Nature-Nurture and the Two Realms of Development: A Proposed Integration with Respect to Mental Development

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McCall, Robert B *Nature-Nurture and the Two Realms of Development A Proposed Integration with Respect to Mental Development* Child Development, 1981, **52**, 1–12 It is argued that developmental psychologists need attitudes, methods, and conceptual schemes that integrate the distinctive contributions of nature and nurture to study developmental change as well as consistency in both developmental functions and individual differences in behaviors of interest A conceptual scheme for early mental development is described that synthesizes these disparate orientations This theoretical viewpoint deals with 2 sets of seemingly contradictory facts (1) the early portion of the developmental function is largely maturational, while individual differences are unstable and not highly correlated with either genetic or environmental factors, and (2) as nature's hold on the developmental function declines with age, individual differences correlate more strongly with both genetic and environmental factors

Young sciences often emerge out of dogma, and the vestiges of dogma sometimes linger in the form of allegiances to narrow conceptions about the fundamental nature of behavior and to insular methodological strategies Such a division characterizes psychology in general and developmental psychology in particular

Specifically, Cronbach (1957) warned us more than 20 years ago about the "two disciplines of scientific psychology"—experimental manipulation of variables, on the one hand, and the consistency of individual differences across contexts, behaviors, and time, on the other The distinction has many partial confounds experimental versus observational research, group means versus individual differences, analysis of variance versus correlations, etc

In the history of our own subdiscipline, the old "child developers," correlationists by nature, were joined by a few animal researchers who brought with them a fervent belief in group differences and the experimental method These newcomers failed to convert the correlationists, although they did manage to make developmental psychology more "scientifically respectable " But coexistence is not integration Those who emphasize group differences and experimental research and students of individual differences are still essentially separate sects (McCall 1977a)—the two realms of developmental psychology

This dichotomy partly influences what we study Consider the immortal nature-nurture debate Behavior geneticists pursue the genetic contribution to a behavior through the study of individual differences, while environmentalists attempt to uncover experiential influences in any way they can For the most part, neither group talks to the other, and both schools ignore Anastasi's (1958) plea, also of more than 20 years ago, to forget these allegiances and to work together to understand *how* heredity and environment jointly contribute to behavioral characteristics

Superimposed on these differences is the fact that few developmental psychologists of any stripe actually conduct a great deal of research on development per se—that is, change within organisms across age (McCall 1977a, Wohlwill 1973) Rather, contemporary devel-

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opmental psychology is mainly the parametric study of immature organisms, it is not primarily the study of longitudinal changes

The ecumenism of Cronbach, Anastasi, and Wohlwill has largely fallen on deaf ears It should be resurrected as often as necessary, because I believe our understanding of many behaviors is limited by these allegiances Each orientation potentially has something unique to contribute, but these approaches also must be woven together into a single conceptual fabric before real progress will be made in understanding behavior and its development

This paper offers a modest step toward integrating the two disciplines of psychology around the nature-nurture issue in the early development of mental behavior It begins with a description of the major issues sketched above, pointing out the limitations of each and the fragmented and sometimes contradictory picture of behavior that results from relying on only one perspective Then a conceptualization of mental development is proposed as an illustration of how an integrated viewpoint can be applied to a behavioral domain

This theoretical scheme helps to reconcile apparently conflicting facts about early mental development For example, how is it possible that much of early mental development is under maturational control, yet individual differences are unstable and do not correlate highly with either genetic or environmental factors? And as the maturational influence declines with age, why do correlates with both genetic and environmental factors increase?

But the importance of this theoretical proposal is not that it represents a detailed model of mental development It does not, and the scheme quickly breaks down when pushed to match the details of the literature Rather, it stands as one example of how a behavioral domain can be conceptualized across traditional boundaries to yield a fuller, more comprehensive understanding of its development

The Cost of Separatism

Specialization is often necessary But the cost is sometimes lack of integration, minimum cross-fertilization of ideas and approaches, and narrowness Developmental psychology suffers these consequences on many fronts, and any comprehensive theory or approach to a problem must integrate several of these otherwise separate stances

