THE CONCEPT OF DEVELOPMENT

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6 COMMENTARY

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COMPLEXITY IN DEVELOPMENT AND DEVELOPMENTAL STUDIES

As I listened to the various papers and thought back over 20 years, I concluded that we have come a long way. I well remember the then dominant position of Behaviorism and its implications for what we studied and how we studied it. As a metaphysical doctrine, Behaviorism ruled out the study of nonvisible matters such as mentation; prescribed a set of experimental procedures; held that we could study the laws of association and end up with an account of behavior; and assumed that the laws of behavior would be free of age and species constraints. There were debates as to whether all learning was based on the classical conditioning of new stimuli to available reflexes on whether there weren't two learning paradigms—classical and instrumental learning. There were debates as to whether learning could take place without reinforcement and or the organism responding to stimuli (see Schwartz, 1978, for an excellent review). Despite the differences, there was nevertheless considerable agreement on the fundamentals: If we studied the laws of associative learning, we would come to know how organisms represented and acted on their environment—children included.

It was about 20 years ago that discordant voices in the background moved into the foreground. There was Chomsky's (1959) review of Skinner's *Verbal Behavior*, which made it very clear that, among other things, we had to recognize that different species responded differently to the same stimuli. There was Simon telling us that it was permissible to use verbal reports from subjects as data.

There was Piaget telling us that we had to interview children if we really wanted to probe their minds. There was Garcia (Garcia & Koeling, 1966) telling us certain learnings were biologically prepared in animals and that the nature of these varied as a function of the beast and its' particular ecological niche. There were ethologists and developmentalists like Piaget who insisted that the age or developmental level of an organism could dramatically alter the ability to learn about at least some things. In short, there were rumblings from divergent sources that the doctrine of Behaviorism vis-à-vis methodology and what to study had to give. And it eventually did, not without struggle to be sure, but it did give in very important ways.

The study of perception and cognition are now more than legitimate topics of study. A diverse set of methodologies are used. And as Flavell noted, a structuralist view has come to dominate the fields of experimental psychology—including developmental psychobiology, human development, and cognitive psychology. It is not simply because the attitudes, assumptions, and methods of our discipline have changed that make me say we've made progress. Rather, it is what we've heard here about what has been accomplished in the current intellectual environment that makes me say it is so.

Consider the impact of Piagetian theory. When skeptics tried to show that it would be trivial to train preoperational children to conserve, classify, and seriate, they initially found that this wasn't so. There then came an acceptance of the stage theory that was subjected to rigorous experimental efforts. And, in the end, the idea that there are grand stages of development has not stood the test of time. This is mainly because we now have much more information and not because the field is, in principle, loathe to accept stage descriptions of development. It's the research findings that are driving the theorizing and not a particular dogma.

As Flavell notes, there are many lines of evidence against the Piagetian stage theory. The kinds of predicted correlations between task performances do not obtain. The model, as inclusive as it is, fails to account for and deal with a range of important phenomena. And the characterizations of a child at a certain stage of development do not hold in many cases. Preschoolers are more competent than expected. Indeed, as Eleanor Gibson and her students have shown, babies *do* coordinate and use information about objects from different modalities. In general, the findings show abilities at earlier and earlier ages than expected within a Piagetian framework. As such, they call into question two related Piagetian views: (1) that structures are in no sense innate; and (2) that there are successive stages of development that bring with them the *creation* of new structures that are different from and more complex and powerful than the preceeding structures.[1]

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[1]My presentation of Piagetian theory is based on the published version of the Piaget-Chomsky debate, edited by Piattelli-Palmarini (1980).

First, the evidence with regard to the issue of truly novel capacities: It used to be commonplace to point to the failure of preschoolers to conserve, seriate, and classify. And the explanation offered was that the young child's structures were not operational. Most people took this to mean that the young child had yet to develop the capacity to form classifications; impose systematic orderings on objects of different dimensions; keep straight whether a particular transformation was quantity relevant or not, and so on. As such, the young child's knowledge was not operative. From this view, the idea that preschoolers think differently about cause and effect, are unable to coordinate two perspectives at once, or center their own perspective followed quite easily. For there was the overall impression of a novel qualitative change in cognitive capacity.

