# Between Culture and Biology

## *Perspectives on Ontogenetic Development*

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# 13 Culture and development

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This chapter addresses the role of culture in development by considering a question that I have been thinking about for some time without coming to any fixed conclusion: *Do any new principles of development appear once a child is born?* As a means of motivating this discussion, I begin by asking the reader to consider the following statements by leading developmental theorists. Some of these statements imply strongly that no new principles of development are introduced following birth. Others imply that the change in environmental conditions has a significant impact on the process of development. Still others are ambiguous on the matter:

1. 'Child psychology should be regarded as the embryology of organic as well as mental growth, up to the beginning of . . . the adult level' (Piaget and Inhelder, 1969, p. vii).
2. 'Neither physical nor cultural environment contains any architectonic arrangements like the mechanisms of growth. Culture accumulates; it does not grow' (Gesell 1945, p. 358).
3. 'The human being is immersed right from birth in a social environment which affects him just as much as his physical environment. Society, even more, in a sense, than the physical environment, changes the very structure of the individual . . . Every relation between individuals (from two onwards) literally modifies them . . . ' (Piaget, 1973, p. 156).
4. 'A new level of organization is in fact nothing more than a new relevant context' (Waddington, 1947).
5. The levels of generalization in [a child's use of words] correspond strictly to the level of social interaction. Any new level in the child's generalization signifies a new level in the possibility for social interaction (Vygotsky, 1956, p. 423).

How are we to decide the truth of these various statements? Could it really be the case that emergence from the mother into the social group and the acquisition of culture introduce no new principles of human development? And if new principles of development emerge, if the process of development itself changes,

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in what do these changes consist? I will examine these issues chronologically, beginning with principles of development widely used to account for change between conception and birth.

## Embryogenesis

It may seem odd to begin a discussion of culture and development with embryogenesis, a period when it is generally thought that culture plays no role. I choose this starting point because, in my view, individual human development, from before the beginning, is an emergent process resulting from transactions among the so-called factors of development parsed as biological, social and cultural, although the precise nature of these transactions varies throughout ontogeny. Moreover, many developmentalists, as the first quotation from Piaget and Inhelder indicates, believe that embryology provides the model for all that is to follow.

When fertilized, the egg released by the female is the largest human cell, many times the size of a normal body cell, encased within a cell wall called the *zona pellucida*. Almost immediately the zygote undergoes a process of cell division in which the single, relatively gigantic cell divides, and redivides. Each division results in identical-looking cells that are successively smaller. Eventually the zygote becomes packed with such identical cells each the size of an average body cell.

Up to this time, the zygote is a world unto its own, feeding on its own internal matter. But once the zygote has exhausted its internal resources, it must begin to take in nutrients from the outside, from its context. No sooner does this process of interaction of organism and environment begin than the heretofore identical cells of the zygote begin to differentiate. Cells at the periphery of the zygote, through which the nutrients crucial to further growth must pass, begin to look different from the cells near the centre of the zygote. 'A new stage of development' takes place: a blastocyst emerges as a consequence of the fact that cells at its borders make possible new transactions with its environment. Here we see the earliest manifestation of development as differentiation and reintegration. It is an epigenetic process arising from interaction of organism and environment. The mechanism that embryologists have proposed as the stimulus for the specific path of differentiation is called induction. While the mechanisms of induction continue to be the subject of research and theorizing, the overall process illustrates the pattern of change which the embryologist C. H. Waddington (1947) was referring to when he remarked that 'A new level of organization is in fact nothing more than a new relevant context.' A blastocyst is clearly a new level of organization; just as clearly, its development is part and parcel of a new relevant context. In a similar manner, when the blastocyst

becomes attached to the wall of the uterus and is transformed into a foetus, a new system of transactions emerges in which a new structure, the umbilical cord, emerges as a 'third part' mediating between organism and uterus.

Another important question of embryonic development is the role of the embryo's activity in the process. Beginning with the first heartbeat early in embryogenesis, the organism becomes and remains active until it dies. However, the functions of this activity are still debated. Viktor Hamburger (1957), an embryologist, asserted

> One can make the general statement that organization and structure develop in forward reference to functional activity, but without its participation as a determining agent. Organs are built up first, and thereafter they are taken into use. (p. 54)

Others disagree, arguing that without such activity as, for example, wing movement in embryonic chicks, more complicated neural circuits needed for coordinated movement could not develop adequately. Chickens curarized in early embryology are deprived of the possibility of pruning the profusion of nerve cells that are produced in the brain and spinal cord, rendering them immobile when no longer curarized (Hofer, 1981). Activity may have forward reference, but such anticipation does not appear to be functionless.