I have argued before in these pages (McCall 1977a) that developmental psychology is rarely actually developmental, and that our discipline does not pursue the study of change nearly as vigorously as it searches after consistency These and other allegiances limit the breadth and social contribution of our discipline Therefore, our approach to major issues must be developmental and must explain change as well as consistency

The Two Realms of Development

Change and consistency over age can occur in both of Cronbach's (1957) two realms Suppose figure 1 is a plot of the growth of an attribute over age—verbal fluency, for example The heavy line depicts the average of a group of subjects, and the thinner lines represent each of the five individuals in the hypothetical sample Statistically, the distinction is simply the difference between the absolute value of the average curve at different ages, on the one hand, and the stability of relative rank orderings of individuals from one age to the next, on the other The average absolute value of a trait in a group is independent of the relative stability of individual differences because the correlation between two sets of scores is independent of the means of those two distributions

Developmental functions —The measured value of a given attribute plotted across age defines the developmental function of that characteristic In figure 1, the thinner lines are developmental functions for individuals, while the heavier line is the developmental function for the sample If the sample is representative of a species, then the group curve is an estimate of the species-general developmental function Developmental functions are what experimentalists and those concerned about the nature of the species in general (e g , Piaget) tend to study

Developmental functions for individuals, groups, or species are either *continuous* or *discontinuous* (Emmerich 1964) By one definition, a developmental function is continuous when changes are quantitative rather than qualitative, that is, when the fundamental nature of the attribute remains the same over age A plot of height over age would be continuous because the fundamental character of height is essentially the same at every age, even though the average measured value changes The developmental function for vocabulary would also be continuous In contrast, a plot of Piagetian sensorimotor development would be discontinuous because its specific behavioral character is different from one stage to the next Obviously, whether a trait is continuous or discontinuous depends partly on how it is measured (e g , the IQ score portrays a continuous function for a characteristic that may actually be discontinuous)

Individual differences —Development can also be assessed in another realm—in terms of the relative consistency of individual differences over age That is, do individuals maintain the same relative rank ordering within their group at two different ages, or does the relative rank ordering change from one age to the next? The term *stability* refers to the relative consistency of such individual differences In the hypothetical plot in figure 1, individual differences are not stable during the early years but become more so later

The costs of separate disciplines —Research on development as well as other areas of psychology tends to be carried out in one or the other of these realms but not simultaneously in both For example, Piaget was concerned only with the species-general function for mental development—he literally did not care about individual differences On the other hand, much research on early mental behavior has revolved around correlates of early mental test performance and predictions to later IQ

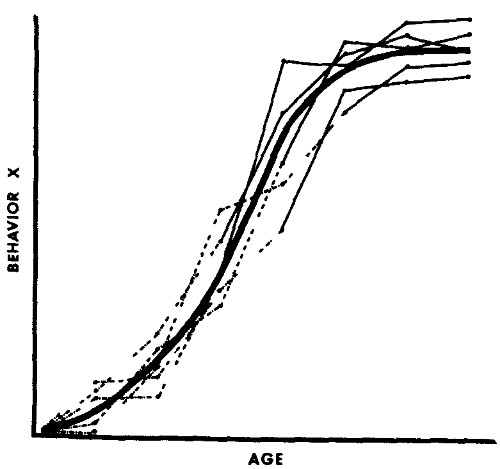

FIG 1 — A hypothetical plot of the developmental function of a given behavior for five individuals (thin lines) and the developmental function of the group (heavy line) (Reprinted from McCall et al [1977], with permission of the Society for Research in Child Development)

(i e , individual differences) Such studies frequently rely on DQ or IQ, indices which essentially obviate any analysis of the qualitative and quantitative nature of the species-general developmental function

Researchers tend to ignore the potential independence of these realms and draw conclusions about a behavior in general on the basis of evidence from only one sphere One classic illustration is Bloom's (1964) suggestion that by the time one is 4 years old, 50% of one's adult intelligence is developed This conclusion was based on the statistical fact that the correlation between IQ at 4 years and at 17 years is approximately 71 ($71^2 = 50$) But this claim for the development of intelligence in general is based solely on the stability of individual differences—it completely ignores the fact that the average child's mental age (i e , the "amount" of mental skill displayed) in some sense will multiply several times during this interval Relying solely on individual differences is like studying the consistency of a difference of a few inches in the heights of giant sequoia trees from seedlings to maturity while ignoring the issue of how all the trees grow to be over 300 feet tall