However, we now know that preschoolers can use a hierarchical classification scheme, have a concept of number, and can order relative lengths. I focus on these domains because they have figured so centrally in the account of concrete operations. Gelman and Baillargeon (1981) review the evidence on these capacities and so here I cover but a few illustrative finds. Consider the use of hierarchical classification schemes. Chi (1980) has looked into the interests of preschoolers—especially 4-year-old boys—in dinosaurs. There are, as it happens, 4-year olds running around this country who are experts on dinosaurs. When asked to tell what dinosaurs they know and what they know about them, they come back with a list that is hiearchically organized by some of the most abstract criteria I can think of, including land-living or not, meat-eaters or not, and so on. They could not do this if they lacked the ability to work with hierarchical classification schemes. Likewise, preschoolers couldn't solve transitive inference problems (Trabasso, 1975) if they couldn't impose an ordering relation on stimuli. Nor could they keep separate number-irrelevant and number-relevant transformations if they could not organize addition and subtraction operations in a separate category from displacement, rearrangement, and item substitution ones (Gelman & Gallistel, 1978).

Findings like these shed doubt on the particular concrete versus preoperational structural account that Piaget gave us. For preschoolers can be shown to solve tasks that require some of these abilities. Hence, at the very least, the descriptive adequacy of the Piagetian stage theory is called into question. But perhaps there are other domains that do dictate a theory that states that there are structural abilities that are absent or different in young children than there are in older children? I'm beginning to have serious doubts. Merry Bullock, Renée Baillargeon, and I conclude that the principles of causal reasoning about physical events used by young children are much like those used by older children and adults (Bullock, Gelman, & Baillargeon, 1981). Flavell and his collaborators have shown that young children can and do take more than one perspective into account (Lempers, Flavell, & Flavell, 1977); and that they know others have minds (Wellman, in press). Sue Carey (1980) shows that young children do not

endow inanimates with animistic characteristics—a fact confirmed by Keil's (1979) work on ontological categories of knowledge as well as research that Elizabeth Spelke, Betty Meck, and I are doing. And so on, the story goes.

In brief, Flavell is quite right—the evidence to date for grand qualitative stage changes is weak. I put it somewhat differently: The evidence that young children have different cognitive structures or, more accurately, parts thereof than older children is not there. Instead, it looks like there is much in common. Although I and disinclined to accept the idea that we need to develop a theory that has the young child using different structural units than an older child, I do not want to say that there is no development of interest. I return to this issue at the end of my comments.

I have often been asked, if preschoolers have so many abilities, where did *these* come from. I've been wary of answering this question but think I should now. It's not just that preschoolers are more competent than we thought; so are babies. Eleanor Gibson went over some of the research. By 3 months of age, babies will not reach for an object that is too far away for them to grasp. And even in the beginning attempts to reach for moving objects, they put their hands where the object *will* be rather than where it is. They pick up visual information that allows them to determine whether an object is rigid or not. They can coordinate visual and auditory information and hence assign the mood of a speaker to that speaker's face. And so on (see Spelke, 1980 for further evidence of early perceptual competence).

In addition to having remarkable perceptual abilities at rather early ages, babies can classify common basic objects (Cohen & Caputo, 1978); and they can abstract the numerical values of small sets of objects and events (Starkey & Cooper, 1980; Starkey, Spelke, & Gelman, 1980; Strauss & Curtis, 1980). Thus, they will habituate to the class of three heterogeneous items in a visual display and then show renewed interest in changes in number. They will also match the number of sounds they hear from a centrally placed loudspeaker to the one of two pictures that show the same number of heterogeneous items (Starkey, Spelke, & Gelman, 1981). Two related conclusions are inescapable: There probably are innate constraints on knowledge acquisition; and the perceptual world of a young baby is far more veridical than the Piaget constructionist account would have it.

So part of my answer to the question of whence the preschooler's ability is that humans come to the world with *pieces* of innate knowledge that serve to guide knowledge acquisition. I say "pieces of innate knowledge" intentionally. I see no reason to adopt the old and extreme nativist position that gave the environment nothing more than a triggering role. Despite demonstrations of early capacities that we did not know about 20 years ago, these capacities are far from full blown: They do develop as the child grows and interacts with his/her environment. Further, the lessons from developmental psychobiologists make it clear to me that it is possible to have an account that acknowledges that there are innate constraints on the course of development and yet requires a great deal of learning

for development to proceed. Consider Marler's (1970) work on the acquisition of bird song.