### Postnatal development

Perhaps nowhere is Waddington's aphorism about the co-development of organism and context more obvious than at birth. Severing the umbilical cord induces a reversal in the direction of the baby's blood flow. Neonates are no longer bound to their environments through a *direct* biological connection. Rather, even essential biological processes occur *indirectly* – they become mediated by the baby's social and cultural environment. The baby's food no longer arrives predigested through the mother's bloodstream. It must now obtain sustenance either through the modification of sucking, grasping and rooting reflexes, in reciprocal interactions with mother, or it must be fed food that has been 'pre-pared'. The process of eating prepared food is neither purely biological nor purely natural. The sociocultural environment of the infant, which was largely muted by the buffering built into prenatal development, becomes an essential aspect of the organism's context, and the interactions that produce development become the special hybrid of natural and sociocultural that is the human way of life.

Following birth, changes in babies' impact on their environments are no less marked than changes in the way the environment acts on them. They make urgent, vocal demands on their caretakers. They become social actors who reorder the social relations among the people around them. At birth, *development*

*becomes a co-constructive process* in which *both* the environment *and* the child are active agents. And after birth, the transactions between baby and context are mediated in a quite obvious way by culture.

Considerations such as these led Hamburger to argue that:

> The ways and mechanisms by which new levels of maturation are achieved are fundamentally different for the embryo and the human person. The most striking contrast is perhaps in the role which the environment plays in the two processes. (1957, p. 53)

Unfortunately, he offers no concrete evidence of how the mechanisms of development change, except to argue that the postnatal environment accentuates individual differences to 'bring them to their full realization' (p. 53). Given the theme of this chapter, I want to focus on that part of the environment referred to as cultural, and its role in mediating the relations between individuals and their social environments.

## Culture as the species-specific medium of human development

Over two decades ago Raymond Williams (1976) commented that 'Culture is one of the two or three most complicated words in the English language' (p. 76). Among other resources, he could refer to Alfred Kroeber and Clyde Kluckhohn's classic monograph, *Culture: a critical review of concepts and definitions* (1952/63) that offered more than 250 different definitions. So, the topic needs some discussion here to avoid difficult-to-detect misunderstandings.

In its most general sense, the term 'culture' is used to refer to the socially inherited body of past human accomplishments that serves as the resources for current life of a social group (D'Andrade, 1997). A good starting point for my own view of culture is provided by Kroeber and Kluckhohn's omnibus definition:

> Culture consists of patterns, explicit and implicit, of and for behavior acquired and transmitted by symbols, constituting the distinctive achievements of human groups, including their embodiment in artifacts; the essential core of culture consists of traditional (i.e. historically derived and selected) ideas and especially their attached values; cultural systems may on the one hand be considered as products of action, on the other as conditioning elements of further action. (1952, p. 181)

The major modification I introduce into this classic view is to broaden the definition of artefacts to make them synonymous with what Kroeber and Kluckhohn refer to as culture's essential core. According to this view, which traces its genealogy back to Hegel and Marx, and which is found in many contemporary sources, an artefact is an aspect of the material world that has been modified over the history of its incorporation into goal-directed human action. By virtue of the changes wrought in the process of their creation and use, artefacts are

*simultaneously ideal (conceptual) and material.* They are ideal in that their material form has been shaped by their participation in the interactions of which they were previously a part and which they mediate in the present.

This conception of artefacts extends to what Wartofsky (1973) refers to as secondary artefacts, representations of primary artefacts and their modes of use. Secondary artefacts play a central role in preserving and transmitting the kinds of social inheritance referred to as recipes, beliefs, norms, conventions and the like. This extension brings the mental entities psychologists refer to as scripts and schemas into contact with the notion of artefact in a manner akin to Bartlett's (1932) notion of schemas as conventions, which are both material practices and mental structures (this convergence was first pointed out to me by Derek Edwards and David Middleton, see Edwards and Middleton, 1986).