Another illustration of the failure to keep these orientations separate is the recent preoccupation with controlling for secular change, time of measurement, and testing experience Much research on individual differences has been maligned or dismissed because it lacked such controls But the data showing secular change and repeated testing effects pertain almost totally to the developmental function, relatively little evidence suggests that these factors influence the stability or pattern of individual differences (McCall 1977a)

Potential or real independence?—While the two realms are potentially independent, they may not be independent in nature But this is an empirical question My point is that it is rarely asked One such attempt (McCall, Eichorn, & Hogarty 1977) found that dips in the level of cross-age correlations for mental test performance coincided with qualitative changes in the fundamental nature of mental behavior assessed by that instrument But this apparently happy convergence may not necessarily be the case, nor have we given much thought to the conceptual relationship between stage changes (i e , discontinuities) and stability of individual differences (see Uzgiris 1977)

The overriding point is that major strategies of inquiry must consider developmental change and consistency in both developmental function and individual differences

Nature-Nurture

The nature-nurture issue is one of the most persistent, celebrated, and heated controversies in psychology It also suffers from allegiances and the failure to distinguish between developmental function and individual differences

A prime illustration is the interpretation of the Skodak and Skeels study (1949, Honzik 1957) on the IQs of adopted children and their biological and foster parents From the standpoint of individual differences, the IQs of the adopted children correlated 38 with those of their biological parents but essentially zero with an estimated index for their rearing parents However, the average IQ of the children was 21 points higher than the average of their biological parents and nearly identical with the estimated average of their rearing parents Hereditarians tend to emphasize the individual-difference result, environmentalists concentrate on the mean difference (i e , developmental function) Both observations are useful but distinct pieces of information, and they are not contradictory (Jensen 1973) But we rarely view them as two pieces of the same puzzle

From another standpoint, essentially all methods of population genetics used to determine the heritability of a characteristic are based on individual differences This fact poses two major limitations First, genetic or environmental factors that influence individual differences may or may not influence the developmental function of that sample For example, circumstances that permit almost all infants to walk and run may not play any role in how well, how fast, or how far one individual can walk or run relative to another And factors that produce precocity in the attainment of object permanency, thus producing a spurt in the developmental function for these individuals, may have nothing to do with how all children ultimately acquire essentially comparable proficiency in the basic elements of this skill

Second, since all methods of assessing heritability rely on individual differences, there is almost no way to assess the heritability of a species-general developmental function because there are no individual differences by definition Race or other subgroup differences could be used, but the races may not differ in the basics of sensorimotor development or early language acquisition, for example Further, factors that determine differences between races may not determine their similarities—which is crucial to the definition of the species-general developmental function

Lest the environmentalists feel smug, they are no better off The environmental as well as the genetic factors necessary to produce fundamental characteristics in the species are available to almost everyone we study As a result, the only way we can study the importance of certain major environmental factors for development is to take advantage of tragedies—children reared in closets, born blind and later given sight, or fed from birth through a fistula

In fact, there may be a good evolutionary explanation for the possibility that one set of factors influences individual differences and another set operates on the species-general developmental function If a given trait favors survival and reproduction, then such an attribute would tend to become characteristic of each member of the species That is, this genetic trait would characterize the species-general developmental function But genetic variability on this attribute would be reduced, consequently, individual differences in this attribute would be caused by environmental circumstances (McClearn & DeFries 1973, Plomin & Rowe 1979) Perhaps, then, it is not surprising that some anthropologists and geneticists (King & Wilson 1975, Washburn 1978) have suggested that 99% of our genetic material produces species-general characteristics, not individual differences (but see Plomin & Kuse 1979)

This is not to say that genetic factors in individual differences are not important, quite the contrary, society is much more concerned with differences between people than with how humans differ from the apes The point, however, is that nearly the entire nature-nurture argument resides in the realm of individual differences and ignores the species-general developmental function Moreover, it is quite possible for the species developmental function to be almost totally under genetic control (given certain necessary environmental circumstances) but for individual differences in that behavior to possess no heritability and perhaps no obvious correlations with stable environmental attributes in most research populations Indeed, this is very nearly the case for early mental development (McCall 1979a, 1979b) Moreover, developmental functions must be studied as functions, and there are distinct limits on our ability to investigate the factors that contribute to species-general developmental functions But this is no reason to dismiss them from our theorizing or to confuse them with other aspects of development

