from. M. Cole's Cultural Psychology

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A Cultural Approach to Ontogeny

WITH A MODIFIED cultural-historical approach to questions of phylogeny and cultural history in hand, we can now turn to the topic that has been the main focus of my own research: ontogeny in its cultural-historical contexts. When we take ontogenetic development as our central concern, we arrive at a level of analysis that corresponds to our everyday experience. But we do so within a theoretical frame in which the developing individual represents a third stream of history, a third strand that becomes interwoven with the phylogenetic and cultural-historical strands. Important principles from our analysis of the processes of change in those genetic domains carry over when ontogeny is approached in this way.

1. Development involves the commingling of different historical strains that follow different processes of change: Darwinian and Lamarckian evolution.
2. Phylogenetic (Darwinian) change and cultural-historical (Lamarckian) change occur at different rates; the historical sources of change relate to each other heterochronously.
3. "Levels of development" are internally heterogeneous.
4. Strict cause-effect relationships do not explain development which entails the emergence of novel forms and functions of interaction among people and their worlds.

5. An appropriate unit of analysis for studying the interanimation of ontogeny and cultural history is a cultural practice, or activity system, which serves as the proximal environment of developmental change.

Patricia Miller provides a useful summary of the general process of ontogenetic development proposed by Russian and American cultural-historical psychologists:

> As children engage in activities with others, intermental activities, particularly dialogue, become intramental. In this way individual mental functioning has sociocultural origins. Language between people eventually becomes spoken speech for self (egocentric speech), then silent, mental, speech-like inner speech. Children internalize (Vygotsky) or appropriate (Rogoff) information and ways of thinking from their activities with parents, teachers, other adults, more capable peers.
>
> Technical and psychological tools provided by the culture mediate intellectual functioning. Language, in particular, helps children to direct their own thinking efficiently; they plan, think logically, and so on. (1993, p. 421)

I read straight through this passage nodding my head, saying to myself "good summary." But there are hidden problems with the view presented. Miller notes one of them: the summary is insufficiently developmental. One can see what she means by looking back at the previous passage and asking oneself how the process of change itself changes in the course of ontogeny. Miller summarizes general principles of mediation and the acquisition of mind, but the conditionality of their embodiment in the experience of children at different ages is left out.

When filling in the needed additional considerations, we might want to note another feature of this description. It is benign and conflict free. We are told that language "helps" children, and this is true. But, as is true of all mediational systems, language simultaneously constrains and assists children, it is simultaneously enabling and constraining. The tug and pull of actual human relationships, as experienced by people enduring the difficulties of everyday life, is absent. This feature bespeaks an idealized representation of the so-

ciocultural role of children in mediating adult experience of the world. Children are not always compliant and adults are not always well intentioned (Goodnow, 1990; Litowitz, 1993; Smolka, De Goes, and Pino, 1995).

This limitation is exacerbated by the absence of methodologies for dealing with the rich variety of activities that serve as the contexts of development. I postpone the methodological discussion until Chapter 8. In this chapter I will examine a variety of ways in which culture enters into the process of ontogenetic development. This treatment will differ from the earlier discussion (Chapter 3) organized around cross-cultural experimental data. While not ignoring those data, my account will be about universal processes of cultural mediation as they play themselves out from birth onward.

The Newborn Encounters the Group

John Dollard, one of the ancestors of current social learning theorists, offered a compelling way of thinking about the encounter of a new human being with the postnatal environment and the eventual impact of culture on its behavior:

> Accept two units for our consideration: first, the group which exists before the individual; and second, a new organism envisioned as approaching this functioning collectivity. The organism is seen at this moment as clean of cultural influence and the group is seen as functioning without the aid of the organism in question . . . Let us ask ourselves at this point what we can say systematically about what this organism will be like when it comes of age, sex granted. All of the facts we can predict about it, granted the continuity of the group, will define the culture into which it comes. Such facts can include the kind of clothes it will wear, the language it will speak, its theoretical ideas, its characteristic occupation, in some cases who its husband or wife is bound to be, how it can be insulted, what it will regard as wealth, what its theory of personality growth will be, etc. (1935, pp. 14–15)

This thought experiment graphically describes some obvious ways in which culture affects children's development. Moreover, Dollard is

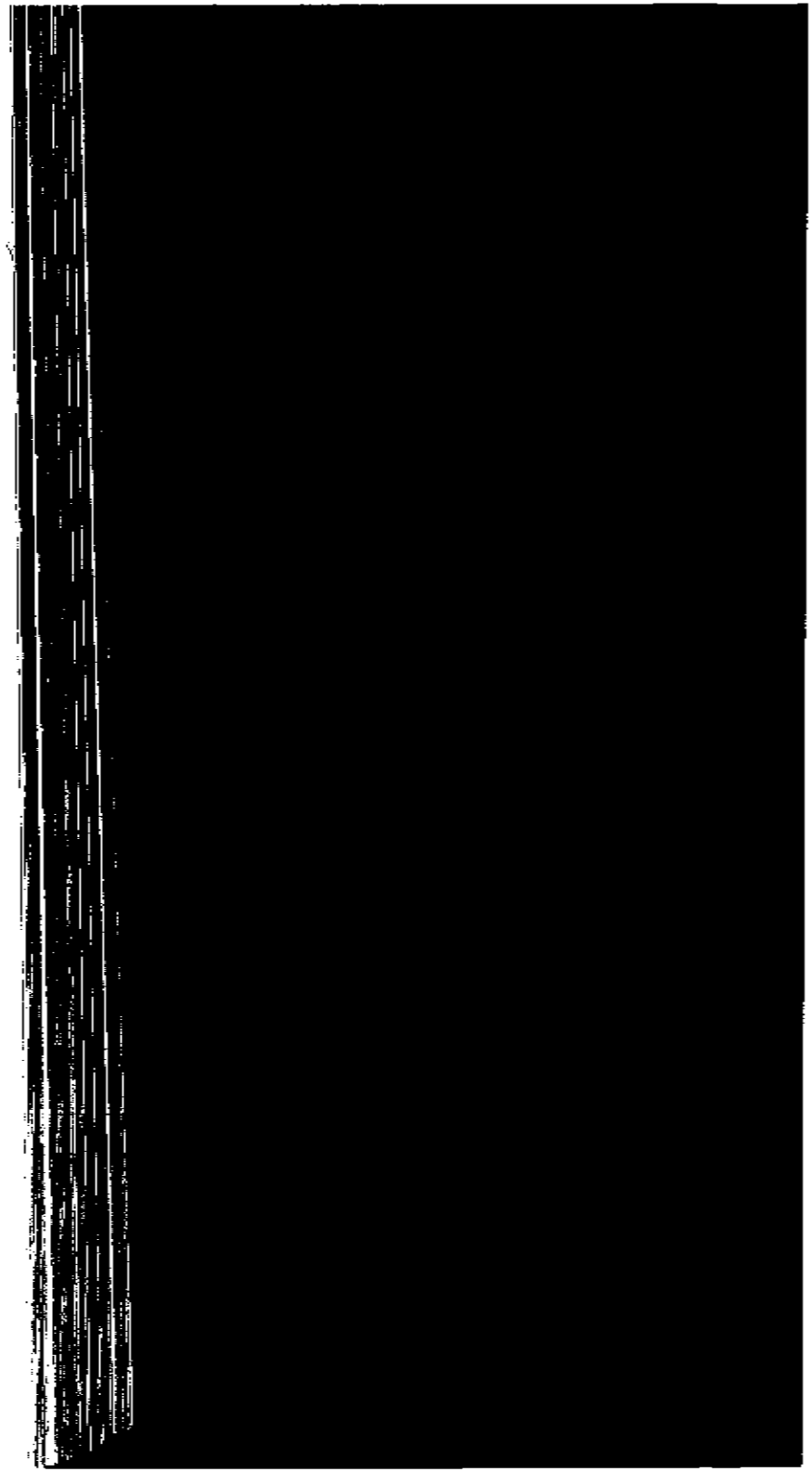
correct that over time new members of the community will come to feel that the culture "belongs to them" in such a powerful sense "that they act as if they had thought up for themselves what had been prescribed by tradition." There is a fundamental structural change during ontogeny such that an organism that lives in a cultural medium but cannot make use of it becomes one for which mediation of action through culture has become "second nature." The challenge is to explain how "over time" this transformation came about.

I will highlight four characteristics of culture discussed in Chapter 5 to explicate the distinct nature of a cultural-historical approach to ontogenic development. First is the basic unit of analysis within which life processes are organized—people's everyday, culturally organized activities (Bruner, 1982; Rogoff, 1990; Super and Harkness, 1986). The representation of context as concentric circles and the garden metaphor of culture both have at their core such everyday activities as the proximal environment of development.

Second is the central importance of artifacts, the ideal/material mediators of human experience that act as tools for, and constraints on, human action. Primary, secondary, and tertiary artifacts all enter into this account. Children are not born able to mediate their activity through artifacts, but they are born into a world where the adults who care for them do have this ability. In fact, as we shall see, children are themselves, in an important sense, cultural objects as they enter the world. The changing means by which they appropriate the cultural tool kit of their society in the process of becoming adult members is central to the process of ontogenetic change.

A third important feature of the way culture enters into ontogenetic development concerns temporality. As a rule, cultural change proceeds more rapidly than phylogenetic change; the biological characteristics of our species have changed relatively little. And cultural change is generally slower than ontogenetic change.[1] This heterochrony among genetic domains provides essential, but little-recognized, resources for human mental functioning and development.

The final property of culture I plan to discuss is connected with the metaphor of weaving together. A favorite theme in Vygotsky's writings was the way that qualitatively new characteristics of the organism emerge when hitherto separate lines of development intersect. Nevertheless, a significant shortcoming of cultural-historical research



at present is the failure to give an adequate account of how the natural and the cultural lines of development, phylogeny and cultural history, coincide and mingle during ontogeny.