I cannot elaborate here on this conception of culture (see Cole, 1996, for a fuller discussion). What it produces is an understanding of culture as a structured, artefact-saturated medium that is simultaneously ideal and material, inside the head and in the humanly transformed environment, that serves to coordinate newborns with their caretakers within the overall circumstances of the social group. It transforms our notion of the transactional processes involved in development by adding a 'third force' to the ordinary dichotomous view of development as a transactional process.

A very similar view of culture and its role in mediating human activity is summarized by Edwin Hutchins (1995) in the context of his efforts to describe the role of culture in cognition through connectionist modelling, which treats each of the three factors that enter into cognition as representational structures:

> Our inventory of representational structure includes *natural structure* in the environment, *internal structure* in the individuals, and *artefactual structure* in the environment. Artefactual structure is a bridge between internal structures. Artefacts may provide the link between internal structures in one individual and those in another individual (as in the case of communication), or between one set of internal structures in an individual and another set of internal structures in that same individual (as is the case in using written records as a memory aid, for example). Internal structures provide bridges both between successive artefactual structures and between natural and artefactual structures. (pp. 161–2)

Cognition, from this point of view, is conceived of as 'the propagation of representational state across representational media that may be internal to or external to individual minds' (p. 160).

Whether starting from the heritage of Hegel and Marx or Hutchins, we arrive at a notion of culture as a medium of coordination and development and as a process of coordinating structures, in a tripartite process.

### Examples from early ontogeny

The role of cultural mediation in coordinating individuals with their environments is evident from the first days of postnatal life. The earliest, essential condition for continued development once neonates have been 'precipitated into the group' is that the newcomer must be incorporated into the group's daily life. This incorporation requires that adults are able to accumulate enough resources to accommodate the newcomer while the newcomer gets enough food, care and warmth to continue developing. Super and Harkness (1986) refer to this process as creating a 'developmental niche' for the child. The process of child-group coordination within developmental niches is both universal and culturally variable.

The Ache, a hunter-gatherer people of eastern Paraguay, arrange for their children under 3 years of age to spend 80–100 per cent of their time in direct physical contact with their mothers and are almost never seen more than three feet away (Kaplan and Dove, 1987). A major reason for this form of coordination 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 arms reach.

Quechua mothers also keep their infants close to them, but in a different way and for different reasons. The Quechua inhabit the 12,000-foot altiplano of Peru, where oxygen is scarce, humidity is extremely low and the temperature reaches freezing an average of 340 days a year (Tronick, Thomas and Daltabuit, 1994). Quechua newborns spend almost all of their time in a specially constructed *manta pouch*, constructed to seal off the child from the outside so that no part of the child's body is exposed except when being changed. Tronick and his colleagues propose that the warmer, more humid, and more stable environment in the pouch helps the infant to conserve energy, reducing the number of calories needed for growth in an environment poor in nutritional resources.

The way in which culturally regulated childcare practices are designed to coordinate infants and caretakers can also be highlighted by contrasting the way parents organize their children's sleeping and eating patterns in the process known as 'getting the baby on a schedule'. This process, an essential part of creating the developmental niche, requires rearrangement of the child's social context as a precondition for its continued development. Bruner (1982) refers to such routines that occur in recurring social events as 'formats', rulebound microcosm(s) 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's notion of format is very similar

to the way in which Nelson (1981, 1986) talks of 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 artefacts, which are embodied in the vocabulary and habitual actions of adults and which act as structured media within which children can experience co-variation of language and action while remaining generally coordinated with culturally organized forms of behaviour that form the process Hutchins refers to as the 'propagation of structure across representational media'.

## Relating past and future: the non-linearity of cultural mediation

With respect to embryogenesis, we have a pretty good idea of the way that 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 the current and future biological constraints within which the biological process of development can take place. It is in this sense that the past enters the future in order that the end can be in the beginning.

There appears to be an analogous set of temporal relationships when the cultural past and present greet the newborn as its cultural future. The name of the cultural mechanism that brings 'the end into the beginning' is *prolepsis*, meaning 'the representation of a future act or development as being presently existing' (*Webster's Dictionary*, 1991). Prolepsis operates throughout ontogeny, but I shall briefly describe only two examples.

## Prolepsis: a cultural mechanism of induction?

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.

