties* or "structured whole" (p. xix, note 18), involving (a) a "complete combinatorial system" with the logico-mathematical properties of a lattice and (b) the coordination of two forms of reversibility—inversion and reciprocity—within the Identity-Negation-Reciprocity-Correlative (INRC) Group. In effect, Piaget postulated a version of propositional logic as the structure underlying formal operational reasoning (Smith, 1987). Although Piaget had earlier sketched a structural account of adolescent cognition as "formal operations" (1947/1960, pp. 147–150), *The Growth of Logical Thinking* was notable for a substantial elaboration of his structural theory. Thus, the theory of formal reasoning became the theory of formal operations (De Lisi, 1988).

Inhelder and Piaget's qualitative account of adolescent cognition as structurally distinct from childhood cognition revolutionized the study of adolescent cognitive development. By the 1970s, a substantial body of literature concerning Piaget's theory of formal operations had emerged. (For a classic Piagetian review, see Neimark, 1975; for an early critical review, see Keating, 1980; for more recent critiques and reformulations, see Braine & Rumain, 1983; Byrnes, 1988a, 1988b; Campbell & Bickhard, 1986; Gray, 1990; Halford, 1989; Keating, 1988, 1990; Smith, 1987.) In recent years, the literature on cognitive development in adolescence and beyond has increasingly transcended the theory of formal operations and branched off in multiple directions. The issues highlighted by Piaget, however, continue to set much of the agenda for research and theory.

DOES COGNITION DEVELOP BEYOND CHILDHOOD?

Piaget's theory claims that (a) developmental changes in cognition continue through early adolescence and (b) the cognitive structure associated with early adolescence, formal operations, is the final stage of development. Both claims are open to question. On one hand, extensive evidence of early cognitive competence (DeLoache, Miller, & Pierroutsakos, this volume; R. Gelman & Williams, this volume; S. Gelman & Wellman, this volume) raises the possibility that the most fundamental aspects of cognition emerge very early; later cognitive changes, it might be argued, are not developmental in nature. On the other hand, a number of theorists have proposed forms of advanced cognition that, they suggest, develop in late adolescence or adulthood (Commons *et al.*, 1984; Miller & Cook-Greuter, 1994). Thus, Piaget's theory is challenged both by claims that cognitive development is limited to childhood, and by claims that it extends beyond adolescence.

In order to address the fundamental question of whether cognition develops beyond childhood, we must consider what we mean by development. Perhaps the paradigm case of a developmental change associated with adolescence is puberty, the transition to sexual maturity. It may be useful to consider what characteristics of this change lead us to construe it as developmental in nature. One obvious characteristic is that puberty is a long-term change. It occurs over a period of months or years, rather than minutes, hours, or days. Three additional characteristics appear worthy of note:

1. Puberty is a *qualitative* change. It involves a coordinated transformation of anatomical and physiological systems resulting in a structurally distinct state of maturity. In contrast, increasing some number of inches in height is not a qualitative transformation. Mere growth is not a core example of *development*.

2. Puberty is a *progressive* change. It has a natural direction that constitutes progress toward a state of maturity. A transition involving a loss of reproductive capacity, by contrast, might be an equally important change, but would be less likely to be construed as prototypically developmental in nature.
3. Puberty is an *internally-directed* change. Although it requires environmental support (e.g., adequate nutrition), it is not caused or directed by the environment. On the contrary, the transition to sexual maturity is typically seen as genetically guided and universal across the species.

It is widely accepted among biologists that certain long-term anatomical and physiological changes, such as puberty, are qualitative, progressive, and internally-directed to a sufficient extent that such changes are usefully construed as falling into a category of change that may be labeled developmental change. Substantial evidence has led many psychological theorists to posit long-term cognitive changes that, like puberty, are sufficiently qualitative, progressive, and internally-directed to be usefully construed as developmental in nature (Case, Ch. 15, this Volume; Valsiner, Volume 1).

Even if cognition does develop, there remains the question of whether such development continues beyond childhood. A negative answer to that question would make this a very short chapter. I hope to demonstrate in this section the plausibility of a positive answer but raise the possibility that cognitive development beyond childhood differs in important ways from prototypical examples of development such as puberty.

Qualitative Change

At the historical and theoretical core of the theory of formal operations is the postulation of a qualitative shift to formal reasoning competence at about age 11 or 12 (De Lisi, 1988; Piaget, 1924/1972). Research on hypothetico-deductive reasoning has provided substantial evidence for such a qualitative transformation at about this age (Markovits & Vachon, 1989; Moshman & Franks, 1986). A number of more recent theories also postulate qualitative changes in cognition beyond childhood. As we will see later in this chapter, there is substantial evidence for the existence of types, forms, or levels of cognition that are common among adolescents and adults, but rarely seen much before the age of 11 (Basseches, 1980, 1984; Campbell & Bickhard, 1986; Case, Ch. 15, this Volume; Chandler & Boutilier, 1992; Commons *et al.*, 1984; Dunbar & Klahr, 1989; Furby & Beyth-Marom, 1992; Inhelder & Piaget, 1958; King & Kitchener, 1994; Klahr, Fay, & Dunbar, 1993; Kohlberg, 1984; Kuhn, 1989; Kuhn, Amsel, & O'Loughlin, 1988; Lamborn, Fischer, & Pipp, 1994; Marini & Case, 1994; Markovits, 1993; Markovits, Schleifer, & Fortier, 1989; Markovits & Vachon, 1989, 1990; Moshman, 1990, 1993, 1995b; Moshman & Franks, 1986; O'Brien, 1987; Overton, 1990; Overton, Ward, Noveck, Black, & O'Brien, 1987; Ward & Overton, 1990).

It is far less clear whether there is a general and/or structural aspect to such change and, if so, how such generality and/or organization is best characterized. If change is general across domains, are qualitative shifts in multiple domains of cognition simultaneous, or at least highly correlated? Are there one or more abstract structures of cognition that can be applied, perhaps with a greater or lesser degree of success, to these domains?

The most influential candidate for a very general form of cognitive structure has been Piaget's conceptualization of formal operations. As we have seen, the theory of formal operations goes beyond Piaget's early postulation of a qualitative shift to formal reasoning by postulating a highly abstract logico-mathematical structure that forms the basis for a general stage of cognitive development. This proposal has been highly controversial (for diverse views, see Braine & Rumain, 1983; Byrnes, 1988a, 1988b; Campbell & Bickhard, 1986; Gray, 1990; Halford, 1989; Keating, 1980, 1988, 1990; Neimark, 1975; Smith, 1987). Even if the theory does provide an adequate account of some forms of reasoning, moreover, it is doubtful that it can fully account for the multiple forms of advanced cognition to be discussed in this chapter (Basseches, 1984; Broughton, 1977; Campbell & Bickhard, 1986; Chandler & Boutilier, 1992; Commons *et al.*, 1984; Kitchener & Kitchener, 1981; Pieraut-Le Bonniec, 1980).

A central theoretical and methodological issue in efforts to identify and characterize structural transformation is the fact that qualitatively distinct forms of thought and knowledge routinely coexist in the same mind (Kuhn, Garcia-Mila, Zohar, & Andersen, 1995; Schauble, 1996; Wark & Krebs, 1996). It often seems reasonable to speak of a qualitative shift when an important new form of cognition appears, even if that form does not completely supplant earlier forms. The appropriate criteria for *structural* change, however, are much less clear. Some researchers attempt to address this problem via methodologies that highlight underlying competence (Overton, 1990) or optimal level of functioning (Lamborn *et al.*, 1994) rather than typical behavior. Such methodologies often do yield evidence for general age-related limits on performance (Case, Ch. 15, this Volume; Marini & Case, 1994), but it remains unclear in what sense there might be general and/or structural change in later cognitive development (Wark & Krebs, 1996).

In sum, there do appear to be cognitive changes of a qualitative nature beyond childhood. The generality and organization of such changes, however, are matters of dispute.

Progressive Change

Another characteristic of developmental change is that it is progressive (R. Kitchener, 1986). With respect to puberty, it is fairly easy to specify a universally achieved state of sexual and reproductive maturity and to assess progress toward that state. With respect to cognition, a variety of formulations concerning the nature of maturity have been put forward. The best-known proposal concerning a state of cognitive maturity is Piaget's account of formal operations. Other theorists have proposed alternative general conceptions of cognitive maturity (Commons *et al.*, 1984). Riegel (1973) and Basseches (1980, 1984), for example, proposed dialectical thinking as a general, post-formal, and final stage of cognitive development. Finally, some theorists have suggested domain-specific conceptions of cognitive maturity. Kohlberg (1984) posits a highest stage of moral development involving an ultimate level of abstract perspective taking. King and Kitchener (1994), to take another example, describe a highest stage in the development of reflective judgment, involving sophisticated conceptions of knowledge and justification.

Although the existence of a developmental endpoint would indicate the progressive nature of cognitive changes in the direction of that endpoint, the existence of such an endpoint is not a necessary condition for progressive change. Formal operational reasoning, for example, is a second-order structure that includes and transcends the first-order structure of concrete operations; the transition from concrete to formal operations can thereby be construed as progress, regardless of whether formal operations is a final stage. Similarly, the emergence of hypothetico-deductive reasoning may be seen as an expansion of the domain of deductive reasoning that constitutes progress, regardless of whether hypothetico-deductive reasoning is, or leads to, some sort of highest stage. Along the same lines, although stage theories such as those of Selman (1980), Kohlberg (1984), and King and Kitchener (1994) typically posit a highest stage, one can often make a strong case for each stage representing progress over the stage before without demonstrating that each stage increasingly approximates a mature state yet to come. Such a case might be made, for example, by showing that the later stage is more differentiated, integrated, organized, metacognitive, reflective, and/or adaptive (Campbell & Bickhard, 1986; Valsiner, Ch. 4, Volume 1).

Cross-sectional research suffices to demonstrate that some forms of cognition typically appear later than others. Longitudinal and cross-cultural evidence may strengthen the case that certain developmental sequences are invariant across individuals and cultures (Boyes & Walker, 1988; Kohlberg, 1984; Snarey, 1985). To make the case for cognitive progress, however, requires a demonstration that later cognitions are in some sense better, an epistemological claim that cannot be supported simply on the basis of empirical evidence. A key issue in the study of cognitive progress, then, is the theoretical coordination of empirical and epistemological considerations (R. Kitchener, 1986; Piaget, 1985; Smith, 1993).

As we will see throughout this chapter, a strong case can be made for progressive changes in cognition during adolescence and early adulthood. The existence of mature cognitive states, however, and the nature of any such developmental endpoints, remain matters of dispute.

Internally Directed Change

Finally, there is the question of whether cognitive transitions beyond childhood are internally directed. The most obvious sense in which a change may be internally directed is that it is guided by the genes. Many of the most important genetically guided changes with respect to anatomy and physiology are universal across the species.

Research on young children has led many theorists to the view that early cognitive development is to a large degree guided by innate constraints that are universal across individuals and cultures (Gelman & Williams, Ch. 12, this Volume; Karmiloff-Smith, 1992; Spelke & Newport, Ch. 6, Volume 1). Nevertheless, it does not follow that cognitive change is directed or determined by genes; any such conclusion would be especially dubious with respect to later cognitive transitions.

There is another sense, however, in which cognitive change might be said to be internally directed. A constructivist view of cognition posits an epistemic subject or rational agent actively constructing new knowledge and forms of thinking on the basis of his or her own perceptions and reasons. Although the constructive activities of such a subject are not genetically determined, they are nonetheless internal to the rational agent, rather than caused by the environment. Without positing either genetic determinism or universality across the species, a constructivist conception does suggest an important sense in which cognitive change is internally directed (Bidell, Lee, Bouchie, Ward, & Brass, 1994; Campbell & Bickhard, 1986; Karmiloff-Smith, 1992; R. Kitchener, 1986; Moshman, 1994, 1995a, 1995b; Piaget, 1985; Smith, 1993).