Each of these aspects of culture is always present as a potential conditioner of, and resource for, interaction and thought, but they are not equally prominent in particular instances. My goal here is not to provide a comprehensive account of how each aspect influences development in all circumstances or at all ages, but rather to illustrate the ways in which each operates in cases where it plays a prominent role.

Past, Present, and Future

I begin my discussion of culture and ontogeny with the temporal properties of culture, in part because this topic has been widely neglected and in part because its operation is visible in a particularly clear way at the moment a newborn child emerges into the world.

With respect to embryogenesis, we have a pretty good idea of the way the past is related to the future and the present. The genetic code assembled from the past when sperm and egg unite at conception provides current and future biological constraints within which the biological process of development can take place. As cells proliferate, distinctive new structures come into being. For example, about five weeks after conception the hands begin to emerge as limb buds. Cells proliferate very rapidly, and soon the limb buds elongate into the shape of a paddle. Then five protrusions appear on the edge of the paddle, which will become a five fingered hand, with muscles, bone, tendons, nerve cells situated in a pattern appropriate to a human hand. None of this could happen if the genetic code had not provided the necessary constraints ahead of time. It is in this sense that the past enters the future in order that the end can be in the beginning.

Note that the genes cannot be said to "cause" development. It is only the combination of the constraints they provide and the interactions of the proliferating cells with their environment (including one another) that permit the emergence of successive physical forms and patterns of interaction between the developing organism and its environment. Developmental change of this kind is called epigenesis, a vague term which identifies local processes of interaction as the

locus of change. Of course, the "final cause" or "telos" coded in the pattern of genetic constraints is only an "if all other things equal" final cause. The actual process of development is one of probabilistic, not predetermined epigenesis (Gottlieb, 1992). If the right sorts of interactions between the organism and its environment do not happen at an appropriate time (for example, if thalidomide disrupts cell division five weeks after conception), distortions in development of a potentially life-destroying type will occur.[2]

There appears to be an analogous set of temporal relationships with respect to cultural constraints and development in Dollard's thought experiment, where the cultural past greets the newborn as its cultural future. But to explain how the palpable constraints in place in adulthood are transformed into palpable constraints at birth we must show how that "future structure from the past" is transformed into constraints on the interaction of organism and environment in the present, starting at birth, if not before. The name of the cultural mechanism that brings "the end into the beginning" is *prolepsis,* meaning, according to Webster's dictionary, "the representation of a future act or development as being presently existing."

Recently there have been several suggestions about the role of prolepsis in the organization of human psychological functions. Ragnar Rommetveit (1974) pointed out that human discourse is proleptic "in the sense that the temporarily shared social world is in part based upon premises tacitly induced by the speaker" (p. 87). Through prolepsis "What is said serves . . . to induce presuppositions and trigger anticipatory comprehension, and what is made known will hence necessarily transcend what is said" (p. 88).

Addison Stone and his colleagues (Stone, 1993; Stone and Wertsch, 1984) use prolepsis to characterize the way teachers seek to induce children's understanding of how to complete difficult cognitive tasks; in effect, the teachers presuppose that the children understand what it is they are trying to teach as a precondition for creating that understanding.

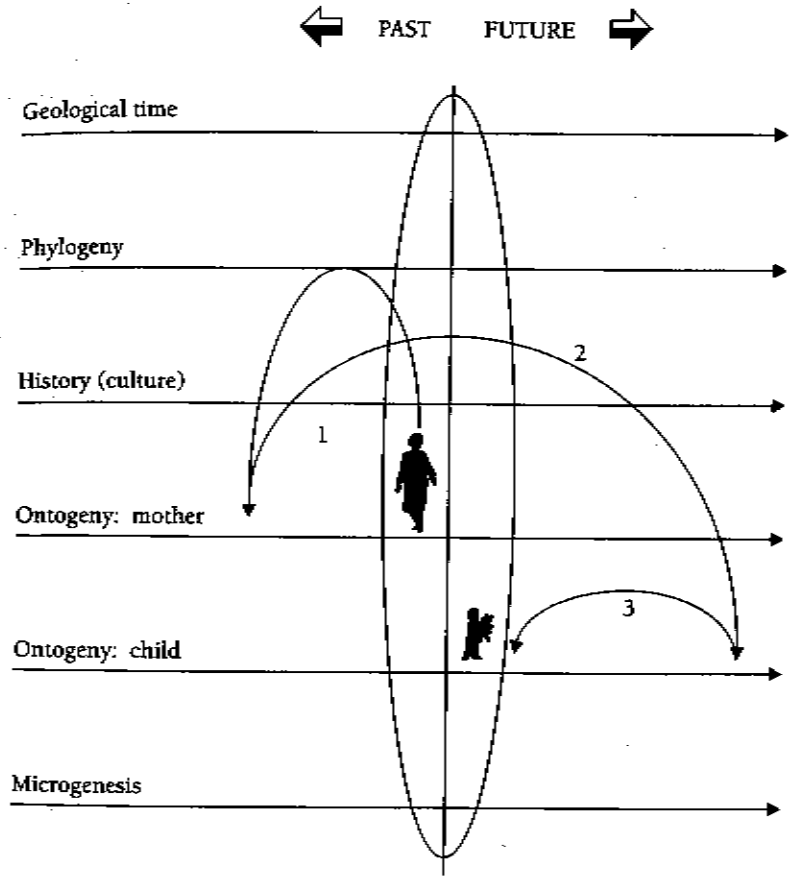
Prolepsis in the First Face-to-Face Meeting

A basic fact about human nature stemming from the symbolic character of cultural mediation is that when neonates enter the world

they are already the objects of adult, culturally conditioned interpretation. To paraphrase Leslie White's comment about water, they come bathed in the concepts their community holds about babies just as surely as they come bathed in amniotic fluid.

In the 1970s the pediatrician Aidan Macfarlane recorded conversations between obstetricians and parents at their children's birth. He found that the parents almost immediately start to talk about and to the child. The things they say arise in part from phylogenetically determined features (the anatomical differences between males and females) and in part from cultural features they have encountered in their own lives (including what they know to be typical of boys and girls). A typical comment about a newborn girl might be "I shall be worried to death when she's eighteen" or "It can't play rugby." Putting aside our negative response to the sexism in these remarks, we see that the adults interpret the phylogenetic-biological characteristics of the child in terms of their own past (cultural) experience. In the experience of English men and women living in the 1950s, it could be considered "common knowledge" that girls do not play rugby and that when they enter adolescence they will be the object of boys' sexual attention, putting them at various kinds of risk. Using this information derived from their cultural past and assuming cultural continuity (that the world will be very much for their daughter as it has been for them), parents project a probable future for the child. This process is depicted in Figure 7.1 by following the arrows (1) from the mother to the (remembered) cultural past of the mother (2) to the (imagined) cultural future of the baby (3) back to the present adult treatment of the baby.

Two features of this system of transformations are essential to understanding the contribution of culture in constituting development. First, and most obviously, we see an example of prolepsis. The parents represent the future in the present. Second, if less obviously, the parents' (purely *ideal*) recall of their past and imagination of their child's future become a fundamental *materialized constraint* on the child's life experiences in the present. This rather abstract, nonlinear process of transformation is what gives rise to the well-known phenomenon that even adults totally ignorant of the real gender of a newborn will treat the baby quite differently depending upon its symbolic/cultural "gender." For example, they bounce infants wearing blue diapers and



Looking backward, looking forward

Figure 7.1. The horizontal lines represent time scales corresponding to the history of the physical universe, the history of life on earth (phylogeny), the history of human beings on earth (cultural-historical time), the life of the individual (ontogeny), and the history of moment-to-moment lived experience (microgenesis). The vertical ellipse represents the event of a child's birth. The distribution of cognition in time is traced sequentially into (1) the mother's memory of her past, (2) the mother's imagination of the future of the child, and (3) the mother's subsequent behavior. In this sequence, the ideal aspect of culture is transformed into its material form as the mother and other adults structure the child's experience to be consistent with what they imagine to be the child's future identity.

attribute "manly" virtues to them while they treat infants wearing pink diapers gently and attribute beauty and sweet temperaments to them (Rubin, Provezano, and Luria, 1974). In other words, adults literally create different material forms of interaction based on conceptions of the world provided by their cultural experience.

Note how this situation differs from that embodied in the learning-theory view of development. The adults are not building upon the child's existing repertoire of behavior and modifying it bit by bit. The baby is, for them, a cultural being, and it is in those terms that they treat it.

Macfarlane's example also demonstrates an important distinction between the social and the cultural, which are often conflated in theories of development based upon such dichotomies as environment versus organism or nature versus nurture. "Culture" in this case refers to remembered forms of activity deemed appropriate, while "social" refers to the people whose behavior is conforming to, and implementing, the given cultural pattern. This example motivates the special emphasis placed on the *social* origins of higher psychological functions by cultural-historical psychologists (Cole, 1988; Rogoff, 1990, Valsiner, 1987; Vygotsky, 1981; Wertsch, 1985). Humans are social in a sense that is different from the sociability of other species. Only a culture-using human being can "reach into" the cultural past, project it into the future, and then "carry" that conceptual future "back" into the present to create the sociocultural environment of the newcomer.

Finally, this analysis of parental comments upon first seeing their child helps us to understand ways in which culture contributes to both continuity and discontinuity in individual development. In thinking about their babies' futures, these parents are assuming that the way things have always been is the way things will always be. This assumption of stability calls to mind White's telling image that temporally, the culturally constituted mind is "a continuum extending to infinity in both directions" (1942, p. 120). In this manner, the medium of culture allows people to "project" the past into the future, thereby creating a stable interpretive frame which is then read back into the present as one of the important elements of psychological continuity.