In the 1970s paediatrician 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. Their comments arise in part from phylogenetically determined anatomical differences between males and females and in part from culturally conditioned experiences they have encountered in their own lives. Typical comments include 'I shall be worried to death when she's eighteen' or 'She 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, parents assume that the world will be very much for their daughter as it has been for them and project a probable future for the child, which shapes their current behaviour and thereby their child's experience.

This process is depicted in figure 13.1 by following the arrows from the mother → (remembered) cultural past of the mother → (imagined) cultural *future* of the baby → present adult treatment of the baby.

Two features of this system of transformations are important for understanding the contribution of culture in constituting development. First, and most obviously, we see prolepsis in action: The parents represent the future in the present. Secondly, we see mutual transformations between the ideal and material sides of an artefact (in this case, beliefs about girls, soccer, and society). The parents' (purely *ideal*) recollection of their past and (purely *ideal*) imagination of their child's future becomes a fundamental *materialized* constraint on the child's life experiences in the present. This rather abstract, non-linear process of transformation gives rise to the well-known phenomenon that even adults totally ignorant of the actual gender of a newborn will treat the baby quite differently depending upon its symbolic/cultural 'gender'. For example, they bounce 'boy' infants (those wearing blue diapers) and attribute 'manly' virtues to them while they treat 'girl' infants (those wearing pink diapers) in a gentle manner and attribute beauty and sweet temperaments to them (Rubin et al., 1974).

Macfarlane's example also motivates the special emphasis placed on the *social* origins of higher psychological functions by cultural-historical psychologists (Cole, 1988; Rogoff, 1990; Valsiner, 1988; Vygotsky, 1987; 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's development.

Space does not permit me to enumerate, let alone analyse, the myriad examples of prolepsis in later development. Bare mention of a few will have to suffice.

Note that in asserting the importance of the social world on the children's development, Piaget sets age 2 as the point at which 'Every relation between individuals literally modifies them'. This is also the time when, according to Vygotsky, children's acquisition of language creates a new level in the generalizations they can make, signifying a new level in the possibility for social interaction. I have already mentioned one of the conditions, in addition to biological integrity of the organism, that appears necessary to the acquisition of language: coordination in the kinds of scripted events Bruner (1982) refers to

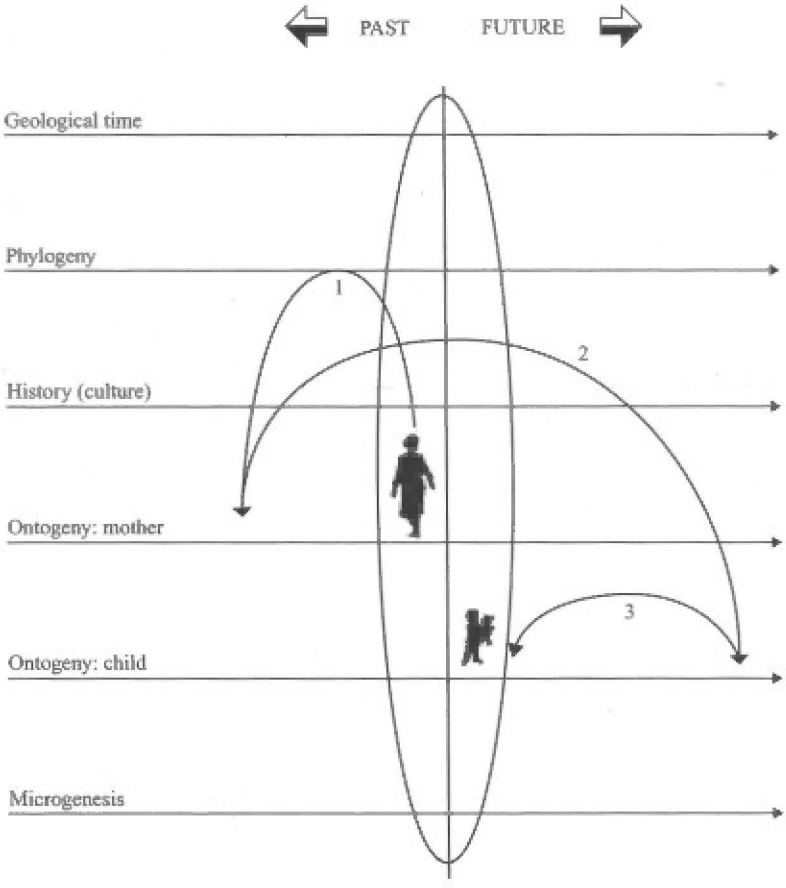


Figure 13.1 Looking backward, looking forward.
*Notes:* The horizontal lines represent time scales corresponding to the history of the physical universe, the history of life on earth (phylogeny), the history of human beings on earth (cultural-historical time), the life of the individual (ontogeny), and the life 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.