Toward a Broader View—the Case of Mental Development

The thesis to this point has been that allegiances and favorite methodological approaches contribute to a narrow, incomplete, and occasionally distorted understanding of some of the behaviors we study We need attitudes, methods, and conceptual schemes that integrate the distinctive contributions of nature and nurture to the study of developmental change as well as consistency in developmental functions and individual differences

The following scheme for early mental development is offered as a step in this direction I caution that it is only a single step New answers to major questions are not proposed Instead, I have tried to understand the apparent contradictions in the data already available Further, what follows is not a detailed theoretical model that must yield a host of innovative testable deductions or must be rigorously evaluated in terms of the evidence Rather, this is an illustration of a way of thinking, it is an example of what one such integrated approach to early mental development might look like in broad outline While the general strategy could be applied to the study of almost any behavior, most of the specifics focus on mental development and may not generalize to social, personal, and other behavioral domains

Canalization

The concept of canalization, described by Waddington (1957) and recently applied to mental development by Scarr-Salapatek (1976), implies a species-typical path, called a *creod,* along which nearly all members of the species tend to develop However, a characteristic follows the creod only as long as species-typical appropriate environments predominate When such environments exist, development proceeds "normally", when such circumstances deviate markedly, development can go awry Therefore, the utility of the concept of canalization depends on the breadth of environments designated as species typical When development is "highly canalized," individuals follow the species creod under a wide range of diverse environments and exhibit strong self-righting tendencies following exposure to severely atypical environments When development is "less canalized," individuals do not follow a common developmental path as uniformly, variability in environments and genetic circumstances produce more frequent and more severe deflections from the species average, and there is less tendency to self-right toward that norm following such deviations

Canalization is a pivotal concept because it has implications for the several aspects of development discussed above These implications may be seen more clearly in the scheme of early mental development described below

A Canalization Scheme of Early Mental Development

A fundamental proposition is that early mental development is highly canalized during the first 18–24 months of life but thereafter becomes less canalized That is, infants proceed along the species-typical path under a wide range of environments, and there is a strong self-righting tendency should extreme circumstances deflect an infant from this creod However, beginning at approximately 18–24 months, mental development becomes progressively less canalized with age, and it is after this point that the self-righting tendency weakens and individual differences become more stable

The scoop approach —This notion is pictured in figure 2 as a scoop or trough The scoop represents the creod or species-general developmental function for mental development The designs on its inside signify different qualitative stages of mentality The predominant character of mental behavior changes during infancy, and these stages are discontinuities in the nature of the developmental function of early intelligence The grooves or chan-

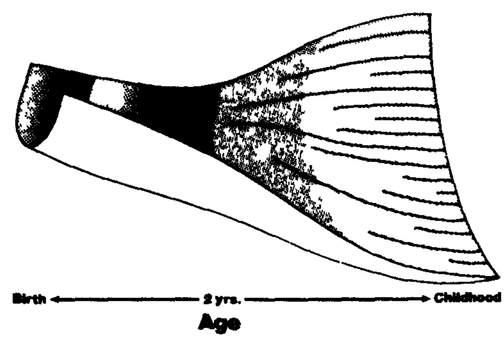

FIG 2 —The "scoop" approach to thinking about mental development nels that appear in late infancy and branch into childhood are individual differences in genetic disposition. They allow for developing variations and divergence in genetic disposition in the population.

Now imagine that a lightweight ball represents an individual who begins life at the leftmost point of the scoop. The ball rolls down the scoop over developmental time. The incline of the scoop represents necessary environmental contributors to the species-general function. However, in the course of development, environmental winds blow over the scoop and produce individual differences in the rate of development (if the winds blow up or down the scoop) or in the nature of the individual's developmental function (if the winds blow across the scoop).