The assumption of cultural stability is wrong, of course, whenever there are conditions of cultural change following the birth of the child. The invention of new ways to exploit energy or new media of representation, or simple changes in custom, may sufficiently disrupt the existing cultural order to be a source of significant developmental discontinuity. As but a single example, in the 1950s American parents who assumed that their daughter would not be a soccer player at the age of sixteen would probably have been correct, but in the 1990s most girls in my home town play soccer.[3]

I know of no recordings equivalent to Macfarlane's from other cultures, but an interesting account of birthing among the Zinacanteco of south-central Mexico appears to show the same processes at work. In their summary of developmental research among the Zinacanteco, Greenfield, Brazelton, and Childs (1989) report a man's account of his son's birth at which the son "was given three chilies to hold so that it would . . . know to buy chili when it grew up. It was given a billhook, a digging stick, an axe, and a [strip of] palm so that it would learn to weave palm" (p. 177). Baby girls are given an equivalent set of objects associated with adult female status. The future orientation of differential treatment of the babies is not only present in ritual; it is coded in a Zinacantecan saying: "For in the newborn baby is the future of our world."

Although I do not pursue the issue here, I take prolepsis to be a ubiquitous feature of culturally mediated thought. Elsewhere (Cole, 1992) I present examples of prolepsis from later infancy and childhood. Chapters 8 and 9 of this book include further discussion of prolepsis.[4]

Routine Activities as Proximal Environments for Development

The earliest, essential condition for continued development once a neonate has been "precipitated into the group" is that the newcomer be incorporated into the daily life of the group. This incorporation requires that children and those who care for them become coordinated in such a manner that the adults are able to accumulate enough resources to accommodate the newcomer while the newcomer gets

enough food, care, and warmth to continue developing. Adults must make room for the child, for one more mouth to feed. The child must fill that space by "making itself welcome." Many ways of conceptualizing the effective unit of analysis linking children to their sociocultural environment and the process of developmental change have been proposed over the years.

Charles Super and Sara Harkness (1972, 1986), elaborating the tradition of eco-cultural theory proposed by J. W. M. Whiting (1977), refer to the child's "developmental niche" within the everyday practices of the community. They conceive of the developmental niche as a system composed of the physical and social settings within which children live, culturally regulated customs of child care, and the parents' theories about children.

My colleagues and I identified cultural practices as the proximal units of children's experience (LCHC, 1983). We defined cultural practices as activities for which there are normative expectations for repeated or customary actions. Within cultural practices, all objects are social objects—they are socially constituted. Cultural practices are functionally and structurally similar to what Super and Harkness refer to as developmental niches, and what others refer to as contexts or activities (see Chapter 5).

Jaan Valsiner (1987) distinguishes niches with respect to the role of adult involvement in a manner that complements the positions sketched out so far. The innermost level of the developmental niche is called the Zone of Free Movement (ZFM); it structures the child's access to different parts of the environment, exposure to different objects and events, and ways of acting. Within the ZFM, adults promote children's actions in various ways, creating the Zone of Promoted Action (ZPA). According to this scheme, Vygotsky's idea of a Zone of Proximal Development (ZPD) is treated as a ZPA so matched to the child's present developmental state that it guides the child's further development. Each way of structuring interactions provides essential constraints enabling development.

An important feature of all of these approaches needs to be emphasized: while adults may initiate the creation of developmental niches and by virtue of their power provide constraints on the organization of behavior within them, the events that transpire within culturally organized activities are *joint* accomplishments. Both the

child and the sociocultural environment are active agents in the developmental process.

Barbara Rogoff makes the cautionary point quite clearly: "Even when we focus attention separately on the roles of the individual and the social milieu, these roles are defined in terms that take each other into account" (1990, p. 28).

Citations emphasizing this point could be drawn from any of the authors cited above, but an excellent summary comes from Sue Savage-Rumbaugh's work on language development in chimpanzees, discussed in Chapter 6. A central part of Savage-Rumbaugh's strategy of inducing language (whether dealing with chimps or children) is to focus on what she and her co-workers refer to as "interindividual routines," defined as "a more or less regularly sequenced set of interindividual interactions that occur in a relatively similar manner on different occasions" (Savage-Rumbaugh et al., 1993, p. 25). Savage-Rumbaugh links interindividual routines to scripted events of which they are a part. Such routines are highly repetitive and rhythmic, while subject to variation within a conventional range. They coordinate the organized patterns of interplay between child and caretaker(s) and synchronize their behavioral-emotional states.

Diaper changing is given as an early prototype of an interindividual routine. Children must cooperate to the extent of lying still enough to keep a pin from being stuck through their skin instead of the diaper. If a caretaker lifts the child in an unfamiliar way the child may wriggle away because she is uncertain of what is to follow. The routine is disrupted if either participant fails to follow it, because it depends upon their joining their behaviors in a smooth manner. As Savage-Rumbaugh and her colleagues put it, "Each sort of interindividual routine is something like a delicate dance with many different scores, the selection of which is being constantly negotiated while the dance is in progress, rather than in advance. Experienced partners know what turns the dance may take, and, more important, they have developed subroutines for negotiating what to do when one or both partners falter in the routine" (p. 27).

Of course, even experienced partners do not always accomplish diapering seamlessly and smoothly. My children, at least, were perfectly capable of resisting being diapered, and I can attest that even highly skilled parents stick pins in even compliant babies. These non-

ideal episodes have a way of being selectively forgotten, and along with them the constant possibility of friction in the enactment of adult scripts.

Interactions in Early Developmental Niches

Examples of early developmental niches illustrate how children are integrated into the social group in a way that simultaneously sustains their development and allows the group to readjust and go on about its business.

Hilliard Kaplan and Heather Dove (1987) report that among the Ache, a hunter-gatherer people of eastern Paraguay, children under three years of age spend 80–100 percent of their time in direct physical contact with their mothers and are almost never seen more than three feet away. A major reason for this situation is that the Ache do not create clearings in the forest when they stop to make camp. Rather, they remove just enough ground cover to sit down upon, leaving roots, trees, and bushes more or less where they find them. In consequence, mothers either carry their infants or keep them within arm's reach.

Quechua mothers also keep their infants close to them, but in a different way and for different reasons. The Quechua inhabit the highlands of Peru, an area approximately 12,000 feet above sea level, where the partial pressure of oxygen is 62 percent of its value at sea level, humidity is extremely low, and the temperature reaches freezing an average of 340 days a year (Tronick et al., 1994). Quechua newborns spend almost all of their time in a *manta pouch*, constructed of at least four layers of cloth, the outer layer being a rectangular wool blanket placed inside a carrying cloth. The blankets are folded to seal off the child from the outside so that no part of the child's body is exposed except when being changed. The environment within the manta pouch is warmer, more humid, and more stable than the outside conditions. Tronick and his colleagues propose that this environment helps the infant to conserve energy, reducing the number of calories needed for growth in an environment poor in nutritional resources. As children grow older and stronger, the wrappings are loosened and exposure to the environment is increased.

The way culturally regulated childcare practices are designed to

coordinate infant-caretaker interactions can be highlighted by contrasting the ways American urban-dwelling and rural Kenyan (Kipsigis) parents organize their children's sleeping patterns (Super and Harkness, 1972). Among children in the United States, there is a marked shift toward the adult day/night cycle a few weeks after birth; by the end of the second week, they are averaging about 8½ hours of sleep between the hours of 7 P.M. and 7 A.M. Between four and eight months the longest sleep episode increases from about four to eight hours a night. The pressures toward sleeping through the night are not difficult to identify. American urban dwellers live by the clock. A large proportion of mothers and fathers must leave the house at a specified time to get to work, and the child must be ready at that time. As a consequence of the child's need for sleep, the adults' need to get to work, and the adults' desire for some leisure time while the child is asleep, American adults are likely to push hard for the child to eat and sleep when it is convenient for them.

The course of getting on a schedule is very different for Kipsigis infants. At night they sleep with their mothers and are permitted to nurse on demand. During the day they are strapped to their mothers' backs, accompanying them on their daily rounds of farming, household chores, and social activities. They do a lot of napping while their mothers go about their work. At one month, the longest period of sleep reported for Kipsigis babies is three hours; and their longest sleep episode increases little during the first eight months. Kipsigis children gradually increase the length of their sleeping as their patterns of participation in community activities broaden. As adults, they will be more flexible in their sleeping patterns than their American counterparts.[5]

Reciprocal Action within Developmental Niches

A shortcoming of the examples I have presented thus far is that they fail to display the *co*-constructed nature of the process. In every case, they imply that agency rests exclusively with the (more powerful) parents and other older kin. However, there is also evidence indicating the reciprocal nature of the interactions between children and their caretakers, even in the early days of postnatal life.

Kenneth Kaye and his colleagues (Kaye, 1982) have provided a

variety of illustrations of this point. One series of studies was devoted to the development of nursing, a form of behavior that Piaget had studied in terms of the gradual modification of reflexes into primary, secondary, and tertiary schemas as a result of assimilation and accommodation. Piaget's account does not consider the active role of the mother in arranging the conditions of the child's behavior. Kaye found that even during the very first feeding mothers occasionally jiggle their baby (or the bottle). These jiggles do not come at random intervals; rather, they are most likely to occur during pauses in the infant's sucking. The jiggles increase the probability of sucking and prolong the feeding session, thereby increasing the amount of milk the neonate receives.