The adult white-crown sparrow has a characteristic song. By varying the kind of environment available to the young, Marler has been able to show that experience plays a central role in the development of that song, which is characteristic of the region the bird lives in. For, if a baby sparrow is raised in isolation, it will sing a distinctly odd song as an adult. Experts agree that this odd song is the basic form of the adult song. It is odd because it is never heard in nature and lacks those characteristics that give it the status of one dialect or another. If the young bird is exposed to the adult song during its first 10–15 days of life but never again, the young bird will grow up to sing the characteristic adult song. This is true even if it is deafened after the exposure. Marler argues from such findings (and other related ones) that the white-crown sparrow is born with a template for the basic song. Experience serves to tune the template so as to allow the young bird to learn its particular dialect. The bird brings to the interaction with the environment a structural advantage that helps him focus attention on, or in Piagetian terms, to assimilate one set of songs as opposed to others. In interacting with the environment, he develops the particular song of his locale (i.e., he accommodates the template).

The idea is *not* that development is a bit of innate structure and a bit of experience; it is a function of a particular organism's interaction with its environment. The genotype sets the range of stimuli that will influence development; nevertheless, the interaction with the environment *must* take place for development to proceed. Put differently, there is a great deal of learning involved in development, but the learning is helped or guided by the innate constraints particular organisms bring to their environments. Psychobiologists and learning theorists alike have shown us that different species, and even the same species in different environments, are often prepared to learn what it is they will learn during development (see Seligman & Haeger, 1972, for an excellent selection of relevant papers). I believe that a similar view is required for accounts of early perceptual and cognitive development.

In some ways, the view I come to today is like Piaget's; I think of development involving an active organism, which seeks out (assimilates) a supporting environment, and which comes away from an interaction with the environment with a changed (accommodated) capacity. The major difference is that I believe these processes are initially guided by some innate constraints on the knowledge that an organism can and will development.

There is a major research agenda for those who agree with my conclusions regarding the interpretation of findings of richer capacities than anticipated even 10 years ago. The basic task is to describe in precise detail what these constraints are; how the constraints guide development as a child interacts with his/her environments; what kinds of environments do or do not affect particular developmental courses, and how best to characterize the capacities at different points

in development. It won't do for us to say to Eleanor Gibson that her recent research leads to the conclusion that babies must have some representation of objects in the world. I'm inclined to this view, but I agree that we shouldn't put pictures of objects in a baby's head. What's needed is a precise description of the nature of the stimuli "out there" that are responded to, as well as a precise account of what it is about the baby's perceptual-cognitive capacities that allows him/her to respond to those stimuli as he/she does. I am comfortable with the idea that in at least some cases there is a representation that guides the baby's ability to respond veridically to a variety of objects and events. Others are not, and I understand—this because we haven't spelled out what we mean. We must do so now.

The idea that there are constraints on the course of human development is more than in the air. Ann Brown (in press) has made related comments. Newport (in press) is trying to work out the nature of learning in language acquisition. Mandler (1980) outlines some structural invariants. Keil (in press) has pulled together the data that we now have on what might be some of the constraints on cognitive development. Spelke (1980) has provided an argument regarding the kinds of perceptual principles that are innate in infants and how these allow for rapid learning. And Wexler and Culicover (1980) have provided one formal account of the constraints on the learnability of a language.

I should point out that the view that there are some innate constraints guiding development is consistent with Flavell's optimism about the payoff that will follow from detailed studies of sequences in development. Further, it avoids the logical problem entailed by Piaget's rejection of the idea that *some* structures or pieces of structures are available for cognitive development to proceed along the very uniform path it does. (I've often wondered how it was possible that normal children all over the world share pretty much the same cognitive structures up to and through the concrete operational period.) Yet, it avoids Piaget's criticism of the form of nativism that treats the environment as nothing but a trigger. Indeed, it calls out for a need to use Piagetian notions like assimilation and accommodation (Gelman & Baillargeon, 1981). But it tempers the extent to which knowledge is constructed, allowing that at least some perceptions are veridical.

Developmental psychobiologists provide many valuable lessons as to how we proceed. Levine makes the point that a multilevel analysis of development is required. Consider the idea that the nature of the organism constrains its behaviors, perceptions, and cognitions. The constraints need not be at just the cognitive level. To mention just a couple of other levels: First, the size of an organism influences the definition of the affordable environment. A twig in a tree affords sitting-on for small birds and bugs, but a twig does not afford sitting for large mammals. Likewise, a lake affords underwater living for fish but not men. These constraints are at the level of analysis that is congruent with the laws of physics. Second, structural features of a given organism's perceptual apparatus

constrain the definition for that organism of certain perceptual experiences; thus, for an eye to pick up color, it must contain cones. Because Sameroff deals at length with the complexity of the levels of analysis involved in the ultimate account of many developmental phenomena, I leave off here on this matter.