To summarize: With respect to the developmental function, the basic path defined by the scoop represents heredity's creod, the force of gravity that pulls the ball (i.e., individual) down the scoop which slants to the right is the environmental component. Both are necessary for species-general development. With respect to individual differences, the diverging grooves in the scoop are individual variations in qualitative genetic disposition, while winds along the scoop that can blow the ball from stage to stage faster or slower or winds across the scoop that can blow the ball into new qualitative emphases are the environmental component.

As a conceptual scheme, this approach is an attempt to combine Piaget's (1954/1966) stage description of the species-general developmental function with what is known about individual differences in mental performance at a given age or across age. A ball starting out at the left is tightly contained by the narrow creod which it follows under a wide range of environmental winds. Even when a strong gust does blow the ball somewhat off course, the steep sides of the scoop force it to right itself. Of course, there are limits, and terribly severe environmental or genetic factors can produce permanent deflections in the developmental course. But, under a wide range of circumstances, infants will follow basically the same developmental path. Nature is governing the developmental function, and individual differences have minimum longitudinal stability and only minor contemporaneous correlations with genetic or environmental variations.

The mental behaviors that emerge during this period tend to be fundamental characteristics which all members of the species attain completely with relatively insignificant individual differences (Horn [1968] has called them *anlagen*). Every infant acquires object permanency, the ability to walk, and basic symbolism under a wide range of genetic and environmental circumstances. Indeed, in their most elementary form, these attributes are developed essentially all-or-none. We can barely imagine adult individual differences in proficiency of basic figure-ground. We are concerned that infants acquire object permanency but not how well they will ultimately achieve it.

Mental development begins to be less canalized at approximately 18–24 months, although it is a gradual process. Characteristics and abilities now emerge that all infants will acquire, but some will eventually attain much different levels of performance from others. Almost all humans acquire language, but some become more facile and fluent than others.

Three factors of the scheme change simultaneously. First, the creod becomes more differentiated (i.e., the grooves representing individual differences in genetic dispositions). Second, the sides of the scoop fall off, making the individual more vulnerable to the differential and variable winds of experience. Notice that both unique genetic and environmental circumstances now have a greater potential impact on an individual, and correlations with genetic and environmental factors are likely to increase and remain more stable over time now that canalization is weakening. Third, the ball is picking up speed. This represents the cumulative effect of experience and the fact that humans are partly able to select their own environments—a circumstance that produces longitudinal stability and correlations between environmental and genetic circumstances.

These changes complicate the theoretical dynamics considerably, but they unquestionably occur in some form. On the one hand, the speed of the ball lends stability to the system (i.e., environmental breezes may have less effect than they might otherwise), and previously established characteristics tend to persist. On the other hand, notice that the lowered walls potentially make the organism more subject to environmental influences, although the winds must be strong enough to overcome the ball's inertia. But, if the ball is blown from its previous course, its gathering speed means that it is more likely to persist in the new direction The individual organism is now potentially more vulnerable to both environmental and genetic influences than when younger, but the impact of these factors may be resisted by the inertia of development (e g , cumulative experience, environment selection) or, once effective, amplified by these same factors Early genetic and environmental factors can now have a more noticeable and prolonged effect on individual differences because of their cumulative character and the fact that people select environments that tend to remain relatively stable over age But at the same time, the potential for change is also greater because of genetic differentiation and the lowering of nature's protective walls Which force wins out in any individual case requires more specific information than this scheme contains, but it is likely that ages 2–4 (approximately) may be the most "sensitive" period for mental development

Implications of the Scheme

The scoop approach suggests several principles which heretofore appeared contradictory but may now be seen to be diverse facets of this broader conception of mental development

The developmental function in the first 18 months —The scheme suggests that infants should follow a relatively common sequence of stages during the first 18 months of life and that most infants who deviate from that course should return to the norm once the deflecting circumstance is removed

Piaget (1954/1966) proposed a stage-sequence theory of early mental development that has received wide acceptance Although recent formulations have made slight changes in the Piagetian model, there is more agreement than disagreement For example, several researchers agree that major stage boundaries occur at approximately 2, 7–8, 13, and 21 months of age (e g , Fischer 1980, McCall et al 1977, Piaget 1954/1966, Uzgiris 1976) Although individual investigators differ on what basic mental attribute underlies each stage, there is much more agreement about the timing and sequence of specific behavioral events (e g , the exploration of objects and perceptual contingencies, object permanency, entity-entity associative relations, imitation, vocabulary, two-word sentences, symbolism) Readers interested in the specific attributes of these stages are referred to the above references