Sucking in response to jiggling is not a reflex in the sense that rooting is a reflex. Rooting is an automatic, involuntary response to being touched on the side of the mouth. There are no known neural connections that make sucking inevitable when a baby is jiggled. Yet it happens, it is to some extent automatic, and it has clear adaptive value. Kaye speculates that the mother's jiggles between her infant's bursts of sucking are her way of intuitively "conversing" with her baby by filling in her "turn" during the pauses in the baby's rhythmic sucking. Mothers' reports support Kaye's view. Although they are not aware that they are jiggling their babies in a systematic way, mothers report that they actively try to help their babies nurse. They notice and disapprove of the pauses between bursts of sucking. When mothers are asked about their jiggling behavior, a typical response is that the baby "gets lazy," or "dozes off," "so I jiggle her to get her to pay attention."

The interactions observed by Kaye are easily overlooked. His research indicates that when we examine the earliest mother-child interactions carefully enough, reciprocity of behavior as part of child-rearing routines is seen to be there from the beginning, though the form of this reciprocity may vary from one cultural setting to another.

By the middle of the first year of life, infants' ability to initiate and share control of interactions, and even to wrest control from adults, is well documented. Barbara Rogoff provides an example in which an adult is trying to initiate a turn-taking routine:

When the adult tried to take the ring, the baby firmly held onto

from the baby's grasp, the baby stared at him with a look of indignation, and then, with her eyes fixed on him, her face melted into a pout. The adult immediately exclaimed, "Oh, don't cry, I'll give it back to you!" and extended the ring to the baby, who was by then shrieking . . . The adult tried four more times to play give-and-take, but each time he took the ring away and handed it back, the baby turned away or looked down, apparently displeased, but eventually grasped the ring when it came in contact with her hand. Finally, the baby pushed the adult's hand away from the ring, and the adult left the ring in the baby's possession. (1990, pp. 91–92)

Rogoff comments that the child provided ample evidence of understanding the adult's give-and-take game script, but an equally strong disinclination to engage in it.

As children's physical abilities and accumulating experience increase, the developmental niche organized for them by adults changes. Beatrice Whiting and Carolyn Edwards (1988), following Margaret Mead (1935), provide a normative developmental sequence of the niches that children are allowed to inhabit. The *lap* or *back* child (0–2.5 years) lives in "a bounded space centered on the emotional and physical presence" of caretakers (p. 35). The *knee* child (2.6–3.5) moves around on its own but in a circumscribed area where it is closely monitored by its caretakers. The *yard* child (3.6–5.5) is allowed access to the entire area in and immediately surrounding the home and begins to come under the control of adults outside the immediate family. *Community* or *school* children engage in activities that take them far from home and also outside of immediate supervision by adults.[6]

Intersubjectivity and Joint Mediated Activity

At the same time that babies and their caretakers are becoming coordinated with each other through joint participation in caretaking routines, they are also establishing the foundations for sharing experiences (Cole and Cole, 1996). Contemporary research demonstrates that immediately after birth infants visually track a schematic face as it moves in front of them (Morton and Johnson, 1991). At

about 2½ months changes in brain functioning owing to maturation are accompanied by increased visual acuity and the appearance of a new form of reciprocal behavior called social smiling. For the first time, children's smiles are reliably connected with events originating in the social environment, and this calls forth stronger feelings of connectedness on the part of caretakers.

The new pattern of interactions provides the potential for the sharing of emotional states that Colwyn Trevarthen (1980) refers to as *primary intersubjectivity*. The following episode of emotional sharing between a three-month-old infant and its mother, described by Daniel Stern, indicates this form of connectedness:

> His eyes locked on to hers, and together they held motionless . . . This silent and almost motionless instant continued to hang until the mother suddenly shattered it by saying "Hey!" and simultaneously opening her eyes wider, raising her eyebrows further, and throwing her head up and toward the infant. Almost simultaneously the baby's eyes widened. His head tilted up . . ., his smile broadened . . . Now she said, "Well hello! . . . heello, . . . heeelloooo!," so that her pitch rose and the "hellos" became longer and more stressed on each successive repetition. With each phrase the baby expressed more pleasure, and his body resonated almost like a balloon being pumped up. (Stern, 1977, p. 3)

At about eight months of age, babies exhibit a variety of behaviors indicating a second marked increase in their level of connectivity with their surroundings. It is at this time that children first begin to search actively for hidden objects, to imitate actions seen several hours earlier, to display overt wariness of novelty, to fear strangers, and to become upset when left by their parents. Changes in EEG patterns indicating increased power and coherence of this measure of brain activity coincide with these behavioral changes (Dawson and Fischer, 1994).

With respect to the capacity for joint activity the most important development in this period is the ability to pay attention to people and objects as part of the same action. Trevarthen uses the term *secondary intersubjectivity* to refer to the new pattern of interpersonal relations that illustrates this ability. The essence of secondary inter-

subjectivity is that the infant and the caregiver can now share understandings and emotions that refer beyond themselves to objects and other people. For example, if a mother and five-month-old baby are looking at each other and the mother suddenly looks to one side, the infant will not follow the mother's gaze and look in the direction she is looking. At about eight months, babies follow the line of their mother's gaze and engage in joint visual attention with her (Butterworth and Jarrett, 1991).

A striking example of secondary intersubjectivity between infants and their caretakers is called *social referencing*. Babies use social referencing when they come upon something unfamiliar and look back to their caretakers for some indication of what they are supposed to do. It comes into prominence as a means of communication as soon as babies begin to move about on their own (Campos and Stenberg, 1981). When babies notice that their caretaker is looking at the same thing they are looking at and appear to be concerned, they will hesitate and become wary. If their caretaker smiles and looks pleased about the new situation, they will be more relaxed and accepting (Walden and Baxter, 1989).

A parallel, and presumably linked, change in children's problem solving is equally important to the development of culturally mediated action. Ever since the pioneering work of Piaget it has been known that during this same period one observes the earliest forms of tool use in which children are able to coordinate two schemas (for example, "drop object in tin box" and "make an interesting sound"). In Piaget's words, the first schema "serves as a means whereas the second assigns an end to the action" (Piaget, 1952, p. 55).

A series of behavioral changes which converge in the months surrounding the child's first birthday initiate a totally new level of ability to mediate actions through artifacts and other people. An example of this is pointing as a means of recruiting a caretaker's attention. Around one year of age babies begin pointing at objects (Bruner, 1983; Franco and Butterworth, 1991). When twelve-month-olds see a remote-controlled car roll past, first they point at it and then they look to see how their mothers react to it (social referencing).

"Verbal pointing" (using nonconventional sounds) also makes its appearance early in the second year. For example, Elizabeth Bates

made the following observation of a thirteen-month-old girl: "C. is seated in a corridor in front of the kitchen door. She looks toward her mother and calls with an acute sound *ha*. Mother comes over to her, and C. looks toward the kitchen, twisting her shoulders and upper body to do so. Mother carries her to the kitchen, and C. points toward the sink. Mother gives her a glass of water, and C. drinks it eagerly" (1976, p. 55).

Michael Tomasello and his colleagues argue that the ways in which infants begin to coordinate attention to objects and people as part of the same act indicate their awareness that persons are intentional agents, unlike inanimate objects: "Infants do not attempt to look where their doll is looking, they do not attempt to use a chair as a social reference point, and they do not request actions from their bottle. They do these things only when they are interacting with another person, and this is because they understand the behavior of other persons in terms of underlying perceptions and intentions" (Tomasello et al., 1993, p. 498). According to Tomasello and his colleagues, this emerging ability to treat others as intentional agents is critical in making possible the forms of imitation children will need to acquire their group's store of cultural knowledge.

Conventional developmental psychological wisdom marks 18–24 months as the period when converging changes in the social, biological, and psychological spheres result in a qualitatively new stage of development, marking the end of infancy. This is the period that Piaget marks as the advent of representational thought. It is the period when, according to Vygotsky, cultural history and phylogeny begin to merge, bringing about a qualitative transformation in human thought. Important markers of these changes include the following:

1. At 18 months the function of pointing becomes communicative in a more complex way. As noted earlier, if a self-propelled toy car rolls across the floor unexpectedly, 12-month-olds are likely to point to the car and then look to see if their mothers are looking too. Around 18 months of age, the children are more likely first to look at their mothers to see if they are looking at the car and *then* to point to it. If infants this age are alone in the room when the electric car appears, they do not point *until the adult walks back into the room,* clearly demonstrating that

their pointing is instrumental and meant to communicate (Butterworth, 1991).

2. Problem solving mediated by symbolic combinations of possible solutions makes its appearance. Piaget's (1952) description of his daughter Lucienne's ability to get a stick through the bars of her crib is a classic illustration. Instead of going through the slow process of trial and error the child seems to picture a series of events in her mind before she acts. Piaget singled out the baby's ability to infer that she could pull the stick through the bars if she reoriented it without making any overt attempts as the key evidence for the existence of a new form of thought separate from immediate action.
3. From about 12 to 18 months, babies use objects in play much as adults would use them in earnest; that is, they put spoons in their mouths and bang with hammers. But as they near their second birthdays, babies begin to treat one thing as if it were another. They "stir their coffee" with a twig and "comb the doll's hair" with a toy rake or pretend that the edge of a sandbox is a roadway. This kind of behavior is called symbolic play—play in which one object *represents* another, as the rake stands for a comb. For the next several years, play will be an important cultural context within which children can simulate the cultural practices they observe and participate in, including the roles they will be expected subsequently to carry out in earnest. Play is proleptic.
4. There is a rapid blossoming of language. Children begin to put together complicated sentences and their vocabulary increases at an accelerated rate.

There are a variety of other indicators that children are beginning to mediate their understandings of the world through symbols. Adult standards begin to guide their behavior. When confronted with their image in a mirror, they recognize themselves. They begin to use words in a way that indicates they are referring to themselves (for example, when a block tower crashes, the child will say "Uh-oh, I did it"). They experience more complex emotions and begin to learn how to navigate a social world that has become more complex and less tied to adults (Cole and Cole, 1996, ch. 6).