One useful approach to investigating the internally-directed nature of change is microgenetic research, in which subjects are observed over a period of time in a rich task environment to see how they construct and apply skills that are not directly taught (Schauble, 1990, 1996). Kuhn *et al.* (1995), for example, studied changes in the coordination of theories and evidence by children and adults over a series of ten sessions. They found progress in the ability to coordinate theories and evidence despite the absence of direct teaching, suggesting an inner-directed process of change. The fact that both children and adults made substantial progress in a relatively short period of time suggests a constructive process rather than a genetically based process of maturation.

Cross-cultural research provides another avenue for identifying changes that are not simply instilled by particular environments (Boyes & Walker, 1988; Snarey, 1985). Outside the realm of moral cognition, however, cross-cultural research on advanced cognitive development is rare.

As we will see, a strong theoretical and empirical case can be made for long-term cognitive changes that are internally directed. At advanced levels, however, there is no evidence that any such changes are genetically driven, and it is unclear what internally directed changes, if any, are universal across the species.

Conclusion

Throughout this chapter, we will see evidence for cognitive changes beyond childhood sufficiently like puberty to be labeled "developmental." Our core conception of development comes from the realm of biology, however, and may be misleading in the realm of cognition. We should not assume that everything we might call cognitive development has all those characteristics that lead us to construe puberty as a developmental change. As we will see, it appears that there are indeed long-term changes in cognition that are qualitative, progressive, and internally directed; some such changes, moreover, continue into adolescence and beyond. It is doubtful that late cognitive changes are genetically driven, however. It remains unclear, moreover, in what respects, if any, advanced cognitive changes are structural, general across domains, aimed at one or more specific endpoints, or universal across persons and cultures (Hoyer & Rybash, 1994; Miller & Cook-Greuter, 1994; Rybash *et al.*, 1986). These are questions to which we will return.

FROM INFERENCE TO REASONING

Cognition is generally construed to be inferential in that it routinely goes beyond the data at hand. In the present section, I will: (a) define thinking as an advanced form of inference; (b) define reasoning as an advanced form of thinking; (c) consider the specificity and generality of reasoning; and (d) suggest that reasoning is the primary locus of late developmental changes in cognition.

From Inference to Thinking

Inference may be defined as the generation of new cognitions from old. Inferential processing is central to most areas of human cognition and is typically automatic and unconscious. Reading, for example, routinely involves inferences that go beyond the text (Lea, O'Brien, Fisch, Noveck, & Braine, 1990). Similarly, effective social interaction involves an ongoing stream of inferences about the moods, meanings, and intentions of those with whom we interact (Hilton, 1995).

Thinking may be defined as the deliberate coordination of one's inferences to serve one's purposes (Moshman, 1995a). We think, for example, in order to solve a problem, make a decision, plan a project, justify a claim, or test a hypothesis. Thus defined, thinking is not limited to late development, nor does it ever replace elementary inference. Young children think, and adults continue to make automatic and unconscious inferences. Nevertheless, the emergence of thinking represents an important advance in the nature and use of inference. Research shows development at least through adolescence in problem solving (Foltz, Overton, & Ricco, 1995), decision making (Byrnes & McClenny, 1994; Furby & Beyth-Marom, 1992), planning (Lachman & Burack, 1993; Scholnick & Friedman, 1993), hypothesis testing (Kuhn *et al.*, 1988), and other types of thinking.

From Thinking to Reasoning

Because thinking is purposeful, an act of thinking may be evaluated with respect to how well it serves the purposes of the thinker. Over the course of development, thinkers increasingly make such evaluations themselves and attempt to improve their inferential activities. Recognizing that some thought processes are more justifiable than others, they increasingly construct standards of rationality and apply these to their own thinking. To the extent that an individual attempts to constrain his or her thinking on the basis of a self-imposed standard of rationality, we may say the individual is engaged in reasoning. Reasoning, then, is epistemologically self-constrained thinking (Moshman, 1995a).

Consider, for example, developmental changes in decision making. At a primitive level, an individual might pursue a course of action on the basis of available information without any intent to select from two or more options or awareness of having done so. A psychologist studying this cognitive process might determine what inferences the individual made and might evaluate the adequacy of those inferences, but it would be misleading to say the individual has made a decision.

At a more advanced level, an individual understands that there are two or more options available, makes a series of inferences intended to determine the best option, and then consciously chooses that option. Such decision making may be usefully regarded as an act of thinking.

Research suggests that for at least some individuals, the quality of decision making continues to improve at least through adolescence (Byrnes & McClenny, 1994). A plausible explanation for this is: Over the course of development, individuals become increasingly successful in constraining their inferences to conform to increasingly justifiable norms. Some such norms may be specific to making decisions, whereas others may be applicable to multiple types of thinking.

At least three general forms of reasoning—to be discussed in the next three sections of this chapter—may play roles in decision making and other types of thinking. First, the decision maker may purposely choose the option most similar to one that has been successful in the past. This is analogical reasoning, a type of case-based reasoning. Second, the decision maker may deliberately constrain his or her inferences to conform to rules of logic or other epistemic laws. Such law-based reasoning is the focus of extensive developmental theory and research. Finally, the decision maker may move progressively toward a decision via some form of dialectical reflection or argumentation.

Developmental changes in problem solving may similarly reflect the emergence and application of epistemic self-constraints. Foltz *et al.* (1995), for example, assessed fifth- and eighth-graders on formal logical reasoning and presented each with a problem involving identification of a hidden figure. Formal reasoning competence was associated with the use of deductive proof construction strategies that enabled more efficient problem solving by avoiding the generation of redundant information.

This theoretical approach to thinking and reasoning has important methodological implications. Given the proposed definitions, an automatic inference is not an act of thinking and does not constitute reasoning, even if the inference conforms to logical, mathematical, or other epistemic norms. Correspondingly, a deliberate effort to constrain one's thinking on the basis of what one believes to be justifiable epistemic norms constitutes reasoning, even if the norms are not successfully applied or are demonstrably inappropriate. Bad reasoning, in this view, is still reasoning, whereas good inferences do not necessarily involve reasoning at all.

In assessing reasoning, then, it is not sufficient to present a task and see if subjects reach the logically or mathematically proper conclusion. Such an approach will overestimate reasoning competence in cases where automatic inferences suffice to reach the approved conclusion; it will underestimate reasoning competence in cases where deliberate efforts to constrain thinking do not suffice to generate the approved conclusion. As we will see, these are important considerations in attempting to reconcile the extensive literatures purporting to demonstrate logical, mathematical, and scientific reasoning in young children and the fundamental irrationality of adults (Hilton, 1995; Jones & Harris, 1982; Markovits, Schleifer, & Fortier, 1989; Moshman & Franks, 1986).

Specificity and Generality of Reasoning

An important issue in the study of cognition revolves around questions of specificity and generality. Rather than reduce this issue to a simplistic dichotomy of domain specificity versus generality, it will be useful to consider the various ways in which reasoning could be specific or general.

One way reasoning could be specific is with respect to domains of knowledge. Recent research with young children has suggested that they routinely construct knowledge within distinct domains such as physical causality, biological systems, social relations, and morality (Flavell & Miller, Ch. 17, this Volume; R. Gelman & Williams, Ch. 12, this Volume; S. Gelman & Wellman, Ch. 15, this Volume; Helwig, 1995b; Karmiloff-Smith, 1992; Maratsos, Ch. 9, this Volume; Spelke & Newport, Ch. 6, Volume 1). Such knowledge enables sophisticated patterns of inference within such domains. Domain-specific inferences undoubtedly play an important role in cognition at all ages. To the extent that people reflect on the epistemic properties of domain-specific inferences, they may construct forms of reasoning specific to particular inferential domains.

A second way reasoning could be specific is with respect to types of thinking. Problem solving, decision making, hypothesis testing, and planning, for example, might each involve distinct forms of epistemic constraint and thus constitute or generate distinct forms of reasoning.

A third possibility is that there are two or more distinct forms of reasoning applicable to multiple types of thinking and multiple domains of knowledge and inference. In the next three sections of this chapter, I suggest that three such forms of reasoning—case-based, law-based, and dialectical—can be distinguished and that each continues to develop long beyond childhood. Without denying the importance of domain-specific patterns of inference and distinct types of thinking, I suggest that each of these three forms of reasoning is applicable to various types of thinking and multiple domains of inference. With respect to specificity and generality, there are specific forms of reasoning, but each is general across types of thinking and domains of inference.

Finally, there remains the possibility that we can identify still broader generalities. Individuals may, for example, achieve levels of metacognitive understanding about the nature of inference that transcend domains of knowledge, types of thinking, and forms of reasoning. Research relevant to specificity and generality will be reviewed later in the chapter. First, in the next three sections, we consider three fundamental forms of reasoning.

CASE-BASED REASONING

Case-based reasoning is thinking constrained by attention to concrete manifestations (cases) that are deemed relevant to achieving a justifiable cognitive outcome in the case at hand. Two categories of case-based reasoning may be distinguished: analogical reasoning and precedent-based reasoning.

Analogical Reasoning

In analogical inference, a situation or issue is considered on the basis of other situations or exemplars. For example, one may approach a problem in a manner constrained by one's perception of how a relevantly similar problem has been solved or may categorize a phenomenon on the basis of its similarities to phenomena already categorized. Medin and Ross (1989) argue that problem solving and categorization often rely more on such use of concrete examples than on abstractions of any sort. Similarly, Halford (1992) notes that transitive inferences and understanding of class inclusion relations may involve use of analogy. Given that A is longer than B and B is longer than C, for example, a child may conclude that A is longer than C by analogy with the spatial relations of top, middle, and bottom. There is substantial evidence that detection, construction, and utilization of analogical relations is routine even in preschool children (DeLoache *et al.*, Ch. 16, this Volume; Goswami, 1991).

The fact that young children make analogical inferences, however, does not show that they intended to make such inferences, that they have conscious control of those inferences, or that they understand the epistemic basis for such inferences. The emergence of analogical thinking may be identified when a child purposely seeks guidance from cases specifically deemed to be analogous. Such thinking may be identified as analogical reasoning, to the extent that the choice of analog and its application to the issue at hand are deemed justifiable by the thinker. Analogical reasoning, that is, is rooted in conceptual understanding about the epistemic advantages of using certain kinds of analogies in certain kinds of situations. Such (metacognitive) knowledge about analogy makes it possible for relevant similarities and differences to be deliberately assessed and coordinated.

The transition from inference to reasoning in the use of analogy has been examined via classical analogies of the form a is to b as *c* is to d. Full comprehension of such analogies requires not only simultaneous attention to two first-order relations (that of *a* to *b* and that of *c* to *d),* but explicit recognition of the asserted second-order relation of equality between the two first-order relations (*a* is to *b* as *c* is to *d*). Piaget's theory postulates that the second-order operations necessary for such comprehension do not develop until the emergence of formal operations at age 11.

Methodologically, identification of second-order relational reasoning requires evidence that the child explicitly compared the two first-order relations. Given the analogical question *Hand is to finger as foot is to what,* for example, a response of *toe* shows analogical reasoning only if there is evidence that the thinker explicitly considered the relation of finger to hand and deliberately sought a response that is related to foot in a similar way. At the very least, this requires evidence that *toe* would not be a spontaneous response to *foot* outside the context of the given analogy. A more stringent criterion is that the thinker can adequately justify his or her response and explain its superiority to alternative possibilities.

Research on classical analogy problems (carefully constructed to require systematic attention to the second-order relationship) indicates that analogical reasoning emerges long after simple analogical inferences, and continues to develop at least through adolescence (Goldman, Pellegrino, Parseghian, & Sallis, 1982; Sternberg & Nigro, 1980; Sternberg & Rifkin, 1979). Ability to explain and justify responses, moreover, is strongly correlated with the proportion of normatively correct conclusions (Goldman *et al.*, 1982). Research and theory of the past decade, however, have focused more on the early development (Goswami, 1991) and pervasive nature (Halford, 1992) of analogical inference (DeLoache *et al.*, Ch. 16, this Volume). Further research on the deliberate and reflective use of such inference—that is, on analogical reasoning—would be welcome. It is here that late developmental trends are likely to be found.