More important from the standpoint of canalization is whether self-righting is a possible phenomenon Infants who have suffered major adversity—including nutritional deprivation, prematurity, anoxia, and other neonatal insults that produce contemporaneous depression in infant test scores—tend to recover and return to essentially normal development within 3 to 6 years if they are reared in adequate environments (Honzik 1976, Hunt 1976, Sameroff & Chandler 1975, Scarr-Salapatek 1976) However, if such infants are reared in markedly inferior environments, the effects of early injury can persist Therefore, infants who are returned to species-typical environments after a variety of major insults can return to the creod

Individual differences in the first 18 months —While infants closely follow the biological creod, most individual differences will be neither as stable across time nor as correlated with genetic or environmental factors as they will later (Honzik 1976, McCall 1979a, 1979b, McCall et al 1977, McCall, Hogarty, & Hurlburt 1972, Scarr-Salapatek 1976) The relative instability of individual differences derives from the strong self-righting tendency characteristic of highly canalized development Perhaps the intraindividual variability characteristic of this period has the adaptive function of increasing the likelihood of eventually matching behavior with environmental circumstances

There has been some debate about the genetic correlates of individual differences in infant test performance Wilson (1978) points to high within-pair concordances among monozygotic (MZ) and dizygotic (DZ) twins for single mental assessments and for developmental profile Others (McCall 1972, McCall, Appelbaum, & Hogarty 1973, Scarr-Salapatek 1976) have argued that heritability is based on the difference between within-pair correlations for MZs versus DZs, and that, while these differences are significant in Wilson's data, they are not large In fact, heritabilities for single assessments in the Louisville Twin Study average 25 between 3 months and 5 years (McCall 1979b), a result consistent with other data demonstrating modest kinship correlations prior to 4–6 years of age (e g , Beckwith 1971, Casler 1976, Honzik 1957)

Age-to-age changes show some heritability in the first 2 years (50), but apparently this declines thereafter (McCall 1970, 1972, 1979b, Wilson 1978) This early heritability for developmental profile among twins has not been demonstrated for singleton siblings (McCall 1970, 1972, McCall et al 1973) This difference may derive from pre- and perinatal circumstances more likely shared by twins in general—and by MZ twins in particular—which decline in influence over the first years of life A similar interpretation based upon temporary perinatal factors may explain Casler's (1976) observation of modest correlations between biological mothers' IQ and Gesell subtest scores of their orphanage-reared infants at 2 months but not at 9 or 15 months of age

Occasionally, a presumed environmental circumstance observed in the first year of life predicts later mental performance to a surprisingly high degree However, it is usually not clear whether this factor actually influenced the child during the first year with enduring consequences, or whether it is an early predictor of more functional environmental variables that have an influence on mental performance only later in childhood For example, one might expect that highly verbal parents would talk to their children a great deal, beginning in early infancy Developmental researchers might observe a correlation between early parental language and later child intelligence and be prone to infer that talking to a 6-month-old infant improves the child's intelligence at 3 years of age However, language stimulation at 6 months may actually have no effect on the child, but it is the same parent who talks to the 6-month-old who also talks to the 3-year-old—at which time such language stimulation actually does have a causal effect This possibility is anathema to researchers, because in the study of the natural development of mental competence it is often impossible to discriminate between the early precursor and the early dysfunctional correlate of a later causal factor (except under certain conditions, e g , adoption and unusual environmental changes in the lives of young children)

By and large, however, age-to-age stabilities and correlations of mental test performance with genetic and environmental factors, while not zero, are quite modest and definitely lower than analogous relationships found after 18–24 months Presumably, this fact derives from the high canalization of early mental development that keeps infants on the species-general developmental creod and returns wayward individuals to that path

This characterization of early mental development may leave traditional developmental researchers frustrated What does one do with a mentality that is both discontinuous and unstable? The developmental function does not plot continuously on the same axis, and there are few correlations to find Even individual differences in age-at-stage-entrance might not be consistent from stage to stage