Modularity and Context

The preceding examples have illustrated cultural contributions to development and more or less ignored the crucial contributions of phylogenetic constraints. To redress the balance I shall turn to a line of modern work on phylogenetic ("innate") contributions to children's intellectual development captured by the notion of "modularity." According to the version of cultural-historical psychology I am advocating, modularity and cultural context contribute jointly to the development of mind.

I am not certain of the origins of the concept of modularity, but my own knowledge of it stems from the debate between Piaget and Chomsky (and various commentators) edited by Massimo Piatelli-Palmerini (1980). In controverting Piaget's claim that language is constructed on the basis of previously developed sensorimotor schemata, Chomsky argued for the existence of what has come to be called a language module:

> If we really look into the details of the development [of a particular linguistic structure] . . . I would expect to find exactly the same thing in the study of any physical organ. The way in which an organ develops is going to depend on all sorts of factors in the environment, but I think that what we would expect to find, and do find over and over again, is that the fundamental organizing properties, the general features, simply are not up for grabs but rather are fixed. (1980, p. 176)

In the course of the debate, Jerry Fodor applied the logic of Chomsky's theory of language to cognitive development in general, an argument for which he provided an extended treatment in his book *The Modularity of Mind* (1983). Simplifying greatly, Fodor claimed that:

1. Psychological processes are domain-specific. Environmental information passes through a system of special input systems or modules (special-purpose sensory transducers) that output data in a common format where it is processed by a "central processor."
2. The psychological principles that organize each domain are in-

of Chomsky. They have a fixed neural architecture, they operate automatically and rapidly, and they are "triggered" by relevant environmental input and not constructed in the manner suggested by Piagetian theory.[7]

3. Different domains do not interact directly; each is a separate mental module. Knowledge provided by modules is coordinated through a "central processor" which operates on their outputs.
4. Modules cannot be influenced by other parts of the mind, which have no access to their internal workings.

Fodor proposed a number of candidate modules in addition to language. These include the perception of color, shape, three-dimensional relations, and recognition of voices and faces. Subsequently, others have suggested a wide variety of possible modules including ones for mechanical causality, intentional movement, number, animacy, and music (Hirschfeld and Gelman, 1994).

The modularity hypothesis comes in both a weak and a strong version. According to the weak version, the behavioral dispositions that are built into the genome are richer and more complex than traditional theories of cognitive development have recognized. These genetically specified characteristics provide the starting point, the initial structure, upon which later cognitive abilities are constructed. They set constraints upon the way the developing organism attends to and hypothesizes about experience, channeling development along species-typical lines. The strong version of the modularity hypothesis goes on to propose that behavioral characteristics within these domains do not really develop at all; they are innate, requiring only the right environmental triggering to realize them (see Fischer and Bidell, 1991; Karmiloff-Smith, 1992; Hirschfeld and Gelman, 1994, for representative discussions).

My own view is that the weaker form of modularity—as skeletal principles and starting points—can be usefully combined with notions of cultural mediation. Such a combination offers an attractive way to account for the intertwining of "natural" and "cultural" lines of development as part of a single process.

The process of language acquisition can serve as a paradigm case. How does the interweaving of genetic and cultural constraints give rise to language?

Language Acquisition

No area of culture and human development has attracted more scholarly attention than the question of the role of cultural experience in the acquisition of language. Must language be acquired through a process of culturally mediated learning or constructive interaction like any other human cognitive capacity? Or is language a specialized, bounded domain (module) which needs only to be triggered to spring into action? (See Bruner, 1983; Piatelli-Palmerini, 1980; and Pinker, 1994, for discussions of the contending viewpoints.)

No one believes that language can be acquired in isolation. Still, the modularity position with respect to language assumes that its development proceeds akin to the development of any bodily organ: any environment adequate to sustain the life of the social group is adequate to produce the development of language without the need for any special attention.

Since the environment that sustains life is one transformed by culture, it is necessary to specify more carefully what minimum conditions of culturally mediated interaction between children and adults are sufficient to support development of the "language organ." It is also necessary, as in the case of the biological study of organogenesis, to specify the nature of the interactions from which the "language organ" emerges.

I find the garden metaphor useful as an aid to thinking about these issues. Consider, for example, an ordinary bean seed of the sort commonly used in kindergarten classrooms to illustrate the process of growth. Imagine placing it in some damp earth in a jar and then placing the jar in a toolshed. After an allotted period of time, say two or three weeks, the seed will begin to sprout. A stem will appear and then leaves, the yellow-green waxy leaves of early spring. However, for further development to occur, the seedling now *must* interact with sunlight. If you do not take it out of the dark toolshed, it will wither and die. But if you place it in the sunshine, it can grow and flower.

I want to draw an analogy between the contrasting conditions of the seed in the shed and in the sunshine and the situation facing human children in their environments. Like a seed in soil, the human child must be provided with sufficient support to maintain life; it must be kept warm enough and fed or it will die.

Several features of the "seeds" of language have been shown to be present at birth or acquired so shortly after birth as to deny the importance of extended experience. These features include the ability to distinguish a very broad set of phonemic distinctions, the ability to distinguish syllables from nonsyllables, a preference for speech sounds over nonspeech sounds, and a preference for speech sounds which adhere to natural clause boundaries, vowel duration, linguistic stress, and rhythm. In short, children are born with a rich supply of linguistically relevant aspects, or seeds of language (for overviews see Adamson, 1995; Karmiloff-Smith, 1992). What then are the conditions under which these seeds will sprout and flower?

Evidence from Children Deprived of Language Experience

Cases of children reared in conditions that reduce their immersion in culture help to specify the universal lower limits of cultural support needed to sustain language development. One is the well-known case of Genie, studied by Susan Curtiss (1977). Genie was locked in a room by herself sometime before her second birthday. For the next eleven years she lived chained to a potty by day and trussed up in a sleeping bag at night. During this time she had virtually no normal linguistic input and only a minimum of social interaction that could be considered normal in any culture. No one was allowed to speak to her, and her father, when he fed her, made only animal noises.

When she was liberated from these horrible circumstances at the age of thirteen, Genie was in pitiful shape: She was emaciated and very short. She could not walk normally, rarely made a sound, and was not toilet trained. Although upon testing she showed remarkable skills for spatial analysis, she had failed to acquire language. Nor did she recover from her many years of severely deprived existence: she acquired a small vocabulary and some forms of appropriate social interaction, but her behavior remained abnormal despite attempts at therapeutic intervention.

There are several intermediate cases between this extreme deprivation and the situation of the vast majority of children. One particularly instructive situation arises among children born deaf to hearing parents who do not believe that it is useful for their children to

sign, insisting instead that they learn to interact through oral language (Goldin-Meadow, 1985; Goldin-Meadow and Mylander, 1990). These children are reared in an environment which is rich in culturally mediated social interactions (including linguistic mediation among other household members) that include the child and proceed very much as they would if the child could hear: people eat meals together, the children are given baths and put to bed, they go to the store, they are toilet trained. Thus they live in a world suffused with meaning, although they lack access to the specifically linguistic behavior that fills the gaps between actions. These children bring to their interactions an active mind that certainly contains event representations and schemas. In many face-to-face situations, these resources suffice both to get the children through the interaction and to develop their underlying schemas to a degree necessary to participate with others.

Under these circumstances, children are known spontaneously to begin to employ "home sign," a kind of communication through pantomime. Goldin-Meadow showed that home sign exhibits a number of properties also found in the early stages of natural language acquisition. Deaf children in these circumstances begin to make two, three, and longer sign sequences around their second birthdays, at about the same time that hearing children create multiword sentences. Most significantly, Goldin-Meadow reported that these deaf children were able to embed brief sign phrases within others ("You/Susan give me/Abe cookie round") even though none of the gestures used by parents had this property. This kind of behavior reveals that the children could engage in an elementary form of recursion, a form of communicative behavior that is characteristic of all human languages. Interestingly, this level of language development appears quite similar to that claimed for Kanzi by Greenfield and Savage-Rumbaugh (1990).

However, their language development comes to a halt at this point. The cultural medium is simply too thin to support the development of fully mature language. It is as if one tried to grow a bean from a seed in deep shade. It appears that unless such children have access to some form of language as a part of their culturally organized environments they will not develop its subtler features, upon which sustainable cultural formations depend. However, if such children are

subsequently taught a sign language such as ASL, they appear capable of developing extensive linguistic abilities, even when their exposure to a full language system occurs in adolescence, well after the critical period usually associated with first-language acquisition (Morford and Goldin-Meadow, 1994; Emmorey, Grant, and Ewan, 1994).[8]

It is important to add that at the other extreme, where children have access to language but not to culturally organized activity, language development also fails to take place. Children who have been left alone for long time with a television set broadcasting in a foreign language do not acquire that language (Snow et al., 1976).

The Normal Environment of Language Acquisition

It seems an inescapable conclusion from this kind of evidence that in order for children to acquire more than the barest rudiments of language they must not only hear (or see) language but also participate in the activities which that language is helping to create. In everyday activity, language is the essential means for establishing and maintaining coordination, for filling in the gaps between gestures and other actions, and for making possible the fine-tuning of expectations and interpretations. Note that I am not saying that adults must deliberately teach language; rather, they must arrange/allow children to participate in culturally organized activities mediated by language.

In attempting to specify the environmental circumstances necessary for language acquisition, Jerome Bruner (1982) refers to the social interactional constraints provided by everyday activities as *formats*. The format, according to Bruner, "is a rule-bound microcosm in which the adult and child *do* things to and with each other. In its most general sense, it is the instrument of patterned human interaction. Since formats pattern communicative interaction between infant and caretaker before lexico-grammatical speech begins, they are crucial vehicles in the passage from communication to language." Bruner later adds that once formats become conventionalized they seem to have a kind of "exteriority" that allows them to act as constraints on the actions that occur within them.