as formats, Savage-Rumbaugh et al. (1993) refer to as 'interpersonal routines' and Nelson (1981) refers to as scripts. Rommetveit (1974) has argued that prolepsis is an essential characteristic of intersubjectivity in such scripted activities that makes language possible. Language-mediated interpersonal routines allow conditions in which speakers can presuppose shared knowledge that has not yet been introduced into the interaction, but which is essential to making their utterances interpretable.

Göncü (1993), following Rommetveit (1974) as well as Stone and Wertsch (1984), shows the crucial role of prolepsis in the development of the forms of language-mediated interpersonal routines needed for symbolic play. Tobin, Wu and Davidson (1989) show how prolepsis operates to structure cultural differences in Japanese and American preschool classroom social structures and interactions. Newman, Griffin and Cole (1989) analyse the operation of prolepsis in the organization of classroom science lessons. In all such cases, the structure of social interactions that provide the proximal environment for children's development is constrained by imagined futures, read back into the present as material constraints on development.

## Interweaving of phylogenetic and cultural lines of development

For my final example I want to concentrate on a topic which serves to illustrate how the cultural-historical view that I have been seeking to develop can be brought together fruitfully with views that do not ordinarily include cultural mediation as a central mechanism of development.

It is now a standard critique of cultural-psychological approaches to development that, contrary to their own principles, they ignore the crucial contributions of phylogenetic constraints on development (for representative critiques, see Moll, 1994; Smith, 1996; Wertsch, 1985). To make the discussion concrete, I have chosen the development of mathematical thinking as the target domain because there is sufficient evidence about the co-action of 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 non-human primates possess some rudimentary knowledge of number (Klein and Starkey, 1987). For example, Sarah Boysen (1993) has demonstrated that when training in number-related skills is integrated into a way of life that is rich in interpersonal routines, and training grows out of a pre-established relationship based on play, a chimpanzee raised by human beings is capable not only of understanding one-to-one correspondence but can learn to count, to add and even to solve arithmetic problems similar to those achieved by 3-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 humanlike 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 can perform elementary arithmetic operations on a small arrays of objects (Gallistel and Gelman, 1991; Wynn, 1992).

For example, Karen Wynn (1992) showed 4-month-old babies a number of events designed to assess their sensitivity to number and elementary number operations. 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. In half the cases there were two dolls behind the screen (the expected outcome). In the other half of the cases there was only one doll (the unexpected outcome). The babies looked longer at the unexpected outcome. Additional experiments showed that the babies expected 2−1 to be 1 and 3−2 to be 1.

In short, it appears that as near to birth as it can be tested for, there is evidence for the presence of what Rochel Gelman (1990) refers to as 'skeletal principles' which provide initial constraints upon which later mathematical understanding can be built. The key argument for the necessity of such constraints is made by Gelman in the following terms:

> 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)

The question then becomes, under what conditions will the primitive abilities of the young infant be realized in appropriate behaviours that are a part of its everyday life?

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 social practices involving the use of mathematical knowledge begins to affect development of mathematical thinking very early. In some cultures, at least, it appears that adult knowledge of mathematical principles does not develop beyond the capacities seen in young infants. Arithmetic operations confined to the 'one, two, many' variety appear to suffice (Lancy, 1983).

Geoffrey Saxe (1991, 1994) studied the development of counting and elementary arithmetic operations (comparison of relative quantity, simple addition) among Oksapmin children of New Guinea who use their body parts as a counting device, and children learn to use this device at an early age. According to Saxe, traditionally the Oksapmin had little need to engage in computations with numbers. When they traded goods within the traditional cultural framework, they ordinarily used various one-for-one or one-for-many exchanges that involved counting, but did not use calculational procedures. Children's ability to use counting to mediate comparisons of number of objects in two arrays or to carry out simple addition is slow to develop. Saxe observed actual arithmetic calculations only among children who began attending school and adults who became involved with the money economy of New Guinea.