But if this is the way nature has created its children, let not scientists cast them into another image Development of this kind is problematic for research only if scientists narrowly focus on continuity, stability, and simplistic dichotomies of heredity and environment This state of affairs forces us to study change—change in the species' developmental function, change in individual differences in developmental function, change in the correlates of mentality at different ages, factors necessary for change to occur, the behavioral consequences of change, the fundamental nature underlying each distinct stage, and the breadth of horizontal décalage

The developmental function after 2 years—After 18–24 months of age, canalization gradually weakens Stages characterizing the species-general developmental function become more widely spaced, and traits emerge (e g , symbolism, verbal fluency) for which proficiency levels will ultimately vary widely between individuals Prior to this point, all developments were essentially species-general and possessed few enduring individual differences After this point, while some fundamental species-general *anlagen* may still emerge (e g , at 5–7 years of age, see Gruen & Doherty [1977], White [1965]), greater diversity occurs within species-general stages as a function of both genetic and environmental factors

Individual differences after 2 years—As a result of the decline of canalization and the increased variability, individual differences in mentality become more stable across age and show higher correlations with both environmental and genetic circumstances (McCall 1979b) Apparently, with the emergence of certain symbolic capabilities, predictions to later IQ increase rapidly (McCall et al 1977), predictions from mental test scores to adult educational and occupational success approach asymptote (McCall 1977b), kinship similarities increase and level off at 5–7 years (Honzik 1957), and correlations with presumed environmental factors also increase (McCall 1979b)

Plasticity

During the past 2 decades, some psychologists have emphasized the malleability of mental development during the early years of life (e g , Hunt 1961, White 1976) The fact that individual differences in IQ stabilize and genetic correlates reach asymptote at this time has led some to suspect that environmental influences would have their greatest impact before 6 or even before 3 years of age It was only a small step to assume that experiences prior to this point were permanent and that subsequent experiences were less influential or even inconsequential In view of the present model, this attitude is oversimplified and possibly misleading There is a difference between saying that many or even most people do not change greatly over age and saying they are locked in and that change under any circumstance is impossible (see Rutter [1979], for a review)

For example, consider the potential for change given contemporary, species-typical environments Contrary to the prevailing notion, the scoop approach suggests that the potential for change, especially improvement, in mental performance is actually greater in early childhood than in infancy The organism would appear most susceptible to variations in environment in early childhood, after the sides of the scoop begin to decline, but before the speed of the ball increases to the point where individuals select their own environments and resist or are denied opportunities for improvement

Longitudinal correlations —Perhaps we have been seduced into believing in the permanence of mental ability after age 6 by longitudinal stability coefficients of 85– 95 and by heritabilities of 70– 80, figures we may mentally round up to 1 00 Even so, neither data set should compel us to believe in the immutability of mental performance First, they are both based on individual differences and are therefore potentially independent of average changes in the groups assessed (as has been illustrated by the Skodak and Skeels data) But, in addition, even year-to-year correlations of 90 permit substantial, gradual change in relative performance for some individuals and not others living in species-typical environments In the Fels Longitudinal Study of middle-class children in Ohio, the average child showed a tested IQ range of 28 5 IQ points between 2½ and 17 years of age, and one in seven children displayed changes of 40 points or more (McCall et al 1973) Increases of more than 70 points are not unknown (Hindley & Owen 1978, McCall et al 1973) These shifts in relative performance were not random error but rather gradual changes over several years with inflection points at 5–7 years and approximately 10 years Such developmental profiles were not more similar among siblings than among unrelated children matched for year of birth, sex, and SES (McCall 1970, McCall et al 1973) Therefore, while approximately half the Fels sample displayed relatively unchanging IQ patterns over age, perhaps because of the stability of their environments, the other children recorded rather substantial, meaningful, and presumably environmentally based changes in relative mental performance in species-typical environments, despite the high year-to-year correlations for the total sample

Similarly, heritabilities of 70– 80 do not obviate substantial environmental changes even within such samples Jensen (1973) has pointed out that the environmental standard deviation for IQ will be 6–9 IQ points, and that the 21-point difference between the means of the adopted children and their biological parents in the Skodak and Skeels (1949) data is quite consistent with a heritability of 70– 80 and with the presumed improvement in home environment provided by their adoptive parents