This does not necessarily mean a return to classical analogy problems, however. Two key limitations of such tasks is that they explicitly request analogical reasoning and highlight the relations to be considered. Future research might focus on how individuals (a) decide to seek or use an analogy, (b) consciously identify potentially analogous cases, and (c) deliberately assess the relevance of those cases via systematic consideration of similarities and differences. These are sophisticated competencies that likely develop in adolescence and beyond, but remain largely unexplored.

Precedent-Based Reasoning

Precedent-based reasoning resembles analogical reasoning in that analogous instances provide a basis for constraining one's thinking. In analogical reasoning, however, the analogous instances are merely heuristic. In precedent-based reasoning, on the other hand, application of the precedent forms a stricter constraint. Fidelity to precedent is considered mandatory; apparent deviations from precedent require specific justification. Precedent-based reasoning is important, for example, to certain kinds of legal thinking. In resolving a case, the previous resolution of a relevantly similar case is not merely an example of how the present case might be handled, but a fundamental constraint on the legitimacy of any solution *(Planned Parenthood* v. *Casey,* 1992; Rissland, 1991).

Research on precedent-based reasoning is sparse. It seems plausible, however, to posit a developmental trend from (a) implicit analogical inference with no differentiation of precedent from analogous instance to (b) explicit recognition of precedent as a distinct type of analogous instance that is to some degree binding, and later toward (c) increasing recognition of the role of current choices in setting new precedents and thus constraining future choices.

Consider, for example, a teacher's response to student behavior that is morally dubious but does not clearly violate any specific rule. Even a young child may see previous responses to such behavior as relevant to the current incident. A more advanced reasoner may explicitly recognize the moral force of precedent: Punishment of the current behavior is more clearly unfair, for example, if another child previously went unpunished for the same behavior. Still more advanced individuals may evaluate a teacher's response to ambiguous behavior with respect to the precedent that response sets for the future.

It seems likely, then, that development of case-based reasoning includes (a) a developmental trend from automatic analogical inference to increasingly self-conscious analogical reasoning and (b) in domains such as law and morality, an increasingly differentiated conception of binding precedents as distinct from heuristic analogies. Such developmental trends, which have received surprisingly little attention from researchers and theorists, almost surely continue into adolescence and beyond.

Legal Reasoning

Legal thinking may be defined as thinking aimed at determining what the law requires or forbids. It is often argued that legal education should be aimed at teaching a student how to "think like a lawyer," that is, to engage in legal reasoning. To refer to legal reasoning is to assume the existence of a particular form of epistemic constraint that is central and/or unique to legal thinking.

As already noted, precedent-based reasoning is important in many legal contexts. It is far from clear, however, that precedent-based reasoning is either central or unique to legal thinking. With respect to centrality, note that laws typically take the form of rules and that judicial decisions often apply and/or provide general principles; thus determination of what the law requires or forbids may involve rule-based or principled reasoning (to be discussed in the next section). With respect to uniqueness, it has already been noted that precedent-based reasoning is important to morality as well as law. If there is no form of reasoning central and/or unique to the domain of law, however, it may be misleading to speak of legal reasoning. Perhaps it would be more appropriate to focus on the application of general forms of reasoning (such as case-based, law-based, and dialectical reasoning) to specific domains of knowledge and action (such as law).

This is an issue to which we will return. First, however, there are other forms of reasoning to be considered.

LAW-BASED REASONING

Law-based reasoning is thinking constrained by the deliberate application of abstract laws that are construed by the individual as justifying his or her beliefs and/or actions. Two general categories of laws may be distinguished: rules and principles. I begin this section by considering logical reasoning, a form of rule-based reasoning that continues to develop well beyond childhood. I then turn to other types of rule-based reasoning. Next, I address principled reasoning as a form of reasoning that is law-based, but not rule-based. Finally, I raise the question of whether scientific thinking constitutes a distinct category of law-based reasoning.

Logical Reasoning

Knowing that a hidden ball is red or blue and that it is not red, 3-year-old Ellen concludes that the ball is blue. From an external perspective, we may theorize that Ellen has made an inference of the form *p or q; not p; therefore q*. Because the conclusion necessarily follows from the premises, we may designate this a deductive inference. Even if Ellen has indeed made this deductive inference, however, many questions remain: Did she intend to reach a conclusion? Did she construe the relevant portion of her knowledge as a set of premises? Does she know that she has made an inference? Does she know that her conclusion follows necessarily from her premises? Is the inference deductive from her point of view, or only from ours?

Children and adults routinely make inferences that can reasonably be construed as involving the application of logical rules (Braine, 1990; Braine & O'Brien, 1991; DeLoache *et al.*, Ch. 16, this Volume; Falmagne & Gonsalves, 1995; Hawkins, Pea, Glick, & Scribner, 1984; Lea *et al.*, 1990; O'Brien, 1987; Rips, 1994; Scholnick, 1990; Scholnick & Wing, 1995; Smith, Langston, .& Nisbett, 1992). Logical inference gives rise to logical thinking as children become increasingly purposeful in the application and coordination of such rules. Logical thinking, in turn, gives rise to logical reasoning as individuals increasingly grasp the epistemic properties of logical rules (Keenan, Ruffman, & Olson, 1994). The transition from deductive inference to deductive reasoning, for example, involves increasingly explicit understanding about the logical necessity of deductions (Moshman, 1990).

Studies by Overton and his associates (reviewed in Overton, 1990) suggest that the emergence of logical reasoning from logical inference is an extended process that typically continues long beyond childhood. In one line of investigation, children and adolescents ranging from Grades 4 through 12 were presented with the four-card *selection task,* a much-studied conditional reasoning problem (Overton *et al.*, 1987; Ward & Overton, 1990). The task involves a proposition of the form *if p then q* and four potential sources of information about the truth or falsity of that proposition. Specifically, the thinker may choose to investigate (a) whether a given *p* is associated with *q* or with *not-q;* (b) whether a given *not-p* is associated with *q* or with *not-q;* (c) whether a given *q* is associated with p or with *not-p;* and/or (d) whether a given *not-q* is associated with *p* or with *not-p.* Solution of the task requires the insight that only the combination *p and not-q* falsifies a proposition of the form *if p then q.* Thus investigations *a* and *d* are relevant to the truth of the conditional proposition because they could falsify it, whereas investigations *b* and *c* are unnecessary because no possible result of these investigations would disconfirm the conditional proposition. Although young children routinely make simple conditional inferences (Scholnick, 1990; Scholnick & Wing, 1995), the selection task is notoriously difficult even for college students (Evans, 1989; Newstead & Evans, 1995).

Part of the difficulty of the selection task is that the thinker must do more than simply generate a conclusion from premises using a conditional inference rule. Rather, the thinker must coordinate a variety of hypothetical conditional relations, including (a) the given conditional proposition, which the thinker knows may be true or false, and (b) the implications of each of the two possible results for each of the four potential investigations. Although some versions of the selection task are rarely solved by individuals of any age, Overton and his associates showed dramatic increases over the course of adolescence in the ability to solve meaningful variations of the task. The effects of content raise issues of generality that will be addressed later. The developmental trends, however, are consistent with a conception of conditional reasoning as a late-developing form of thinking involving deliberate coordination of conditional inferences on the basis of explicit understanding about the nature and justifiability of conditional inference rules.

In a more direct approach to assessing the development of understanding about the nature of logic, Moshman and Franks (1986) presented 197 individuals in Grades 4 (ages 9 to 10), 7 (ages 12 to 13), and college (ages 18 to 43) with a variety of logic-related tasks. Some of these simply required participants to make a correct inference from a set of premises. Performance on the simple inference tasks was nearly perfect at all ages across a variety of logical forms.

Other tasks involved the same logical forms, but required metalogical judgments about entire arguments. In a variety of conditions across three studies, participants were asked to sort, rank, and evaluate arguments varying with respect to: (a) form; (b) content; (c) empirical truth of the premises; (d) empirical truth of the conclusion; and (e) validity (i.e., whether the conclusion followed from the premises). Of central concern was whether participants would distinguish validity from truth, recognizing that (a) an argument in which the conclusion follows logically from the premises is valid even if the premises and/or conclusion are false, and (b) an argument in which the conclusion does not follow logically from the premises is not valid, even if the premises and/or conclusion are true.

As expected, truth was a salient consideration at all ages. In cases where truth status and validity were in conflict, even college students often had difficulty focusing on the latter. There were substantial age differences, however. Most college students clearly understood the metalogical distinction between valid and invalid arguments and applied this distinction spontaneously, albeit inconsistently. Seventh graders were usually less spontaneous in their application of the concept of validity but nevertheless, in supportive circumstances, most showed genuine understanding. Fourth graders, by contrast, generally failed to distinguish validity from truth, even in conditions where they were provided with definitions, examples, and/or feedback concerning the nature of validity.

Related research by Markovits and his associates (Markovits & Bouffard-Bouchard, 1992; Markovits & Nantel, 1989; Markovits & Vachon, 1989; see also Efklides, Demetriou, & Metallidou, 1994) has shown that the ability to deduce conclusions from premises explicitly known to be hypothetical or false shows substantial development over the course of adolescence. Markovits and Bouffard-Bouchard (1992), moreover, found a positive relationship between (a) explicit knowledge about the distinction between inferential validity and empirical truth and (b) reasoning in accord with logical norms. Metalogical insight does not guarantee perfect reasoning, but may facilitate the application of logical rules to abstract content and the successful coordination of inferences on complex logical tasks.

Such findings are consistent with the core Piagetian claim that formal or hypothetico-deductive reasoning develops much later than competence in elementary logical inference. Without indicating a sudden transition at any particular age, developmental research on logical reasoning suggests that formal reasoning is common (albeit inconsistent) in adolescents and adults, but rarely seen much before the age of 11. This is not to say, however, that formal reasoning rests on formal operations. The transition from logical inference to logical reasoning may have less to do with logical structure than with the thinker's metacognitive attitude toward the propositions under consideration (Campbell & Bickhard, 1986).

Logical reasoning, then, seems to emerge long after logical inference. Although young children routinely make inferences in accord with rules of logic, only later in development do individuals increasingly think about such rules and understand their epistemic role in justifying connections among propositions. The construction of such metacognitive knowledge about logic may account for late developmental trends in the deliberate application and coordination of logical rules.

Rule-Based Reasoning

Although logical reasoning is the most researched form of rule-based reasoning, similar trends from rule-based inference to rule-based reasoning can be identified with respect to other systems of rules. In a classic investigation of the development of probabilistic concepts, Piaget and Inhelder (1951/1975) interviewed children and adolescents of ages 3 through 15 about chance phenomena involving balls, coins, cards, marbles, counters, toy men, and a spinner rigged with hidden magnets. Results showed developmental changes extending through early adolescence in conceptual knowledge about randomness, proportionality, normal distribution, the law of large numbers, and combinatorial possibilities. Unlike children under age 11, adolescents were frequently able to devise systems for generating all possible permutations, combinations, or other arrangements of a set of elements. Explicit knowledge of combinatorial possibilities, argued Piaget and Inhelder, provides the basis for insight into statistical regularities and thus for rule-based reasoning about patterns and distributions of chance events.

Research over the past several decades has shown that elementary laws of probability are implicit in the probabilistic inferences of children as young as age 4 (Huber & Huber, 1987). Consistent with Piaget and Inhelder's findings, however, it appears that probabilistic and proportional reasoning develop over a period extending well into adolescence (Ahl, Moore, & Dixon, 1992; Dixon & Moore, 1996; Kreitler & Kreitler, 1986; Moore, Dixon, & Haines, 1991). Sophisticated probabilistic concepts and associated forms of reasoning, in fact, remain elusive even in adults (Jones & Harris, 1982; Kosonen & Winne, 1995).