These studies fit nicely with the idea that culture builds upon primitive, universal mathematical knowledge based upon skeletal principles specific to this cognitive domain depending upon their centrality to the culturally organized, scripted, formatted activities of everyday life. But they do not tell us much about the dynamics of the process by which children come to acquire the knowledge embodied in the cultural system used by adults for whom new cultural practices have brought the system into more widespread use. Granted the generally accepted view of cultural psychologists 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 skeletal principles and cultural practices combine in the process of development?

Research by Saxe, Guberman and Gearhast on the development of arithmetic knowledge among 30–48-month-old American children illustrates how these dynamics work in a manner that links up nicely with the idea of prolepsis introduced earlier and the notion of a zone of proximal development from the Russian cultural-historical tradition (Saxe et al., 1987).

From work on early arithmetic understanding such as that described above, Saxe and his colleagues identified four kinds of numerical tasks (Saxe refers to these tasks as cognitive *functions*) that American 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*, that is 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 analysed according to the numerical functions involved, such as identifying and pushing elevator buttons or counting coins, and how these functions were carried out. These data revealed regular age-related changes in the level of arithmetic tasks which children encountered and accomplished.

Next the investigators sought to observe the dynamics of change. They videotaped mothers and children engaging in practices that required either a low-level function such as determining the total number of objects in an array or a higher-level function such as 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, 'Get nine pennies' might be the instruction. 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 supports the conclusion that the principles found in this example operate quite broadly (Saxe, 1994).

Results such as these have produced what appears to be a growing consensus on a model of development that combines the idea of innate skeletal constraints with the idea of cultural mediation in cultural organized, scripted activities.

For example, Lauren Resnick (1994) offers what she calls a 'situated rationalist' synthesis of the cultural historical and skeletal principles points of view. By 'situated' Resnick means a loose collection of theories and perspectives that propose a contextualized (and therefore, particularist) and social view of

the nature of thinking and learning. By rationalist she means the theorists who 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'.

> 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. (1994, p. 479)

This idea, which appears similar in its essentials to Gelman's, is echoed by several scholars, including Giyoo Hatano (1995) and Howard Gardner (1991).

### A tentative summation

The tentative conclusion I would like to draw from this discussion is that it is at least heuristically useful to consider the possibility that all of the statements about development I quoted at the beginning of this chapter are true. Throughout development we see the principles of development present in embryology at work. Development, at least from the time when the zygote begins to interact with the intra-uterine environment, is an epigenetic process of the emergence of more complex structures in which each new level of organization is associated with a new relevant context and a new form of mediation between the individual and at least one other human being.

In the effort to ferret out essential differences in the process after birth my thoughts return repeatedly to the properties of the cultural medium and the forms of interaction which it mediates. During embryogenesis it seems as if phylogenetic/biological processes mediate cultural influences while, following birth, the terms of this mediational process appear to shift. The wing movements of the embryonic chick are certainly anticipatory and the role of the environment as an inducer of differentiation clearly provides the antipode of the epigenetic process. But play, for example, seems anticipatory in a quite different way, and the kinds of moves made by mothers interacting with their children to induce higher levels of mathematical reasoning appear proleptic in a way that the induction of a blastocyst through interaction of the zygote with the intra-uterine environment does not.

In so far as the processes to development are different, it is to the properties of culture and the capacity/requirement of humans to acquire culture that I think we must look to arrive at a more satisfactory answer to my starting question. In so far as it is dominated by phylogenetic influences, development is a Darwinian process of natural selection operating on the random variation of genetic combinations created at conception. But cultural change operates

according to a different set of principles: cultural variations are not randomly generated, they are, rather, descended from the successful adaptations of prior generations passed down extrasomatically. While natural selection has the final say, in so far as human behaviour is mediated through culture it is 'distorted' by a Lamarckian principle of evolution. In acquiring culture (and especially, as both Piaget and Vygotsky emphasize, with the acquisition of culture's most flexible form, language), culture becomes a 'second nature' which makes development a goal-directed process in a way in which phylogenetic change is not. As I have argued elsewhere (Cole, 1996), human beings are hybrids. This hybrid nature is central to the process of postnatal development in a way that is not true before birth. Understanding this hybridity is, I suggest, necessary in order to understand if and how the principles of development change once children leave the womb and are precipitated into the social group.

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