The work by development psychobiologists makes yet another methodological point. This is that much can be learned about the normal course of development, and what environmental influences are or are not causal from studies of abnormality. Of course, researchers who study children cannot deafen them or produce any other abnormalities. But there are children who have suffered the burden of nature's damage, the cruel treatments of caretaker's, etc. Having heard the many elegant uses of the comparison between normal and abnormal children made by Rutter, I doubt that I need dwell on this message. And again, it is in the air, especially by those who study language acquisition (Feldman, Goldin-Meadow, & Gleitman, 1978; Lenneberg & Lenneberg, 1976 a,b).

Arguments about innate constraints are often supported with evidence about universality, the clear case being the ability to acquire language. It was not just that I found preschoolers could count or that babies can abstract the number of objects an event presented them that pushed me to the preceding view. There was evidence from cross-cultural work that converged on the idea that the ability to count and invent counting algorithms are natural cognitive abilities (see Gelman, in press, for a review). One way to test a hypothesis regarding a natural ability is to go cross cultural and thereby bring another level—the comparative one—on the issue of analysis to bear.

Having talked about the brilliance of the infant and preschooler, I now turn to a puzzle. Despite the many competences of the young, they nevertheless fail or err on a wide range of tasks that do not seem to be *that* difficult. The fact remains that young children fail the many concrete-operational, Piagetian tasks. If they have the competence as reflected on many new tasks, why not on the seemingly similar Piagetian tasks? If they are so much like older children, how can they yet be so different? Obviously, something or some things are developing, but what?

Brown (in press) points to one major development. Whereas preschoolers can apply their ability to only very special tasks, older children can apply the ability more broadly. Development involves, in part, the ability to transfer or generalize a capacity. The work by Flavell and others on metacognition points to yet another major developmental course. Children come to be able to reflect on their abilities to use language and remember things. I agree with Brown that metacognitive skills contribute to the ability to generalize their implicit abilities. And related to these arguments are notions about development making explicit the implicit knowledge a child has at an earlier point (Greeno, 1976). Although I grant preschoolers an implicit set of counting principles, I do not believe they have explicit, stateable knowledge of these principles.

With development also comes the ability to access the structures underlying early cognitive and perceptual abilities and to them combine those to produce

novel abilities (Fodor, 1972; Rozin, 1976). To my knowledge, no one believes that the ability to read is itself coded in genes. However, as Rozin points out, in some cases at least, related abilities are. I believe that an important aspect of learning to read is learning to compute a phonetic representation of written material and recognize the lawful relationship between spelling and pronunciation. But it is known that young children have trouble accessing the speech stream for purposes of obtaining a phonetic representation (Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Rozin & Gleitman, 1977). Eventually they do, and as Rozin and Gleitman argue, take a major step toward developing the ability to read.

Following up on Rozin's ideas, I see that development involves yet another trend. The young child, to be sure, has many pieces of competence. However, they are exceedingly fragile (Gelman, 1979). The older child can show that competence across a wide range of tasks. Hence, the idea is that development involves going from the fragile (and probably rigid) application of capacity to a widely based use of these. Indeed, for those who want to study the why and wherefore of transfer and generalization, I submit that the preschool to elementary-school period is a remarkable target for finding out how this happens, because it clearly does.

Sue Carey (1980) and others suggest that development involves the filling in of incomplete theories about the world and the substitution of more correct theories for incorrect ones. As an example of what kind of substitution might be required, I draw attention to work by Green, McCloskey & Caramazza (1980) and others who are finding that college students use an Aristotelian theory of physics. Obviously, a theory change is required. This position is congruent with those that argue that an increasing amount of knowledge is part of the developmental story. But, it goes beyond that. The idea is not just that children need to acquire a list of facts. They may have to reorganize those facts to accommodate yet further facts. Or, as we (Bullock, Baillargeon, & Gelman, in press) suggest, they may have to acquire an understanding of the nature of a good explanation.

Flavell drew attention to yet another trend in development, this being one of going from novice to expert. Experts do things quite differently, and, in general, young children are universal novices. And I agree that this is one theme in development. However, I don't think that all development can be characterized as nothing but a move from novice to expert. In the case of language acquisition, it is quite clear that it is the young who are more expert at learning a second language than are the old.

Actually, I've come to doubt that there will be one grand account of how development will proceed. The facts dictate that many things are happening, and as I look at it today, I wonder why I didn't see the hand writing on the wall at any earlier point. So much develops that it has to be a complex tale we will tell. Again, we've been forced to accept the complexity because of the amount of progress we have already made. Yes, we have a long way to go. But I submit that

the papers presented at this symposium provide many insights as to what does or does not develop, what our research programs will look like, and how to best get the data.

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