One area of probabilistic reasoning in which late developmental trends have received substantial attention is correlational reasoning. The standard methodological paradigm, devised by Inhelder and Piaget (1958), is to present children and/or adults with frequency data allowing judgments about the covariation of two dichotomous variables. For example, given information about the frequency of each of four potential combinations of hair color and eye color—dark hair/dark eyes; dark hair/light eyes; light hair/dark eyes; light hair/light eyes—it is possible to determine the direction and magnitude of the correlation, if any, between hair color and eye color. Although correlational inferences can be made from isolated bits of data, defensible conclusions about the existence and direction of a correlation require appropriate coordination of frequencies with respect to each of the four possible combinations. Research indicates that systematic application of sophisticated rules for assessing covariation in such data continues to develop at least through adolescence (Inhelder & Piaget, 1958), with substantial variation in adult performance (Shaklee, Holt, Elek, & Hall, 1988).

In many studies of logical and mathematical cognition, response patterns across carefully designed variations of standard tasks suggest the rule-based nature of subjects' inferences and judgments. Through systematic application of this rule-assessment methodology, Siegler (1981) has demonstrated that even young children use rules in responding to a variety of tasks. His research has indicated developmental trends in multiple domains toward increasingly systematic coordination of such rules.

In addition to logical and mathematical rules, individuals may also apply a variety of social and moral rules. Although such rules may be identified in the ongoing social and moral inferences of young children, increasingly sophisticated conceptual knowledge regarding the nature and justification of such rules may underlie the long-term construction of social and moral reasoning through adolescence and, for many, well into adulthood (Moshman, 1995b).

Holyoak and Cheng (1995a, 1995b) have proposed that people often solve logical reasoning tasks by assimilating them to their knowledge of certain kinds of social, moral, and legal rules. Depending on content and context, for example, a conditional of the form *if p then q* might be construed as a deontic statement of permission or obligation (e.g., if you are at least 21 years old, then you may drink beer). This may activate a pragmatic reasoning schema that might suffice to solve the task in question. Research with variations of the selection task has indicated that pragmatic reasoning schemas may enable appropriate selections by adults (Holyoak & Cheng, 1995a, 1995b; Manktelow & Over, 1995) and by children as young as age 7 (Girotto, Blaye, & Farioli, 1989; Girotto, Gilly, Blaye, & Light, 1989; Light, Blaye, Gilly, & Girotto, 1989).

The work on pragmatic reasoning schemas suggests that rule-based inference and reasoning often rely on content-specific social and moral rules, rather than on more abstract logical rules. A more radical approach entirely rejects the assumption that people engage in rule-based inference or reasoning. Johnson-Laird and Byrne (1991; Johnson-Laird, Byrne, & Schaeken, 1992) have argued that reasoning involves the construction and manipulation of concrete mental models of potential states of affairs and is thus a semantic, rather than a formal or syntactic, process. Reasoning does not require the application of rules, at least none that can be designated as logical. Developmental changes in reasoning, in this view, reflect (a) emergence of the linguistic ability to comprehend logical terms in the premises (e.g., *all, some, none, if, and, or,* and *not*), and thus construct appropriate models of the premises, and (b) improvements in the manipulation of these models due to the growth of processing capacity (Johnson-Laird, 1990).

Although theorists generally agree that children and adults can and do use pragmatic reasoning schemas and mental models for a variety of cognitive purposes, including solving many kinds of logical problems, most argue that people also apply logical and other rules (Braine, 1990; Braine & O'Brien, 1991; DeLoache *et al.*, Ch. 16, this Volume; Nisbett, Fong, Lehman, & Cheng, 1987; O'Brien, Braine, & Yang, 1994; Scholnick, 1990; Sloman, 1996; E. E. Smith *et al.*, 1992; L. Smith, 1993). Consistent with the view that people use both rules and models, Markovits (1993; Markovits & Vachon, 1990) has proposed a theoretical integration of Piagetian and information-processing approaches to conditional reasoning in which developing conceptions of necessity and possibility (Piaget, 1987) are associated with qualitative transitions to increasingly abstract uses of mental models over the course of childhood and adolescence.

We may thus posit a category of rule-based reasoning including, but not limited to, logical and mathematical reasoning. Regardless of the specific rules involved, rule-based inference gives rise to rule-based thinking as children become increasingly purposeful in the application and coordination of rules (Zelazo, Reznick, & Piñon, 1995). Rule-based thinking, in turn, gives rise to rule-based reasoning as individuals increasingly grasp the epistemic properties of their rules (Keenan *et al.*, 1994; Moshman, 1995a, 1995b).

Methodologically, then, a key criterion for demonstrating that an individual has engaged in rule-based reasoning is evidence that the individual is purposely applying what she or he deems to be epistemologically justifiable rules. Strict application of this criterion may be useful in resolving the apparent paradox that young children routinely make inferences in accord with logical, mathematical, and other norms (Braine, 1990; Hawkins *et al.*, 1984; Huber & Huber, 1987; Scholnick, 1990; Scholnick & Wing, 1995), whereas adults routinely make inferences that deviate systematically from such norms (Evans, 1989; Newstead & Evans, 1995).

With respect to young children, task demands are often such that genuine reasoning is unnecessary. Hawkins *et al.* (1984), for example, showed that young children can reach correct conclusions from various sets of premises. Markovits *et al.* (1989) replicated these findings, but showed that removing the logical connections across premises made little difference in young children's responses, with increasing attention to logical form over the course of later childhood.

Tasks designed for adults, on the other hand, are often sufficiently complex that, depending on how a participant interprets the social context and task instructions, she or he may engage in sophisticated reasoning without reaching the conclusion indicated by the normative rules that the researcher intended to assess. Hilton (1995), for example, shows how conversational assumptions and attributions may account for reasonable but incorrect responses to a variety of reasoning tasks. Thus, early success on some logical tasks and adult failure on others may mask an underlying developmental transition from automatic rule-based inferences to self-consciously rule-based reasoning.

Principled Reasoning

Reflection on laws may generate a distinction between rules and principles. Rules are algorithms that yield a determinate answer—for example, laws of deduction, arithmetic, or probability. If two individuals are applying the same rule in the same circumstance, they must reach the same conclusion unless one of them makes a mistake. Principles, in contrast, are general guidelines whose application involves heuristic judgments. Reasonable people may differ about such judgments. Principled reasoning derives from commitment to some set of principles on the basis of a general metacognitive understanding about the nature and use of principles.

A variety of theorists have proposed principles implicit in everyday inference. Hilton (1995) and Politzer (1986), for example, discussed conversational principles that guide social interaction. Walton (1996) proposed a set of argumentation schemes that provide heuristic guidance in contexts where formal rules of logic are inadequate. Tversky and Kahneman (1974) identified several judgment heuristics routinely applied to probabilistic situations by children (Jacobs & Potenza, 1991) as well as adults.

In a study of mathematical reasoning, Dixon and Moore (1996) presented 116 students in Grades 2, 5, 8, 11, and college with tasks requiring them to predict the temperature that would result from adding one container of water to another. Patterns of judgment across tasks and verbal protocols were used to identify (a) intuitive principles concerning the effects of relative temperature and quantity on the direction and relative magnitude of temperature change and (b) mathematical strategies for calculating final temperature. Application of appropriate principles increased with age through adolescence and was a necessary, but not sufficient, condition for use of appropriate mathematical strategies.

Kohlberg (1984) suggested that principled reasoning is central to higher levels of moral development. The advanced moral reasoner construes morality as a matter of acting in accord with justifiable principles. Unlike moral rules, such principles do not dictate the one right solution to a moral dilemma. Rather, they constrain the range of acceptable solutions. Kohlberg's theory, especially in its later versions, sets stringent structural criteria for principled moral reasoning, with the result that such reasoning apparently fails to develop in most people and is rarely seen prior to late adolescence. Moshman (1995b) proposed a less stringent conception of moral principles in the form of metalaws justifying a variety of moral rules. Such principles, he suggested, are implicit in the understanding and use of moral rules by young children and increasingly become explicit objects of reflection over a period extending through adolescence.

Helwig (1995a, in press) and Dunkle (1993) specifically studied the development of principles related to freedoms of expression and religion. They found substantial improvement over the course of childhood and adolescence in the comprehension, application, justification, and coordination of such principles. Evidence for both early competence and late developmental change notwithstanding, it appears that adolescents and adults show forms of principled reasoning that are qualitatively superior to the rule-based inferences of young children (Moshman, 1993).

Available evidence is thus consistent with a general trend from the use of implicit principles to the deliberate application of explicit principles (Moshman, 1995b). One may thus posit a developmental trend from (a) undifferentiated law-based inferences toward (b) rule-based and principled reasoning.

Scientific Reasoning

Many theorists and researchers have been particularly interested in empirical inference, in which the thinker generalizes from what is construed as information about some aspect of reality. At a primitive level, an individual might simply make inductive inferences from available data without any intention to generate knowledge. At a more advanced level, the individual may intend to make inferences in such a way as to yield correct generalizations about specific empirical phenomena and may deliberately seek new evidence with this in mind. We may call this scientific *thinking*.

In attempting to reach the best generalizations, thinkers may constrain their inferences in accord with what they take to be appropriate norms. A major line of research initiated by Inhelder and Piaget (1958) has assumed that the isolation of variables and corresponding rules of inference are fundamental norms of science. Such research indicates developmental trends extending into adolescence in the successful use of such rules (Kuhn & Brannock, 1977).

Others, however, have argued that scientific thinking cannot be reduced to some set of rules; rather, it relies heavily on heuristic principles. Principled scientific reasoning might, for example, involve general preferences for theories superior in parsimony, explanatory range, empirical adequacy, and internal consistency. Samarapungavan (1992) found that conformity to some such principles can be detected in the scientific thinking of children as young as age 7, but that there is improvement well beyond that age in the ability to provide explicit justifications based on principles of theory selection and in the application of such principles to theories inconsistent with one's own beliefs.

Theorists have also questioned the common assumption that scientific reasoning, at its core, involves seeking data that would disconfirm one's hypothesis. A number of theorists have proposed that confirmation bias—an allegedly irrational tendency to accumulate supportive evidence, rather than genuinely testing a hypothesis—may be better construed as a confirmation heuristic that serves a useful purpose in early phases of scientific inquiry (Tweney & Chitwood, 1995). Similarly, Koslowski and Maqueda (1993) argue that confirmation and disconfirmation are interrelated aspects of a defensible heuristic approach to testing and revising theories.

These considerations suggest that scientific thinking may improve with the development of rule-based and principled reasoning and raise the possibility that some sorts of law-based reasoning may be sufficiently central and unique to science as to be designated *scientific reasoning*. As we will see, however, questions about the existence and nature of scientific reasoning are complicated by indications that scientific thinking involves a complex dialectical coordination of theories, evidence, and methodologies (Chinn & Brewer, 1993; DeLoache *et al.*, Ch. 16, this Volume; Dunbar & Klahr, 1989; Klahr *et al.*, 1993; Kuhn *et al.*, 1988, 1995; Kuhn, Schauble, & Garcia-Mila, 1992; Schauble, 1990, 1996). The present discussion of methodological rules and heuristics only begins our consideration of scientific reasoning. We will return to the topic shortly.

DIALECTICAL REASONING

Although the term *dialectic* is notably protean in its meanings, it generally refers to a developmental transformation. Cognitive development is construed by many theorists as an intrinsically dialectical process. We may define dialectical thinking as the deliberate coordination of inferences for the purpose of making cognitive progress. Such thinking may be designated as *dialectical reasoning* to the extent that it rests on explicit knowledge about criteria for assessing such progress. Thus, the development of dialectical reasoning involves increasingly explicit knowledge about the nature of cognitive development and increasingly deliberate efforts to further that process.

Dialectical Reflection

In some cases, a thinker believes that a previous concrete case provides an appropriate constraint for resolving a current issue. I have defined the effort to apply a previous case to a current one as case-based reasoning. In other cases, a thinker believes that an abstract law provides the appropriate constraint. I have defined the application of such a law as law-based reasoning.