In this respect, Bruner's notion of format is very similar to the way in which Katherine Nelson (1981, 1986) talks of the generalized event schemas called *scripts*, "sequentially organized structures of

causally and temporally linked acts with the actors and objects specified in the most general way." In effect, formats or scripts are event-level cultural artifacts, which are embodied in the vocabulary and habitual actions of adults, and which act as structured media within which children can experience the covariation of language and action while remaining coordinated in a general way with culturally organized forms of behavior. In the process of negotiating such events with enculturated caregivers, children discover the vast range of meanings encoded in their language at the same time as they find new ways to carry out their own intentions.[9]

Bruner nicely captured the cultural view of language development when he wrote that language acquisition cannot be reduced to "either the virtuoso cracking of a linguistic code, or the spinoff of ordinary cognitive development, or the gradual takeover of adult speech by the child through some impossible inductive *tour de force*. It is rather, a subtle process by which adults artificially arrange the world so that the child can succeed culturally by doing what comes naturally, and with others similarly inclined" (1982, p. 15).

Arguments over the importance of the environment in language acquisition gave rise to a large literature on parents' ways of structuring children's activities (see, for example, de Villiers and de Villiers, 1978). Parents in many societies adopt something akin to "baby talk" when speaking to their children, before and while the children are acquiring language. Ferguson (1977) speculated that a special "baby talk register" (using higher pitch and intonation, simplified vocabulary, grammatically less complex sentences, and utterances designed to highlight important aspects of the situation) is a universal, acquisition-enhancing form of adult language-socialization behavior. Cross-cultural data have shown, however, that while adults everywhere speak to young children in ways different from their talk with older children and adults, the particular form of baby talk involving simplified grammar and vocabulary characteristic of middle-class American parents is not universal. There is some evidence that other features of baby talk such as the use of distinctive pitch and intonation may be universal, but the data on cultural variation remain sparse (Fernald, 1991).

In many societies, adults deliberately teach vocabulary, styles of address, and other linguistic features. The Kaluli of Papua New

Guinea, for example, are reported to hold their small infants facing away from them and toward other people while the mother speaks *for* them rather than *to* them. There are also subcultures within the United States (working-class people in Baltimore; Miller, 1982) in which it is firmly believed that children must be explicitly taught vocabulary, using quite rigid frames of the sort "How do you call this?" (see Schieffelin and Ochs, 1986, for a wide range of examples). However, while the adults involved in such practices may believe that such special tailoring helps their children acquire language, the data indicate that significant benefits associated with variations in cultural patterns of mother-infant interactions involving language are found rather rarely and in restricted domains (Snow and Ferguson, 1977).

It is also a mistake to believe that the kinds of formats that serve as proximal environments for language acquisition are tightly knit with language acquisition as a major adult goal. An example from the work of Richard Shweder provides a more representative example of the contexts of language acquisition:

> *"Mara heici. Chhu na! Chhu na!"* is what a menstruating Oriya mother explains when her young child approaches her lap. It means, "I am polluted. Don't touch me! Don't touch me!" If the child continues to approach, the woman will stand up and walk away from her child. Of course, young Oriya children have no concept of menstruation or menstrual blood; the first menstruation arrives as a total surprise to adolescent girls. Mothers typically "explain" their own monthly "pollution" to their children by telling them that they stepped in dog excrement or touched garbage, or they evade the issue. Nevertheless, Oriya children quickly learn that there is something called *"Mara"* (the term *chhuan* may also be used) and when *"Mara"* is there, as it regularly is, their mother avoids them, sleeps alone on a mat on the floor, is prohibited from entering the kitchen . . . eats alone, does not groom herself and is, for several days, kept at a distance from anything of value. Children notice that everything their mother touches is washed. (Shweder, Mahapatra, and Miller, 1987, p. 74)

Despite the ambiguity of the term *Mara*, children begin to attach meanings to it that are consistent with adult usage, if incomplete.

Most six-year-olds think it is wrong for a "*Mara*" woman to cook food or sleep in the same bed with her husband, and by nine years of age most children think that *Mara* is an objective force of nature that makes it immoral for women the world over to touch or cook for other people when they are in that state.

In addition to illustrating the range of activities within which children come to acquire language, this example illustrates Vygotsky's insistence that word meanings develop over time. Oriya children can use the term *Mara* in appropriate ways to interact with adults long before they come to share adult meanings of the term.

Culturally organized joint activity that incorporates the child into the scene as a novice participant is one necessary ingredient in language acquisition. As children in such activities struggle to understand objects and social relations in order to gain control over their environment and themselves, they re-create the culture into which they have been born, even as they reinvent the language of their forebears.

Modular Contributions to the Development of Thought

When we move from the domain of language to that of cognitive development, the weak form of the modularity hypothesis is most frequently invoked using the concept of constraints. The key argument is made by Rochel Gelman (1990).

> It is necessary to grant infants and/or young children domain-specific organizing structures that direct attention to the data that bear on the concepts and facts relevant to a particular cognitive domain. The thesis is that the mind brings domain-specific organizing principles to bear on the assimilation and structuring of facts and concepts, that learners can narrow the range of possible interpretations of the environment because they have implicit assumptions that guide their search for relevant data. (p. 4)

Gelman refers to these constraints as "skeletal principles" because they provide the core structure that supports the growth of knowledge.

Much of the current evidence that modular-like constraints affect development comes from studies with young infants (some as young as a few hours, but more often two to four months of age) indicating the existence of an impressive array of innately specified, "skeletal" cognitive structures. These include "proto-knowledge" in such widely dispersed domains as basic physical properties of objects (Baillargeon, 1987; Spelke, 1990) intentionality (Bruner, 1990; Premack, 1990), arithmetic (Gelman, 1990), the animate-inanimate distinction (Gelman, 1990), and physical causality (Leslie, 1994).

Relating Modular Constraints to Cultural Constraints

Theorizing about modular, biologically constrained, psychological processes became fashionable in psychology at almost the same time that the idea of contextually, cultural-historically constrained processes came into fashion. Many reasons can be offered for this "specificity Zeitgeist," but perhaps most relevant to the present discussion was a growing dissatisfaction with the Piagetian research program, especially Piaget's claims that the thinking abilities of three-to-five-year-olds are severely limited and that human infants are born with only a few reflexes and three poorly specified mechanisms for producing change (assimilation, accommodation, and equilibration), on the basis of which all later knowledge is constructed (Gelman, 1978; Gelman and Baillargeon, 1983; LCHC, 1983).

Those who emphasized factors of cultural context sought, in the spirit of the cross-cultural work discussed in Chapter 3, to determine if preschoolers' failure to manifest various cognitive abilities in researchers' tests resulted from the researchers' unwitting use of unfamiliar problem content and procedures. They focused on tasks that make sense to small children in everyday terms (Donaldson, 1978). Concepts such as "context" or "domain" were used loosely in this work to refer either to culturally identifiable forms of activity or to psychological tasks presumed to assemble cognitive processes applicable to a wide variety of domains or contexts, such as perspective taking, various kinds of reasoning, and remembering (see Cole and Cole, 1996, ch. 9, for a review of this literature).

Those emphasizing modularity focused primarily on young infants

or on exceptional children who demonstrated apparently wide discrepancies in development across conceptual domains (child chess whizzes, mathematicians, musicians, and, on the negative side, children with autism or Williams' syndrome: Frith, 1989; Bellugi et al., 1990; Feldman, 1994). While researchers pursuing these topics also employ procedures that minimize extraneous features of the tasks presented (for example, relying on demonstrations of surprise rather than requiring a motor response such as grasping or a linguistic response), their choice of tasks has been motivated by the idea that children's intellectual development is organized around a few (presumably key) ontological domains which specify the kinds of objects that are relevant and the ways in which those objects act upon one another.

Annette Karmiloff-Smith (1991) sums up the implications of this research: "Piaget's view of the initial state of the neonate mind was wrong. It is clear that at the outset some aspects of human mind are innately specified, and often in some detail. Knowledge is initially domain-specific and constrains subsequent learning in complex interaction with the environment. It is not based solely on the outcome of domain-general sensori-motor action. Subsequent development can be viewed within a constructivist framework" (p. 192). Karmiloff-Smith's conclusion sets the terms for the following discussion: to be successful, a cultural theory of development must incorporate the findings of research on early, phylogenetically constrained cognitive processes, and must show how culturally mediated social interaction contributes to the development of more complex thought.

Mathematics

The literature on modularity has been extensively reviewed in recent years (Carey and Gelman, 1991; Karmiloff-Smith, 1992; Hirschfeld and Gellman, 1994). As a concrete and representative example of how cultural-historical psychology can incorporate the findings of modularity theorists, I have chosen to focus on the domain of mathematics because there is sufficient evidence about the phylogeny, ontogeny, and cultural organization of thinking in this domain to provide an integrated picture of development and culture's role in it.

Phylogenetic precursors. Research has demonstrated that some birds and nonhuman primates possess some rudimentary knowledge

of number (Klein and Starkey, 1987). Hicks (1956) reported that rhesus monkeys could be trained to choose collections of precisely three items when presented with stimuli in groups of one to five. This learning required thousands of trials, but once the monkey could reliably pick the array with three objects it generalized this learning to entirely new kinds of stimuli.

Sarah, a chimpanzee who starred in David Premack's work on language acquisition, was able to match stimuli with one to four elements by selecting an appropriate, numerically matching response object (Premack, 1986). Sarah also learned to construct arrays of objects in one-to-one correspondence with one another. But when Sarah was tested on new stimuli she failed; the ability was locked into the context of training.