Longitudinal correlations and heritabilities provide some information about the effectiveness of differences in environments represented in the samples studied But the environments not represented in those samples also have implications for the potential to change Clarke and Clarke (1976) have recently reviewed some unusual cases of children subjected to miserably restrictive circumstances for the first years of life Of course, these naturalistic tragedies do not afford the experimental rigor we would like (Sroufe 1977), and not all children recover completely from such debilitating circumstances But that some do overcome severe deprivations during the first 6 years of life indicates that the potential for massive change under some circumstances for some children and across some portions of the mental scale is possible during childhood (Rutter 1979)

Factors that produce change —But what environmental circumstances contribute to change? What shall we look for? Because of the wide range of environments in the population and their correlation with mental test scores, we have traditionally concentrated our attention on between-family environmental factors (e g , general intellectual climate of the home, opportunities for education and enrichment, general language environment, encouragement for mental accomplishment, etc) No question, these factors have an effect

But we have ignored another sphere of potential environmental influence, that is, within-family or developmental environmental factors—an odd omission for our subdiscipline In a group of subjects assessed at any one age, the environmental variance can be conceptually partitioned into between-family and within-individual components If the heritability is assumed to be 70– 80, then the standard deviation associated with environmental factors will be approximately 6–9 IQ points But longitudinal studies of children remaining in their middle-class families suggest an intraindividual standard deviation between 2½ and 17 years of age of 7 8 IQ points, and the form of this variation is not more similar among siblings than among unrelated children (McCall et al 1973) While it is impossible to conclusively attribute all this intraindividual variation to environmental factors plus error, there is reason to believe that a good part of it is environmentally based For example, a review of recent data on the heritability of intelligence suggests a more substantial role for within-family environmental factors than previously suspected (Plomin & DeFries 1980), and much of that variability may be developmental change within individuals

Therefore, a major domain of environmental circumstances not often mentioned or investigated for its potential impact on mental performance includes specific environmental events that are "matched" with the child's intellectual and motivational disposition at a specific time For example, a trip to Cape Canaveral may have a profound influence on the mental development of an 8-year-old who happens to be studying airplanes and space and has a teacher who is a private pilot But the same experience may have no influence on that child's older brother who is heavily into basketball, girls, and rock music

Limitations

The scoop approach has profound limitations It is incapable of predicting how much environmental wind is sufficient to blow an individual off the creod at what age It does not predict when an environmental wind will overcome the increasing momentum of a rolling ball It does not specify the characteristics of the stages of the species-general function across age, and it does not deal with the facts of mental performance among the aged

Another possible problem is that the approach has emerged from and is intended to explain the literature on the nature of mental development primarily as reflected in IQ scores It is possible that measures of more specific mental abilities would give quite a different picture of environmental and genetic correlates, developmental stability and instability, and the changing degree of canalization over age

Further, many of my colleagues have suggested a wide variety of changes or additions to the scoop to help it handle one or another specific aspect of mental development It is understandably tempting to see how many different phenomena can be accommodated by a model

But I have not tried to present a model of mental development which will make decisive predictions about parameters of mental performance which can be forthrightly tested My claims for this approach are much more modest I have tried to sketch a way of thinking that has helped me see the relationship between heredity and environment and their differential influences on the developmental function and individual differences Stability of individual differences and continuity of developmental function are potentially distinct realms of development, and they may be under the influence of different factors at the same or different ages While holding these realms of development conceptually distinct, this approach permits an understanding of how both are woven into the same fabric of mental competence and how they change over age This conceptualization has also shown me how it is possible for nature to hold its young close to a single developmental creod while individual differences are unstable and relatively uncorrelated with both environmental and genetic circumstances It helps me appreciate that strong early influences may have enduring effects because of the branching nature of the creod and the dynamic character of individuals operating on their own environments But on the other hand, the potential for change is nevertheless present, perhaps more strongly in childhood than in infancy, at least under certain circumstances It stimulates me to search for more specific intraindividual environmental factors that are matched with an individual's abilities and motivations

As is often true in the growth of knowledge, what seems like a clarification may actually complicate our pursuit of understanding But the job of describing and explaining the development of mentality is a fundamental responsibility of our discipline If nature has made it more complicated than we thought, then let us be about our business with renewed vigor

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