However, there are often a variety of potentially applicable cases and laws. It is not unusual, moreover, for these to point in different directions. With respect to a particular moral dilemma, for example, the thinker may perceive conflicts among applicable rules, principles, and precedents. Moreover, the moral obligations indicated by applicable rules, principles, and precedents may be construed as inconsistent with moral intuitions based on one's experience with analogous situations. Deliberate efforts to achieve coherence by reconstructing one's rules, principles, intuitions, and/or conceptions of precedent may be designated as *dialectical reflection.* More generally, dialectical reflection may be defined as a deliberate effort to make conceptual progress through active metacognition.

Basseches (1980, 1984), expanding on the work of Riegel (1973), formulated a set of 24 dialectical schemata—forms of thinking that apply sophisticated knowledge about structure, relations, context, perspective, contradiction, activity, change, and progress. He then interviewed nine first-year college students, nine seniors, and nine faculty members about the nature of education in order to get samples of reasoning about a complex issue. The dialectical schemata turned out to be well represented in the thinking of these research participants, and use of the schemata was positively correlated with educational level, consistent with the view that, at least among well-educated individuals, dialectical reflection continues to develop through late adolescence and early adulthood. Research by Chandler and Boutilier (1992) suggests that dialectical reasoning may be critical for understanding living, social, and other dynamic systems.

For reflection to be designated as dialectical reasoning, it must involve a deliberate effort to apply some criterion of progress. As already suggested, a common and important such criterion is increasing coherence. Thus, dialectical reflection may be construed broadly as encompassing what Moshman (1995a) called coherence-based reasoning. This would include both (a) reasoning aimed at achieving the temporal coherence of a narrative that unfolds across time (Feldman, Bruner, Kalmar, & Renderer, 1993), and (b) reasoning aimed at achieving more abstract forms of structural coherence (Fallon, 1987). Although an implicit preference for narrative or structural coherence may be characteristic even of young children's cognition (Piaget, 1985), the deliberate quest for coherence is usefully construed as a form of dialectical reasoning.

Argumentation

In many cases, dialectical reasoning is a profoundly social process. Kuhn (1991) investigated how adolescents and adults justify and defend their ideas in the face of alternative interpretations and viewpoints. Although participants were interviewed individually, they were challenged to provide arguments adequate to convince others and to respond to potential others who might hold different ideas.

The data showed argumentation skills to be far from perfect. People frequently failed to justify their own ideas and to evaluate alternatives on the basis of relevant considerations. Nevertheless, Kuhn provides a picture of reasoning as a collaborative process in which people formulate, communicate, criticize, justify, and revise their various ideas. Argumentation is usefully construed as a process of dialectical reasoning in which two or more individuals coordinate multiple cases and laws in a shared effort to make conceptual progress. That is, although arguments may be formulated and evaluated by individuals, argumentation is a fundamentally social process of collaborative reasoning. A number of studies suggest that, in some circumstances, reciprocal argumentation among two or more individuals may yield better results than individual reasoning (Dimant & Bearison, 1991).

Moshman and Geil (in press), for example, showed qualitatively superior performance in groups of college students reasoning about the original and most difficult version of the selection task (see earlier discussion under *Logical Reasoning*) than in individuals faced with the same task. Students solved the task either individually or in groups of 5 or 6. The groups were instructed to discuss the task with each other until reaching a consensus. Thus, in addition to the logical reasoning required in both conditions, the group condition involved a sustained process of argumentation. That is, group members engaged in a process of collaborative reasoning in which they proposed, justified, criticized, and defended a variety of potential solutions.

The difference between individual and group conditions was stark. Consistent with earlier research using this version of the task (Evans, 1989; Newstead & Evans, 1995), only 9% of students in the individual condition success-fully tested the hypothesized conditional relation by systematically seeking evidence that could falsify it. In contrast, the correct falsification pattern was the consensus response for 75% of the 20 groups.

In half of the groups, individuals were asked to propose their own solutions prior to group discussion, thus enabling comparison of individual and group solutions. Of the 57 students in these 10 groups, 35 switched from incorrect to correct response patterns in the course of discussion, while only two showed the reverse transition. Moreover, these changes were not simply a matter of succumbing to peer pressure. The falsification response pattern was not initially the most common view in any group. Nevertheless, it was the pattern chosen by eight of these 10 groups. There were three groups, in fact, where not a single individual had initially selected the falsification pattern; all three of these groups, however, were among those that ultimately selected this pattern as the consensus solution.

These results support a conception of argumentation as a rational group process that may, in some circumstances, be superior to individual reasoning (Kobayashi, 1994). Such a conception, in turn, has important implications for our conception of reasoning. Reasoning is traditionally viewed as taking place within an individual. An alternative is to view reasoning as a fundamentally social process of group interchange, with individual reasoning a derivative phenomenon involving internalized aspects of the group process (Salmon & Zeitz, 1995). A middle-ground possibility is that individual and collaborative reasoning are partially distinct and equally fundamental, developing via a complex process of reciprocal influence.

Legal and Scientific Reasoning Revisited

As noted earlier, precedent often plays a central role in legal thinking. It would be too simple, however, to identify legal reasoning as a version of precedent-based reasoning. Fallon (1987), for example, proposes that constitutional interpretation not only involves consideration of (a) precedent, but also of (b) the literal meaning of specifically relevant provisions of the constitutional text; (c) historical considerations regarding the intended meaning of that text; (d) general considerations of constitutional theory; and (e) general ethical principles. Constitutional reasoning, in his view, properly involves a process of dialectical reflection that attempts to bring these five considerations into equilibrium. More generally, it appears that legal thinking involves a variety of forms of case-based, law-based, and dialectical reasoning.

Scientific thinking, it appears, is no less complex. Kuhn and her associates (1989; Kuhn *et al.*, 1988, 1992, 1995; Schauble, 1990, 1996) have investigated scientific thinking as a dialectical process involving the coordination of theories and data. As noted earlier, scientific thinking can be construed more simply as a matter of following methodological rules, such as holding all variables but one constant or seeking data that would falsify one's hypothesis. Philosophers of science generally agree, however, that no set of methodological rules provides a direct path to scientific truth (R. Kitchener, 1986). Although acknowledging the role of methodological rules, Kuhn and her associates have found that (a) people's theories affect the collection and interpretation of data; (b) nevertheless, the resulting evidence sometimes leads to appropriate changes in those theories; and (c) the effort to coordinate theories and data sometimes leads to reflection on and reconstruction of strategies for knowledge acquisition. Research by Dunbar and Klahr (1989; Klahr *et al.*, 1993) has yielded similar results (see also DeLoache *et al.*, Ch. 16, this Volume).

In a broad-ranging review of the philosophical and psychological literatures on reflective theory change, Chinn and Brewer (1993) noted seven ways that individuals may respond to anomalous data.

1. The data may simply be ignored;
2. The data may be rejected as resulting from methodological error, random processes, or fraud;
3. The data may be excluded as outside the domain of the theory in question;
4. The data may be held in abeyance pending further articulation and development of the theory;
5. The data may be reinterpreted so as to render them consistent with the theory;

6. Peripheral aspects of the theory may be modified to accommodate the data; and,
7. There may be a change in core theoretical commitments.

What happens when one confronts anomalous data is a function of many factors, including (a) entrenchment of the relevant theory; (b) metatheoretical beliefs about theories and theory change; (c) other background knowledge; (d) availability of a plausible alternative theory; (e) quality of the alternative theory with respect to metatheoretical criteria such as scope, parsimony, empirical support, internal consistency, consistency with other theories, and fruitfulness in generating new research; (f) credibility, clarity, and scope of the anomalous data; and (g) the extent to which the individual reflects on the relevant theories and data.

Developmentally, the ability to distinguish generalizations from data and apply logical rules concerning the relation between these is typically present by age 6 (Ruffman, Perner, Olson, & Doherty, 1993; Sodian, Zaitchik, & Carey, 1991). The ability to construe such generalizations as hypotheses and evaluate potential sources of data, however, continues to develop at least through adolescence (Overton, 1990; Overton *et al.*, 1987; Ward & Overton, 1990). The ongoing coordination of theories, data, and methodologies over a series of investigations, moreover, may require processes of dialectical reflection that continue to develop, for some, long beyond childhood (Dunbar & Klahr, 1989; Klahr *et al.*, 1993; Kuhn, 1989; Kuhn *et al.*, 1988, 1992, 1995; Schauble, 1990, 1996). Although demonstrably inadequate strategies and interpretations are common at all ages, these studies have shown developmental progress beyond childhood in the ability to deliberately coordinate theories, data, and methodologies so as to improve one's understanding. Scientific thinking, in other words, appears to become increasingly dialectical.

With these considerations in mind, we may return to the earlier questions about legal and scientific reasoning. Given that there does not appear to be any form of reasoning central and unique to thinking about law, it is not clear what it means to speak of legal reasoning. Similarly, given the lack of evidence for a particular form of reasoning central and unique to empirical investigation, it may be misleading to speak of scientific reasoning.

A direct comparison of legal and scientific thinking, however, suggests that they may indeed rest on distinguishable forms of rationality. Precedent often plays a key role in the justification of a legal claim, whereas in the scientific context, a comparable appeal to history or authority would likely be seen as fundamentally illegitimate. Correspondingly, scientific respect for empirical data arguably defines a form of rationality distinct from the precedent-based rationality of law. Such considerations suggest the possibility that various forms of case-based, law-based, and dialectical reasoning can be coordinated so as to produce new forms of reasoning unique to particular domains of knowledge (such as law) or types of thinking (such as hypothesis testing). Empirically and conceptually, however, we are a long way from knowing what those forms of reasoning might be.

THE RATIONAL BASIS OF REASONING

Reasoning, as defined earlier, involves constraining one's thinking on the basis of explicit knowledge about various mental actions and the justifiability of their results. By definition, reasoning is done by a rational agent, one who has reasons for his or her beliefs and behavior. In this section, I elaborate on the nature and development of rationality.

Metacognitive Understanding

Research already reviewed suggests that conceptual knowledge about cognition begins to emerge during childhood but, for most individuals, continues to develop at least into adolescence. A strong case can be made that the emergence of increasingly sophisticated metacognitive understanding is a central aspect of advanced cognitive development.

With respect to logical reasoning, for example, we have seen that even young children routinely make a variety of correct inferences (Braine, 1990; Hawkins *et al.*, 1984; Scholnick, 1990; Scholnick & Wing, 1995). Metalogical understanding, however—conceptual knowledge about the nature of logic—is a later development. Although young children have intuitions of possibility, impossibility, necessity, and contingency, reflection on the logic of such intuitions generates higher levels of understanding about their significance and interrelations (Piaget, 1987; Piaget & Voyat, 1979; Pieraut-Le Bonniec, 1980). Recognizing logically necessary relations of hypothetical possibilities, for example, most adolescents and adults show an appreciation of inferential validity rarely seen in children much before age 11 (Markovits & Vachon, 1989; Moshman, 1990; Moshman & Franks, 1986).

Similarly, even young children are able to reach a conclusion about a hypothesis on the basis of evidence. Research suggests that children begin distinguishing generalizations from data as early as age 6 (Ruffman, *et al.*, 1993; Sodian *et al.*, 1991). The construction of metatheoretical understanding, however, appears to continue at least through adolescence. Developing individuals show increasing ability to construe generalizations as hypotheses, and to construe data as evidence bearing on those hypotheses. This may account for the long-term development of a deliberate orientation toward isolating variables, seeking falsifying evidence, and coordinating theories with evidence in ongoing investigations (Kuhn, 1989, 1991; Kuhn *et al.*, 1988, 1995; Overton, 1990; Schauble, 1990, 1996). Thus, with development, the use of theories may become increasingly sophisticated because of the increasing ability to think *about* theories (Inhelder & Piaget, 1958).