More recently, Sarah Boysen (1993) has demonstrated that when training in number-related skills is integrated into a way of life that is rich in what Savage-Rumbaugh refers to as interpersonal routines, and when training grows out of a preestablished relationship based upon play, a chimpanzee not only is capable of understanding one-to-one correspondence but can learn to count, to add, and even to solve arithmetic problems similar to those achieved by three-year-old children.

I interpret these data on the phylogeny of arithmetic to indicate that elements of the form of activity we call mathematical thinking can be achieved by nonhuman primates raised in a cultural environment that includes them in a human-like way. These results fully accord with evidence concerning language in chimpanzees. What then of human ontogeny?

Early ontogeny. Under the influence of Piaget, developmental psychologists spent a great many years assuming that mathematical abilities make their earliest appearance late in infancy as infants become capable of mentally representing an absent object.

Current research leaves no doubt that by the middle of the first year of life, more than a year before they will be able to engage in a simple conversation, babies are able to respond to numerosity and to count small arrays of objects (Gallistel and Gelman, 1992; Klein and Starkey, 1987; Wynn, 1992). A few examples illustrate the conditions under which this knowledge is tapped.

Infants six months old or younger were habituated to visual dis-

plays containing two to six dots (the number differing for each group) and then shown a different dot pattern. The patterns were so arranged that they controlled for such potentially correlated cues as array length, density, and configuration. The babies dishabituated to a new number of dots if the number was four or fewer (Antell and Keating, 1983). Infants are also capable of recognizing that the number of drumbeats corresponds to a visual display with the same number of visual objects; that is, a primitive, amodal, numerical matching mechanism operates for small numbers (Starkey, Spelke, and Gelman, 1990).

Karen Wynn (1992) showed four-month-old babies the events depicted in Figure 7.2. First a mouse doll was placed on an empty stage while the baby watched. Then a screen was raised to hide the doll from the baby's view. Next a hand carrying an identical doll moved behind the screen and withdrew without the doll. The screen was then lowered. When the screen was raised again, in half the cases there were two dolls behind the screen (the expected outcome). In the other half there was only one doll (the unexpected outcome). The babies looked longer at the unexpected outcome. Additional experiments showed that the babies expected two minus one to be one and three minus one to be two.

There is some controversy about how number is processed by preverbal infants. Klein and Starkey (1988) lean toward the explanation that a special perceptual process, called subitizing, is the basis for infant numeration. This primitive process is then supplemented by a more elaborate counting procedure. Gallistel and Gelman (1992) believe that infants in fact have a preverbal enumeration system, identical in its basic properties to elementary enumeration abilities in nonhuman primates, which serves as the species' general foundation, or initial set of constraints, upon which various counting systems are imposed.

The details of this dispute are not important here, but evidence of very early enumeration abilities is relevant because this system provides the initial, module-like crude structure upon which a more elaborate, cultural system of mathematics can be constructed. The question then becomes, under what conditions will the primitive abilities of the young infant be realized in appropriate behaviors that are a part of its everyday life?

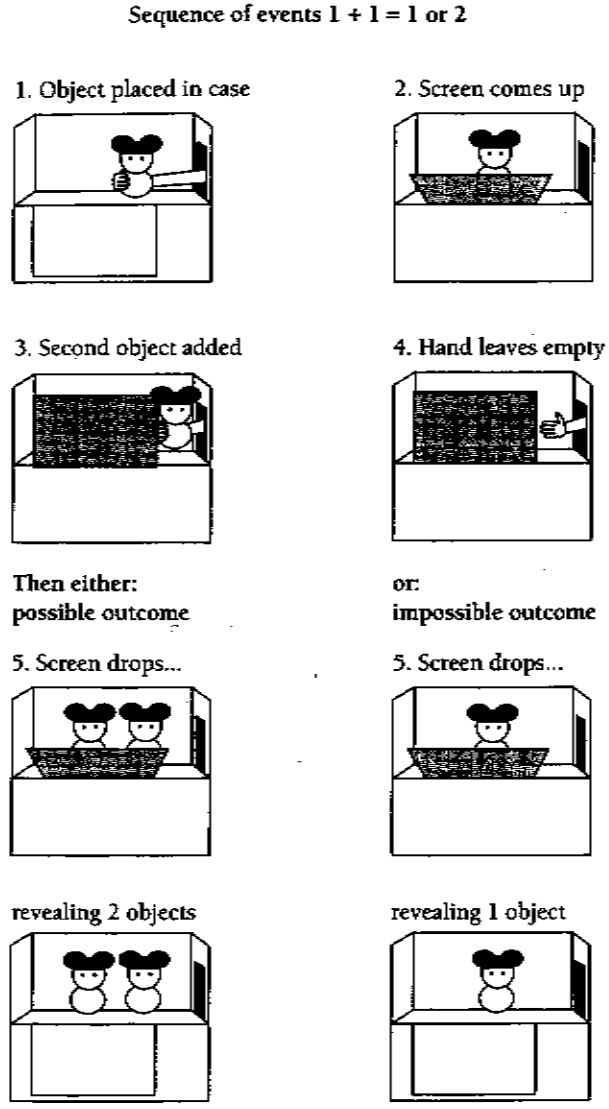


Figure 7.2. Sequence of events presented to infants to assess their sensitivity to number. While a single mouse is out of sight, a second mouse is placed behind the screen. Infants indicate surprise if only one mouse is revealed when the screen is lowered, suggesting that they mentally calculate $1 + 1 = 2$.

Although there is only spotty evidence of early number-related knowledge in children growing up in societies where mathematical knowledge is not highly elaborated, what little evidence we have indicates that the density of mathematical knowledge in a culture begins to affect development of mathematical thinking very early. Jill Posner (1982) compared the development of the ability to identify relative quantity and carry out elementary arithmetic operations among children from two West African tribal groups. Children from the group which engaged in commercial trading for a living outperformed those from a subsistence agricultural group.

Geoffrey Saxe (1981, 1982) studied the development of counting and elementary arithmetic operations (comparison of relative quantity, simple addition) among Oksapmin children of New Guinea. The Oksapmin use their body parts as a counting device, and children learn to use this device at an early age. However, according to Saxe, the Oksapmin have little need to engage in computations with numbers. When they trade goods within the traditional cultural framework, they use various one-for-one or one-for-many exchanges that involve counting but no need for the use of calculational procedures. Children's ability to use counting to mediate comparisons of the number of objects in two arrays or to carry out simple addition is slow to develop. Saxe observed actual arithmetic calculations, of the sort studied by Klein and Starkey among American children, only among children who began attending school and adults who became involved with the money economy of New Guinea.

While these studies fit nicely with the idea that culture builds upon universal mathematical knowledge based upon skeletal principles specific to this cognitive domain, they do not tell us much about the process by which children come to acquire the knowledge embodied in the cultural system used by adults (cf. Saxe, 1994). Granted the points made earlier in this chapter about the process of ontogenetic change—that cognitive development occurs within scripted events and that children must actively appropriate the cultural tools of their society in the process of development—how does one make available for analysis the ways in which modular knowledge and cultural practices combine in development?

Research by Saxe and his colleagues on the development of arithmetic knowledge among American children aged 2½–4 illustrates

how these dynamics work in a manner that links up nicely with the notion of a zone of proximal development from the Russian cultural-historical tradition (Saxe, Guberman, and Gearhart, 1987). From work on early arithmetic understanding such as that described above, they identified four kinds of numerical tasks (Saxe refers to these tasks as cognitive *functions*) that children are capable of achieving in early childhood: naming, counting and cardinality (using last count name as the name of the set), comparing and reproducing sets, and using arithmetical operations to transform numerical values. They also expected to see various cognitive *forms* (such as strategies for achieving an accurate count of a set or for adding two sets together).

The research began with interviews of mothers about the everyday practices in which issues bearing on number and arithmetic arose. Maternal responses were analyzed according to the numerical functions involved (for example, identifying and pushing elevator buttons, counting coins, comparing amounts of two sets of numbered buttons on an elevator, counting pennies, comparing two piles of coins, adding checkers to find their sum) and how these functions were carried out. The data revealed regular age-related changes in the level of tasks which children encountered and accomplished.

Next the investigators sought to observe the dynamics of change. They videotaped mothers and children engaging in tasks that required either a low-level function (determining the total number of objects in an array) or a higher-level function (reproducing the total number in one array with a new array). Analyses of the videotapes showed the development of more complex functions and how mothers and children adjusted to each other as subgoals of the task emerged.

For example, in the number-reproduction task, mothers were given an array containing three or nine pictures of the *Sesame Street* Cookie Monster and asked to instruct their child to put as many pennies in a cup as there were Cookie Monsters in the array. Mothers of older (or more competent) children tried to structure the task in terms of its highest-level goals, while mothers of younger (or less competent) children provided instructions focused on simpler goals.

The highest-level instructions simply repeated the overall goal, "Get just the same number of pennies as there are Cookie Monsters." If the child had difficulty, the mother might say "Get nine pennies

for the Cookie Monster." If that failed, the mother might ask "How many Cookie Monsters are there?" or "Count the Cookie Monsters." When all else failed, the instruction might be "Get nine pennies." Saxe (1994) summarizes the pattern of results concerning the way new functions arise in the course of this activity: "Mothers were adjusting their goal-related directives to their children's understandings and task-related accomplishments and . . . children were adjusting their goal-directed activities to their mother's efforts to organize the task. Further, as children's ability to produce numerical goals of different complexity levels changed with development, they were afforded new opportunities for creating more complex numerical environments" (p. 147). Research focused on many different activities in different societies indicates that the principles found in this example operate quite broadly (Saxe, 1994).