These findings have important implications for our conception of the development of rationality. If we define rationality as correct inference, even young children are substantially rational and developmental trends in rationality are far from robust. If, on the other hand, we define rationality as involving some degree of metacognitive understanding about knowledge and thinking, a stronger case can be made that rationality develops over a period of time that, for many people, extends long beyond childhood (Moshman, 1994). Theoretical conceptions of cognitive development increasingly stress emergence of metacognitive understanding. Campbell and Bickhard (1986), for example, define higher stages as higher levels of reflection. Taking a somewhat different approach, Demetriou, Efklides, and Platsidou (1993) posit a "hypercognitive system," a developing "supersystem" that understands, organizes, and influences other aspects of cognition.

There remains the question of the relation of metacognitive understanding to reasoning. If metacognitive understanding were completely unrelated to normatively correct reasoning, one might wonder why it develops. Moshman (1994) suggests a conception of rationality as "metasubjective objectivity," involving defensible forms of reasoning that emerge via reflection on one's subjectivity. Correlational evidence indicates positive relationships between metacognitive understanding and normatively appropriate reasoning (Goldman *et al.*, 1982; Kuhn, 1991; Markovits & Bouffard-Bouchard, 1992). Microgenetic research suggests that long-term reflection on reasoning leads not only to knowledge about reasoning, but to corresponding improvements in the quality of reasoning (Kuhn *et al.*, 1992, 1995; Schauble, 1990, 1996).

Epistemic Cognition

Epistemic cognition is an aspect of metacognitive understanding involving knowledge about the nature and limits of knowledge, including knowledge about the justifiability of various cognitive processes and actions. A variety of theories and research programs have addressed the development of epistemic cognition (Baxter Magolda, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986; Broughton, 1978; Chandler, Boyes, & Ball, 1990; King & Kitchener, 1994; K. Kitchener, 1983; Kuhn, 1991; Orr & Luszcz, 1994; Perry, 1970; Reich, Oser, & Valentin, 1994; Schommer, 1994; Schommer & Walker, 1995; Schraw & Moshman, 1995).

Research into epistemic cognition typically involves interviewing children, adolescents, and/or adults about the justification of knowledge in general and/or about the epistemic properties of their own theories and reasoning. The most systematic approach to the assessment of epistemic cognition is the Reflective Judgment Interview (RJI) developed by King and Kitchener (1994). The RJI uses a semistructured format in which the interviewer presents a series of epistemic dilemmas. One such dilemma, for example, involves contradictory evidence regarding the safety of chemical additives in food. For each dilemma, the interviewee is asked about the origin and justification of his or her own viewpoint; whether this viewpoint could ever be proven correct; why people, including experts, disagree; and how such disagreements should be interpreted or resolved. Research with the RJI has provided substantial support for King and Kitchener's seven-stage model of the development of reflective judgment.

Although differing as to specifics and terminology, most theorists of epistemic cognition have postulated a developmental sequence from objectivist to subjectivist to rationalist conceptions of cognition over the course of adolescence and early adulthood, with substantial individual differences in the extent of progress through these levels. The objectivist construes knowledge as absolute and unproblematic. Justification, if considered at all, is simply a matter of appealing to direct observation or to the pronouncements of an authority. Such epistemic conceptions are typical of children and commonly seen in adolescents and adults as well.

Subjectivist conceptions of cognition involve relativist epistemologies. Knowledge is deemed to be uncertain, ambiguous, idiosyncratic, contextual, and/or subjective; justification in any strong or general sense is considered impossible. As one subject put it, "I wouldn't say that one person is wrong and another person is right. Each person, I think, has their own truth" (King & Kitchener, 1994, p. 64). Although some researchers have concluded that systematic subjectivism is rarely predominant before the college years (King & Kitchener, 1994), there is evidence that relativist conceptions of knowledge are common among adolescents (Chandler *et al.*, 1990).

Finally, some individuals appear to make progress in late adolescence or beyond toward a more rationalist epistemology. Without returning to earlier notions of absolute and final truth or abandoning insights regarding context and subjectivity, the rationalist believes there are justifiable norms of inquiry such that, in some cases, some beliefs reasonably may be deemed to be better justified than others. Theory and research on epistemic cognition, then, are consistent with a view of rationality as metacognitive in nature and developing, at least in some cases, well into adulthood.

There is also evidence linking epistemic cognition to other aspects of cognition. Schommer (1994; Schommer & Walker, 1995) has identified epistemic beliefs that predict better comprehension and academic performance. Kuhn (1991) has shown a positive relationship between holding a rationalist epistemology and skill in argumentation. Chandler *et al.* (1990) provided evidence that advanced forms of epistemic cognition are positively associated with identity formation and negatively associated with psychopathology. Thus, epistemic cognition appears to be interconnected with learning, thinking, reasoning, and development.

Rational Identity

Although rationality is in part a cognitive phenomenon, the development of rationality should not be narrowly construed as the development of purely cognitive competencies. The ideally rational individual is one who spontaneously seeks relevant evidence and alternative views with the intent of altering his or her beliefs as appropriate. Such a person may be conceived as having a "critical spirit" (Siegel, 1988).

Critical spirit is more a matter of disposition than of ability. Perkins, Jay, and Tishman (1993) propose that good thinking includes dispositions to (a) be open-minded, flexible, and adventurous; (b) sustain intellectual curiosity; (c) clarify and seek understanding; (d) be planful and strategic; (e) be intellectually careful; (f) seek and evaluate reasons; and (g) be metacognitive. Although such dispositions would be of little use without associated cognitive abilities, those abilities may remain inert without the associated dispositions.

At a more global level, Cederblom (1989) suggests a developmental trend from (a) identifying oneself with one's beliefs toward (b) identifying oneself as a belief-forming process. To the extent that one identifies oneself with one's beliefs, any threat to those beliefs is likely to be seen as a threat to the self. Thus, even if one has the cognitive competence to change those beliefs appropriately, one is likely to resist evidence or arguments that suggest such change is necessary. To the extent that one identifies oneself as a belief-forming process, however, one is more likely to apply one's rational competencies. In this latter case, one construes the process of appropriately changing one's beliefs as confirming one's identity as a rational agent.

Rationality, then, transcends cognition to include motivational and dispositional considerations. The development of rationality is best construed as including the formation of a variety of intellectual dispositions and, more broadly, a critical spirit and a rational identity.

THE REFLECTIVE CONSTRUCTION OF RATIONALITY

I have proposed that advanced cognitive development is in large part the development of reasoning—that is, epistemologically self-constrained thinking. Reasoning, thus defined, is done by a rational agent—that is, an individual whose thinking is rooted in epistemic forms of metacognitive understanding. It follows that cognitive development beyond childhood consists largely of the development of rationality.

Now turn to questions of developmental process. In the present section, I present two approaches to accounting for the development of rationality—causal determinism and rational constructivism. Highlighting the latter, I conclude that rationality is best construed as a metacognitive phenomenon constructed through active processes of reflection.

Causal Determinism

A standard form of scientific explanation is to suggest that some event or process is caused by some other event or process. For example, if object *A* collides with stationary object *B* and the latter immediately begins to move, we are likely to explain the motion of *B* as caused by the impact of *A*. Causal explanations raise a variety of philosophical questions and become increasingly problematic as one moves from (a) physical interactions of macroscopic objects to (b) biological processes of anatomic and physiological development, then to (c) psychological processes of elementary behavioral development, and finally to (d) advanced cognitive development. In the present subsection, I consider three variations of the causal determinist approach and some limitations of each (Table 19.1).

The *universalist maturationist* approach makes the nativist assumption that cognitive development is an epigenetic process directed by genetic programs universal across the human species. Genes, in this view, not only play a role in cognitive development, but have primary responsibility for directing its course.

The proposition that genes influence cognitive development is not controversial. Characteristics of the human genome undoubtedly affect the course of cognitive development (Karmiloff-Smith, 1992; Spelke & Newport, Ch. 6, Volume 1) and influence the nature of advanced human cognition. A number of neo-Piagetian theories, moreover, have suggested age-related constraints on cognitive development, perhaps due to changes related to processing capacity (Case, Ch. 15, this Volume; Demetriou & Efklides, 1994; Demetriou *et al.*, 1993; de Ribaupierre & Pascual-Leone, 1979; Halford, 1993; Johnson-Laird, 1990; Lamborn *et al.*, 1994; Marini & Case, 1994). Although the explanation of such constraints is a matter of dispute, it seems plausible that they reflect genetically-based maturation of the nervous system.

Even if nervous system maturation plays a role in later cognitive development, however, there do not appear to be genetically based "critical periods" for such development (Kuhn *et al.*, 1995). There is a fundamental difference, moreover, between the views that genes constrain development and that they determine its course. There is no evidence that the structure of advanced cognition is genetically determined. Substantial individual and cultural differences with respect to advanced cognition, in fact, are difficult to reconcile with a universalist maturationist metatheory. No current theorist, to my knowledge, proposes that advanced cognitive development is a causal process directed by the genes.

TABLE 19.1 Theoretical Approaches to Advanced Cognitive Development

Developmental Paradigm	Basis for developmental change	Nature of developmental pathways
Universalist Maturationist	Genetic determinism	Psychologically universal
Relativist Enculturationist	Cultural determinism	Unique to each culture
Interactionist Contextualist	Interaction of genes and environment	Unique to each individual
Rational Constructivist	Reflective construction by rational agent	Epistemologically universal

The *relativist enculturationist* approach suggests that cultures differ in fundamental ways with respect to what is deemed to be advanced cognition. Changes in advanced cognition involve the inculcation of culturally valued skills and ideas and are unique to particular cultures. Indeed, from this perspective, there is no such thing as advanced cognition except within the context of a particular culture.

Culture and cognition are indeed intricately interrelated across the lifespan (Rogoff, 1990, Ch. 14, this Volume; Rogoff & Chavajay, 1995). Available evidence provides little or no support, however, for a determinist view that late cognitive changes are directly caused by forces unique to particular cultures. Even if environmental forces do exert some degree of causal influence, moreover, there are major conceptual difficulties for any suggestion that such changes constitute cognitive development.

An *interactionist contextualist* view would suggest that later changes in cognition are generated by complex ongoing interactions of genetic and environmental (including cultural) factors. One would therefore expect substantial variability in pathways of cognitive change. Such pathways, in fact, might be largely unique to particular individuals. Again, this casts considerable doubt on the existence of forms of cognition that are in some general sense advanced and raises questions about what changes in cognition, if any, are in some general sense developmental.

Interactionist contextualism is a more plausible and sophisticated perspective than either genetic or cultural determinism. The idea that genetic and environmental forces interact throughout the course of development, in fact, is fully consistent with a constructivist metatheory. The conceptual and empirical problems with construing genetic and environmental factors as causal forces that determine developmental change, however, are not resolved simply by recognizing the complex interactions of such factors. In particular, it is difficult to see how any causal determinist view can account for the sort of epistemic self-understanding that marks progress in rationality.

Rational Constructivism

A *rational constructivist* perspective emphasizes the active role of the developing individual in constructing advanced forms of cognition that transcend less adequate earlier forms. The result is an ongoing progress toward higher levels of rationality. Theorists in this tradition typically postulate developmental sequences that are deemed to have epistemological validity across cultures. Because the construction of advanced cognition may be facilitated or hindered by a variety of individual and cultural factors, individual and cultural differences in the rate and extent of progress through these idealized stages are likely. Thus, although the stages have some degree of epistemic universality, psychological progress through them need not be universal.

Rational constructivism, by postulating a rational agent, may provide a more plausible account of progress in rationality than any version of the causal determinist perspective. Without denying the importance and interactive nature of genetic and environmental influences, rational constructivist theories emphasize the mediating role of the epistemic subject as an active force in its own development (R. Kitchener, 1986; Smith, 1993).