The Intertwining of the Natural and Cultural Lines Reconsidered

In Chapter 6 we encountered the problems caused by "critical point" theories that assume a discrete break between phylogenetic and cultural change. I argued there that the evidence urges upon us the idea that phylogenetic and cultural change are intertwined and fused in the process of anthropogenesis, creating the qualitatively distinct nature of *Homo sapiens* as a species.[10]

When considering processes of ontogenetic and microgenetic change a similar set of issues arises. Just as the cultural-historical theorists assumed a critical point theory of anthropogenesis, they identified the fusing of ontogeny and cultural history that occurs with the acquisition of language as the critical point in the acquisition of higher psychological functions and the "cultural habit of thinking." An analogous critical point is to be found in Gelman and Greeno's (1989) modification of Fodor's ideas about modules and cognition; first come modular filters, then cultural constraints, which the central processor then works on. *With respect to human ontogeny, one cannot say that first comes the phylogenetic part and then comes the cultural part and the individual part. All are there from the outset.*

I can illustrate contrasting views of how cultural mediation and

modular processes might combine by referring to the graphic representations in Figure 7.3. At the top left is a visualization of Fodor's modularity position. Input transducers feed a central processor which reconciles their inputs in the service of action. The drawing at top right includes cultural mediation but retains a "critical point" perspective in that the modular outputs come first and are then filtered by a set of cultural models, which the central processor then works on. At the bottom is the kind of cultural-historical approach suggested by contemporary research. Cultural "threads" are interwoven with modules, arranging and rearranging their contexts of existence. The active organism must of course do its part, using the cultural tool kit and its phylogenetic resources to promote its own development.

I am encouraged that during the time I have been working on this book other scholars who have been puzzling about the relationship of domain-specific biological constraints and sociocultural contexts have begun to argue for a similar view of the role of biological and cultural constraints in the process of developmental change. Gelman and Greeno (1989) point out that not only do children start life with "skeletal principles" to constrain and enable them to acquire knowledge in various essential cognitive domains; also, the sociocultural environment comes packaged in ways that have developed to take account of that prepackaged structure; the two levels complement each other. Giyoo Hatano (1995) makes a similar argument.

Karmiloff-Smith (1992) has proposed that knowledge develops through iterative transformation in which "skeletal modules" are modified by a process that she calls "redescription." Her claim is that "a specifically human way to gain knowledge is for the mind to exploit internally the information that it has already stored (both innate and acquired), by redescribing its representations or, more precisely, by iteratively re-presenting in different representational formats what its internal representations represent" (p. 15). The process she describes is referred to within the cultural-historical framework as remediation—a new, differently mediated form of interaction between individuals and their environments.

Karmiloff-Smith's study of children's increasingly complex representations of a maze illustrates the process of redescription. The maze

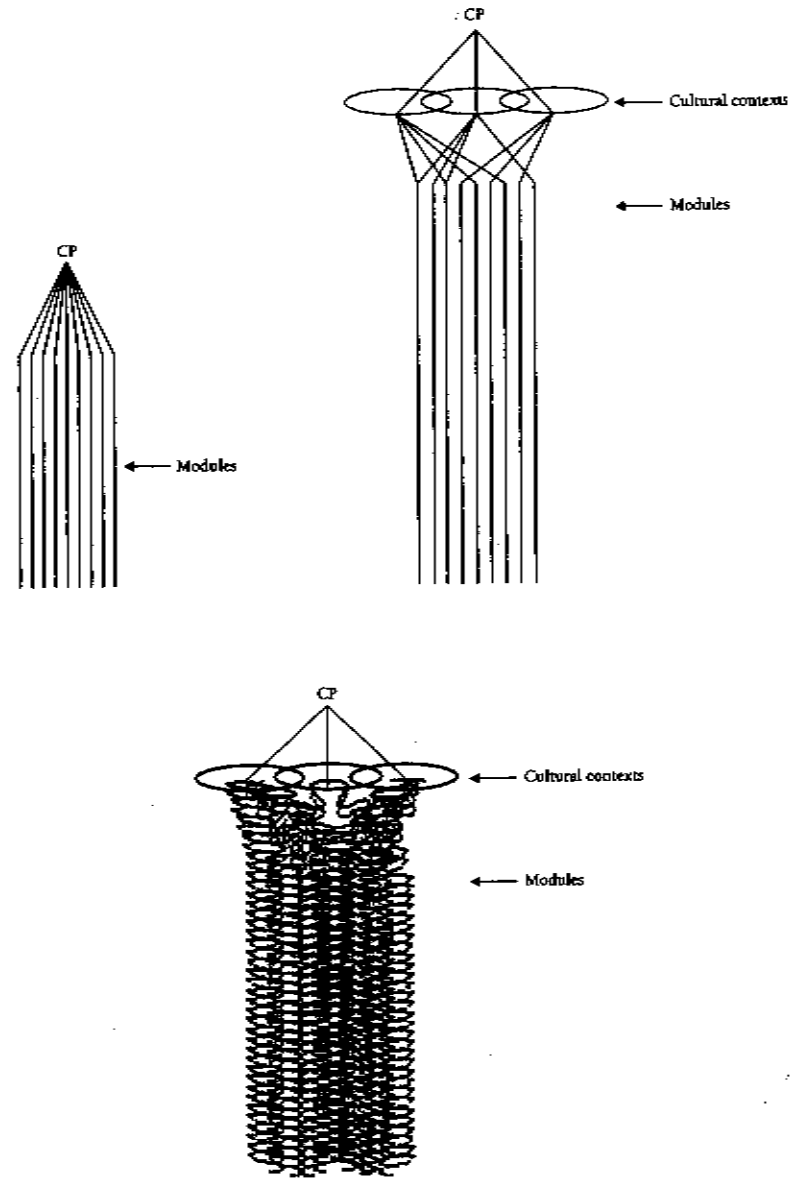


Figure 7.3. (top left) A schematic representation of the modularity point of view put forward by Fodor (1983). (top right) Intervention of constraints arising from the cultural context between input and the central processor (CP), as suggested by Gelman and Greeno (1989). (bottom) A preliminary attempt to represent the interweaving of modular and contextual constraints which denies temporal priority to either and which provides for "leakage" between modules in microgenetic time.

consisted of a series of branching choice points laid out on a long piece of rolled-up butcher paper. Each new choice point was exposed as the paper was unrolled and it was the child's task to learn the entire sequence. The child was given a pencil to record the sequence. At first the recordings were iconic, consisting merely of redrawings of the maze. But as children gained more experience traversing such mazes, they began to develop symbolic shortcuts to the iconic map. At first this might be a long list of L's and R's for left and right turns, but eventually, without any feedback or correction from the experimenter, children invented the maximally compact and abstract sequence of letters and numbers (for example, 2R, 3L, R, 2L . . .). From a cultural-historical perspective Karmiloff-Smith's work provides evidence of the intimate interconnection between the overall system through which the child achieves a new level and the mediational means that afford that new achievement.

Lauren Resnick (1994) offers what she calls a "situated rationalist" synthesis of the cultural-historical and modularity points of view. By situated Resnick means a loose collection of theories and perspectives that propose a contextualized and social view of the nature of thinking and learning. By rationalist she means the theories that claim a priori biological constraints on the development of domain-specific knowledge (Carey and Gelman, 1991).

Resnick unites the ideas of sociocultural and biological constraints in the concept of a "prepared structure." According to this view, individuals develop their abilities in a domain-specific manner, in each situation, on the basis of their prepared structures. These prepared structures are both biological and sociocultural in origin. What changes with development is their relative contributions.

According to Resnick, the biological roots of development predominate in infancy and early childhood, while the sociocultural roots take "increasing control . . . as each individual's personal history of situations grows and initial biologically prepared structures are successively modified" (p. 479). As a coda she notes that there are good reasons to believe that the earlier, biologically based schemas do not wholly disappear in adulthood.

Howard Gardner adopts a similar view in his discussion of the cognitive abilities of young children as they reach the threshold of formal schooling:

> The category of "natural development" is a fiction; social and cultural factors intervene from the first and become increasingly powerful well before any formal matriculation at school . . . Once the child reaches the age of six or seven, however, the influence of the culture—whether or not it is manifested in a school setting—has become so pervasive that one has difficulty envisioning what development could be like in the absence of cultural supports and constraints. (1991, p. 105)

I hope it is clear from the foregoing discussion that Vygotsky was perfectly justified in claiming that the process of development undergoes a qualitative change with the acquisition of language. However, in my view he misjudged the nature of that change in two basic ways. First, he repeated Kroeber's error by placing phylogenetic influences ahead of cultural ones temporally without taking into account the coevolution of culture and the human body. Second, he failed to understand that even very young infants incorporate cultural constraints as basic constituents of their developing selves because they are "inside adult scripts" and adults embody their (ideal) cultural futures in the ideal/material current contexts of their everyday lives. As a consequence, he underestimated the extent to which the cultural and natural lines of development—cultural history and phylogeny, in my rendering—have interpenetrated each other well before the acquisition of language. The metaphor of the intermingling of two multistranded ropes, rather than two (implicitly homogeneous) lines, would have more accurately embodied his basic insights.

It is clearly impossible in a single chapter to encompass all of cognitive development as seen from a cultural-historical perspective. Consequently, my presentation has been highly selective and there are many issues I have not covered.

Elsewhere I have sought to provide a broad reconciliation of cultural-historical ideas with the traditional paradigms of psychology (Cole and Cole, 1996). I believe it is an attainable goal, although how changed a cultural-historical theory will be when such a synthesis is achieved remains difficult to say. But I do not want to belabor that issue here. Whether it is achieved or not, further understanding will

projects designed to provide the methodological foundations for a cultural-historical psychology that I turn in succeeding chapters. Each of these projects is aimed at providing methodologies that would allow cultural-historical psychologists to follow their principles by grounding their theories in people's everyday activities.