There remains, however, the problem of accounting for the origin of rational agency. A plausible developmental scenario is that an interaction of genetic and environmental forces produces an active biological agent, which transforms itself into an active cognitive agent, which increasingly constructs an ability to reflect on its own cognition, thus transforming itself into a rational agent that, to some extent, acts on the basis of its own reasons. Thus, a causal determinist view may be helpful in explaining the prenatal beginnings of developmental change. A constructivist worldview, with its emphasis on the active organism, becomes more and more relevant, however. With further development, moreover, the process of construction becomes increasingly cognitive and ultimately self-reflective, thus generating the sort of rational agent whose actions are best understood from a rational constructivist perspective.

For a rational constructivist, then, development occurs not as a result of genes, environment, or some interaction of the two, but as a result of active cognitive reflection (Berkowitz & Keller, 1994; Kitchener, 1986; Piaget, 1985; Smith, 1993). By reflecting on current cognition, the thinker may reconstruct his or her own cognitions in such a way as to render their implicit properties explicit (Campbell & Bickhard, 1986; Karmiloff-Smith, 1992). As we have seen, for example, reflection on the logical necessity implicit in one's deductive inferences may be central to the construction of deductive reasoning (Moshman, 1990).

Reflection is an inferential process, however, and at higher levels, is usefully construed as an act of reasoning. Rational constructivism thus directs our attention to reasoning as both a context for, and a process of, development.

Reasoning and Development

A rational constructivist perspective suggests that reasoning is not only a product of reflection, but also a context for further reflection and thus, further development. In the process of applying analogical relations, precedents, rules, and/or principles, one is likely to reflect on one's reasoning in such a way as to generate higher levels of epistemic understanding and, over the long run, better reasoning.

With respect to the role of reasoning in development, however, there is an important distinction to be made between (a) case-based and law-based reasoning and (b) dialectical reasoning. Although case-based and law-based reasoning may generate reflection and, in time, developmental change, they are not developmental processes per se. Dialectical reasoning, on the other hand, is usefully construed as a self-conscious form of the developmental process of reflection.

Consider, for example, an individual who applies a moral principle to resolve some dilemma. If the principle is merely implicit in his or her processing of information, this would be an example of inference, but not reasoning. If the individual understands the principle as a principle and deliberately applies it because it is perceived as morally relevant, this would be reasoning. Provided the dilemma is adequately resolved, however, there may be no further reflection on the principle.

If, however, the individual is motivated to engage in extended reflection on the principle, including its justifiability and its relation to other principles, this may lead to a qualitatively higher level of moral understanding and thus constitute a developmental transition. At the very least, we may suggest that such reflection involves an implicit dialectic. To the extent that the individual perceives difficulties with his or her current set of principles and intentionally coordinates and reconstructs them for the purpose of achieving a higher level of moral understanding, we may posit a process of dialectical reflection that is simultaneously a process of reasoning and a process of development.

Important developmental changes in cognition may also be generated by extended argumentation. Argumentation may not only be a context that encourages reflection, but may also enable the co-construction of a collective rationality that serves as a particularly useful object of reflection. Peer discussion of a moral dilemma, for example, may generate a set of principles, including associated justifications, critiques, responses, and rejoinders, that constitute a collective structure of moral understanding none of the participants could have generated alone. Reflection on this structure may, for some of those participants, contribute to progress in moral understanding. A variety of theorists have emphasized the epistemic and developmental significance of argumentation among peers (Goldman, 1994; Habermas, 1990; Kuhn, 1991; Moshman, 1995a, 1995b; Piaget, 1924/1972; Salmon & Zeitz, 1995; Youniss & Damon, 1992), and there is substantial evidence for the role of peer interaction in developmental change (Dimant & Bearison, 1991; Kobayashi, 1994).

In a microgenetic study of combinatorial reasoning, for example, Dimant and Bearison (1991) had college students, over a series of six sessions, engage in incrementally more complex versions of a task in which they had to determine what combination of chemicals would generate a particular change in color. Some students worked on the task individually and others in dyads. All were pretested and posttested individually on a task requiring them to systematically generate all possible combinations of five candies.

For students in the dyadic condition, each speech act was coded using a system of categories designed to distinguish (a) collaborative engagement, in which individuals agree, disagree, ask questions, or supply explanations, from (b) speech acts not considered theoretically relevant to cognitive development. Collaborative engagement increased over the course of the six sessions. Pretest-posttest gains in combinatorial reasoning were greater for (a) students in dyads with above-average levels of collaborative engagement than for (b) students in dyads with below-average levels of collaborative engagement or (c) students who worked alone. The latter two groups did not differ, nor was there any effect for theoretically irrelevant speech acts. The developmental impact of peer interaction was apparently a function of the quality of argumentation.

In contrast to case-based and law-based reasoning, then, dialectical reasoning—including dialectical reflection and argumentation—is not only a context for developmental reflection, but a developmental force in itself. With the rise of dialectical forms of reasoning, the study of reasoning becomes indistinguishable from the study of development. Dialectical reasoning is, in fact, usefully construed as an effort to take control of one's cognitive development.

TOWARD A PLURALIST RATIONAL CONSTRUCTIVISM

This rational constructivist metatheory, I suggest, is best able to account for the developing rationality that is central, in my view, to advanced cognitive development. The most familiar theoretical instantiation of the rational constructivist paradigm is Piaget's theory of cognitive development, which proposes the rational construction of structures that are general across domains and universal across persons and cultures, culminating in formal operations as the highest stage of cognitive development. Now consider evidence for cognitive variability that suggests a pluralist-rather than universalist-version of rational constructivism.

It should be emphasized that pluralist rational constructivism leaves open the possibility that there may be forms of advanced cognition that have a considerable degree of generality across cognitive domains and/or universality across individuals and cultures. There is substantial evidence for such generalities and universalities. Pluralist rational constructivism assumes, however, that there are also important forms of advanced cognition specific to particular domains, individuals, and/or cultures.

Specificity and Generality Revisited

Piaget proposed formal operations as a general structure of advanced cognition applicable to all domains of knowledge. It is possible, however, to construe logic as a domain and formal operations as the structure of advanced cognition within this domain, rather than as a general stage of development. Recent theories have proposed specific forms, structures, or processes of advanced cognition not only with respect to logic (Efklides *et al.*, 1994; Markovits, 1993; Moshman, 1990), but in domains such as morality (Helwig, 1995b; Kohlberg, 1984), perspective taking (Selman, 1980), narrative interpretation (Feldman *et al.*, 1993), and reflective judgment (King & Kitchener, 1994).

The domains potentially relevant to advanced cognitive development constitute a heterogeneous set that overlap each other in complex ways. Even if there are aspects of cognition specific to logic and other aspects specific to morality, for example, logic and morality do not appear to be domains in the same sense. Morality, for example, arguably involves a particular type of content, whereas logic is applicable to a variety of types of content, including morality. Whatever the evidence for domain specificity of cognition, it is doubtful that advanced cognitive development consists of independent developmental transitions in some finite number of distinct domains.

As suggested earlier, it is important to avoid a simplistic choice as to whether advanced cognition is domain specific or general across domains. Rather, I proposed a focus on reasoning and distinguished four ways in which reasoning could be specific or general.

1. There could be forms of reasoning unique to particular domains of knowledge and inference such as physical causality, biological systems, social relations, or morality;
2. There could be forms of reasoning unique to particular types of thinking, such as problem solving, decision making, or hypothesis testing, though these types of thinking may be applicable to multiple domains of knowledge and inference;
3. There could be two or more distinct forms of reasoning, each of which is applicable to multiple types of thinking and multiple domains of knowledge and inference; and
4. There could be generalities that transcend particular forms of reasoning.

To further complicate matters, it is important to distinguish epistemological from psychological considerations with respect to specificity and generality. In comparing two domains of knowledge, for example, we must distinguish (a) the epistemological question of whether it is possible to identify a form of reasoning applicable to both domains (epistemic generality) from (b) the psychological question of whether the development of that form of reasoning is general across domains (psychological generality). Even if a given form of reasoning is broadly applicable (epistemic generality), for instance, the application of such reasoning in multiple domains of knowledge may develop independently (psychological specificity). Without some conceptual basis for suggesting some sort of epistemic generality, however, psychological research on questions of generality may be meaningless. Inquiry into questions of specificity and generality, then, requires ongoing coordination of epistemological analysis concerning the nature and applicability of various forms of reasoning and psychological research concerning synchronies and asynchronies in developmental change.

A number of researchers have addressed questions of specificity and generality with respect to reasoning about the physical and social worlds. Marini and Case (1994), for example, assessed levels of performance on (a) the Piagetian balance beam task (Inhelder & Piaget, 1958) and (b) a newly designed personality diagnosis task, requiring ability to identify abstract personality traits and use these to predict behavior. Four levels of complexity applicable to reasoning on both tasks were identified. Assessing 80 individuals ranging in age from 9 to 19, they found that most showed identical levels of performance on the two tasks, and almost all the rest differed by just one level. Without suggesting identical rates of development in the two domains, they concluded that a general potential for abstract reasoning typically develops about age 11 or 12 and can be observed in multiple domains under suitable experimental conditions.

The case for psychological and developmental generality is greatly strengthened by results from microgenetic research. In one such study, Kuhn *et al.* (1995) presented physical and social content to fourth graders and adults each week for a period of ten weeks. Participants generated and tested theories in their efforts to comprehend the causal relations in each domain. Developmental change in reasoning strategies was found for both age groups and, at each age, generalized across content. The authors concluded that both the children and the adults were constructing reasoning strategies applicable to both knowledge domains and were able to apply those strategies to a domain different than the domain in which they were constructed.

In still another approach to the generality of advanced cognition, Schraw, Dunkle, Bendixen, and Roedel (1995) assessed 269 college students in multiple domains with respect to both cognitive performance and several aspects of self-monitoring. The resulting pattern of correlations suggested that monitoring competence is neither entirely general nor entirely specific to domains. Acknowledging the importance of domain-specific knowledge, the authors concluded that monitoring within domains is in part a function of general metacognitive processes. In sum, studies differing greatly in design and focus provide converging evidence for the generality of advanced cognition across content. (For related research and theory, see Case, Ch. 15, this Volume; Chandler & Boutilier, 1992; Klahr *et al.*, 1993; Kosonen & Winne, 1995; Kuhn, 1991; Kuhn *et al.*, 1992; Nisbett *et al.*, 1987; Schauble, 1996; Schommer & Walker, 1995; Smith *et al.*, 1992.)

Although research of this sort undercuts strong versions of domain specificity, it provides little reason to think that advanced cognitive development can be understood as progress along a single developmental pathway toward a general structural endpoint. I have already proposed that case-based, law-based, and dialectical reasoning constitute distinct forms of reasoning, each of which may include two or more distinct variants (e.g., analogical versus precedent-based forms of case-based reasoning). It is well-established, moreover, that even young children have richly structured domain-specific knowledge and there is substantial evidence that such domains remain important beyond childhood (Helwig, 199513). Schauble (1996) provides detailed examples of the many ways specific knowledge affects the reasoning people use and the conclusions they reach. Pluralist rational constructivism does not assume that every identifiable domain constitutes its own form of rationality, thus generating its own form of reasoning, but neither does it rule out the possibility of domain-specific forms of rationality and reasoning. The earlier discussions concerning the nature and existence of legal and scientific reasoning illustrate the complexity of the theoretical and empirical questions that arise in this regard.

Whether the present analysis is seen as supportive of domain specificity or of domain generality depends on one's perspective. From the standpoint of Piaget's theory of formal operations, the present emphasis on several qualitatively distinct forms of reasoning may seem a move toward domain specificity, with each form of reasoning potentially constituting a distinct domain of development. On the other hand, the proposed forms of reasoning are applicable to multiple types of thinking and multiple domains of knowledge. Analogical reasoning, for example, can be used in solving problems, making decisions, and conceptualizing relationships with respect to a wide variety of physical, biological, social, and moral phenomena (DeLoache *et al.*, Ch. 16, this Volume; Halford, 1992). From the standpoint of a theory emphasizing distinct types of thinking or distinct domains of knowledge, the present approach would seem domain general in its emphasis on broadly applicable forms of reasoning.

Evidence for distinct forms of reasoning applicable to multiple types of thinking and multiple domains of knowledge and inference, then, suggests a conception of advanced cognitive development more pluralist than that of Piaget, but nonetheless general in important ways. It remains to be seen whether it will be possible to identify specific forms of reasoning, rooted in specific forms of rationality, that are unique and central to particular types of thinking and/or to particular domains of knowledge and inference.

Human Diversity and Universality

Cognitive variability may also be present or absent with respect to various biological and/or social groupings of individuals. Some studies, for example, have shown statistically significant differences between males and females in the prevalence of various forms of advanced cognition (Foltz *et al.*, 1995; King & Kitchener, 1994; R. Orr & Luszcz, 1994; Shaklee *et al.*, 1988; Walker, 1991; Wark & Krebs, 1996). Most theorists and researchers conclude from such differences that, in a given culture at a given point in its history, one gender may be somewhat more likely than the other to show certain forms of advanced cognition, due largely to differences in the socialization and experiences of males and females in that cultural context (Baxter Magolda, 1992).

Some theorists, however, have proposed that there are innate, fundamental, and/or essential differences between men and women such that certain developmental pathways and/or forms of advanced cognition may be considered prototypically masculine and others prototypically feminine (Labouvie-Vief, Orwoll, & Manion, 1995). It has been suggested, for example, that women use different logics than men (D. Orr, 1989), that they have different "ways of knowing" (Belenky *et al.*, 1986), and that they typically construe moral issues in terms of care, compassion and relationships, whereas men focus on rights, justice, and autonomy (Gilligan, 1982).

Research has not supported the stronger claims of fundamental sex differences. With respect to morality, for example, it appears that both men and women are capable of both care and justice reasoning; how an individual thinks depends more on the nature of the moral dilemma than the gender of the thinker (Helwig, 1995a, in press; Jadack, Hyde, Moore, & Keller, 1995; Walker, 1991; Wark & Krebs, 1996). Similarly, research on logical reasoning, mathematical reasoning, epistemic cognition, and argumentation generally shows sex differences to be minimal, if they are found at all (Chandler *et al.*, 1990; King & Kitchener, 1994; Kosonen & Winne, 1995; Kuhn, 1991; Moshman & Franks, 1986; R. Orr & Luszcz, 1994; Shaklee *et al.*, 1988).

Overall, there is no evidence for any form of advanced cognition that is common among men but rare in women, or vice versa (Menssen, 1993). Correspondingly, there is little support for theories postulating qualitatively distinct pathways of late cognitive development for females and males. Even theorists who continue to highlight the role of gender in advanced cognition maintain complex and ambivalent positions on the question of sex differences (Baxter Magolda, 1992; Clinchy, 1995; Labouvie-Vief *et al.*, 1995).

Culture may be a more important variable than gender with respect to advanced cognitive development (Rogoff, 1990; Rogoff & Chavajay, 1995). Two key questions about the relation of advanced cognition to culture are as follows: Are there forms of advanced cognition that are specific to particular cultures? Are there forms of advanced cognition that are common to diverse cultures? Each of these questions has a developmental counterpart: Are there developmental pathways specific to particular cultures? Are there developmental pathways traversed by individuals in many, and perhaps all, cultures?

The most systematic body of cross-cultural research on advanced cognitive development derives from Kohlberg's theory of moral development. It appears that the moral reasoning of individuals in a wide variety of cultures can be classified and understood with respect to Kohlberg's stages (Boyes & Walker, 1988; Snarey, 1985). The evidence is consistent with the view that these stages emerge in an invariant sequence, though strong tests of this are limited to a narrow range of cultures. There are substantial differences both within and across cultures in how far individuals progress.

Even within the domain of morality, however, there is evidence that certain forms of cognition are associated with certain cultures; we cannot rule out the possibility of developmental pathways specific to particular cultures or individuals (Campbell & Christopher, 1996; Moshman, 1995b). Given the paucity of cross-cultural evidence in other domains of advanced cognitive development, we must be cautious about any strong conclusions concerning the nature of human diversity and the extent of universality. Further research is likely to reveal both (a) forms of cognition appearing in adolescence or adulthood that are specific to particular individuals or cultures and (b) forms of cognition that may be deemed advanced in a general sense and that, even if not universal across individuals, are found in sufficiently developed individuals from a variety of cultures. Correspondingly, it continues to be a reasonable working hypothesis that cognitive development beyond childhood includes: (a) progress along developmental pathways that are universal across cultures; (b) progress along pathways that are arguably developmental but specific to particular cultures; and (c) progress along pathways that are arguably developmental but specific to particular individuals.

With respect to universalities in advanced cognition, for example, some plausible candidates are: (a) hypothetico-deductive reasoning; (b) principled reasoning; (c) precedent- based reasoning; (d) deliberate coordination of theories with evidence; (e) systematic strategies for testing hypotheses; (f) dialectical argumentation; and (g) rationalist conceptions of knowledge. This is not to say such forms of advanced cognition are likely to be found to be the predominant modes of thinking in all adults in all cultures. On the contrary, as we have seen, there is already substantial evidence against this. It may turn out, however, that such forms of cognition exist in a variety of cultures among individuals who, according to epistemic criteria that transcend any particular culture, may be deemed advanced in their cognition. It may also turn out that those who achieve these or other forms of advanced cognition do so by progressing through the same sequence of stages, though again, the universality of the sequences may be more epistemological than psychological.

With respect to diversities, there may be some forms of advanced cognition specific to particular cultures or individuals. Constitutional reasoning, for example, may be a particular synthesis of rule-based, principled, and precedent-based reasoning constructed only within specialized contexts in cultures with a particular kind of legal system (Fallon, 1987). In some cases, an individual may progress through a unique series of conceptual revolutions to an advanced and novel form of understanding, as in the case of Darwin's construction of the theory of evolution through natural selection (Gruber, 1974). Individuals may construct their own domains of knowledge, and such domains may vary across cultures, thus adding another dimension to the issues of specificity and generality discussed earlier in this section (Campbell & Christopher, 1996; Moshman, 1995b; Rybash *et al.*, 1986).

Universalist rational constructivism suggests that forms of cognition specific to particular individuals and cultures are special cases of more fundamental and universal forms of advanced cognition. This cannot be assumed in advance, however. Pluralist rational constructivism, without denying the existence and importance of universals, suggests that open-minded investigation of individuals and cultures may reveal advanced and fundamental forms of cognition undreamt of in our universalist psychologies (Campbell & Christopher, 1996; Miller & Cook-Greuter, 1994; Moshman, 1995b).

In sum, it is doubtful that late cognitive changes move exclusively toward or through formal operations, and unclear whether they approach any other general and universal endpoint. Current research and theory suggest the value of pluralist rational constructivism, a metatheoretical perspective within which active construction by rational agents is assumed, but generality across domains and universality across persons and cultures are open empirical and conceptual questions.

CONCLUSION

Does cognition develop beyond childhood? As we have seen, there is much evidence for long-term changes in cognition beyond childhood. Early in this chapter, I proposed that long-term changes are usefully construed as developmental if they are qualitative, progressive, and internally directed. I anticipated that some long-term changes in cognition beyond childhood are developmental in this sense, but that advanced cognitive development may not have other characteristics typically associated with developmental change. We now return to these issues.

Qualitative Change

Piaget's (1924/1972) theory of formal reasoning postulated the emergence of hypothetico-deductive reasoning at age 11 or 12. Hypothetico-deductive reasoning, for Piaget, was not a narrow technical skill but a self-conscious coordination of logic and hypothesis—or, in the language of Piaget (1987), of necessities and possibilities—that defined a new and final stage of cognitive development. The later theory of formal operations (Inhelder & Piaget, 1958; Piaget 194711960) proposed a logical structure central to this final stage.

The theory of formal operations-strictly construed as the logical model proposed by Inhelder and Piaget (1958) no longer plays much role in the literature. A variety of neo-Piagetian theories posit the construction of cognitive structures, variously defined and characterized, and propose that such structures achieve higher levels of abstraction beginning age 11 or 12 (Case, Ch. 15, this Volume). Other theorists, however, focus more on level of metacognitive reflection (Campbell & Bickhard, 1986; Kuhn, 1989, 1991; Moshman, 1990, 1994, 1995b). Although no one doubts that cognition is highly organized, the nature and breadth of advanced cognitive structures remains a matter of uncertainty and dispute.

I have suggested that three forms of reasoning—case-based, law-based, and dialectical—can be distinguished, with the possibility that these can be differentiated and/or coordinated to generate additional forms of reasoning. There is substantial evidence that some such forms of reasoning are general across domains of knowledge and inference (Kuhn *et al.*, 1995; Marini & Case, 1994; Schauble, 1996), but this does not rule out the possibility that we will identify types of thinking or forms of reasoning specific to such domains. It appears that advanced cognition is both specific and general in multiple ways.

Although we have much to learn about matters of specificity, generality, and structure, the case for qualitative change in cognition beyond childhood is strong. Adolescents and adults show forms of reasoning and levels of understanding qualitatively different from the cognition of children (Basseches, 1984; Campbell & Bickhard, 1986; Case, Ch. 15, this Volume; Chandler & Boutilier, 1992; Commons *et al.*, 1984; Inhelder & Piaget, 1958; King & Kitchener, 1994; Kohlberg, 1984; Kuhn, 1989; Markovits, 1993; Moshman, 1990, 1993, 1995b; O'Brien, 1987; Overton, 1990). In fact, there is surprisingly strong support for Piaget's 1924 proposal that formal or hypothetico-deductive reasoning—deliberate deduction from propositions consciously recognized as hypothetical—plays an important role in the thinking of adolescents and adults but is rarely seen much before the age of 11 or 12 (Markovits & Vachon, 1989; Moshman & Franks, 1986). The stronger support for the original theory of formal reasoning than for the structural theory of formal operations suggests that what emerges at about age 11 may not be a better logic, but a deeper level of reflection about the nature of logic, theory, and evidence (Campbell & Bickhard, 1986; Kuhn, 1989; Moshman, 1990).

Progressive Change

There appears to be a consensus that many of the qualitative changes in cognition beyond childhood observed in developmental research represent progress (R. Kitchener, 1986). The consensus may be due in part to the focus of so much research on aspects of logic or mathematics where the superiority of some cognitions to others seems clear.

The consensus may also be due in part, however, to the narrow range of cultures represented by most theorists and research participants. Pluralist rational constructivism suggests the need for more data on advanced cognition in multiple cultures and the corresponding need for more epistemological analysis of what constitutes advanced cognition and how progress in cognition can be identified in a manner that is not completely relative to culture.

The present analysis suggests ongoing transitions that are arguably progressive in a general sense. The emergence of thinking involves the deliberate coordination of inferences and thus represents a higher level of intentionality and complexity. The emergence of reasoning involves increasingly explicit knowledge about the epistemic properties of one's inferences, thus representing a higher level of reflection. It remains unclear toward what endpoints, if any, cognition tends, but such endpoints may not be necessary to identify cognitive progress.

Reflective Construction

I have suggested that advanced cognition is constructed via a process of dialectical reflection that coordinates multiple cognitions and renders their implicit properties explicit. It is in this sense that later cognitive changes, without being genetically determined, may be said to be internally directed and thus developmental. Pluralist rational constructivism suggests there may be forms of advanced cognition unique to individuals, forms associated with particular cultures, and forms universal across many or all cultures. Although some plausible universals have been proposed, evidence relevant to questions of universality and diversity is sparse and ambiguous.

Existing research and theory are sufficient, however, to suggest that advanced cognitions are not only constructed via reflection, but serve as a means of further reflection. Such reflection takes place in individuals, in groups, and in diverse cultural contexts. Our scientific efforts to understand cognition and development, moreover, are themselves reflective and constructive, generating theories of cognition that are themselves sophisticated forms of cognition.

It becomes increasingly difficult at higher levels to separate the application of cognition, the study of cognition, and the process of cognitive development. In both its universal and plural aspects, cognition develops beyond childhood via reflective processes that are simultaneously individual, social, and rational.

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