The Role of Immaturity in Human Development

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The possibility that infants' and young children's immature behaviors and cognitions are sometimes adaptive is explored and interpreted in terms of evolutionary theory. It is argued that developmental immaturity had an adaptive role in evolution and continues to have an adaptive role in human development. The role of developmental retardation in human evolution is discussed, followed by an examination of the relation between humans' extended childhood and brain plasticity. Behavioral neoteny, as exemplified by play, is examined, as are some potentially adaptive aspects of infants' perception and cognition that limit the amount of information they can process. Aspects of immature cognition during early childhood that may have some contemporaneous adaptive value are also discussed. It is proposed that viewing immaturity as sometimes adaptive to the developing child alters how children and their development are viewed.

Nature wants children to be children before they are men. If we deliberately depart from this order, we shall get premature fruits which are neither ripe nor well flavored and which soon decay. We shall have youthful sages and grown up children. Childhood has ways of seeing, thinking, and feeling, peculiar to itself; nothing can be more foolish than to substitute our ways for them.

—Jean Jacques Rousseau

People understandably tend to see development as being progressive; from immature and inefficient structures and functions to mature and efficient ones. Early, immature forms are seen as "unfinished" and incomplete versions of the adult; the child is a "work in progress." From this viewpoint, immaturity is a necessary evil, something that people must get through on their way to adulthood, where the "real show of humanity emerges on stage" (L. Thomas, 1993, p. 175). This is not an unreasonable view. A prolonged period of youth is necessary for humans. Humans, more than any other species, must survive by their wits; human communities are more complex and diverse than those of any other species, and this requires that they have not only a flexible intelligence to learn the conventions of their societies but also a long time to learn them. But the species's physical and cognitive development need not progress synchronously. Their prolonged bodily development could in theory be accompanied by rapid cognitive and social development. This would result in a physically dependent child who has the intellectual and social wherewithal to master the ways of the world.

The conclusion that development is progressive seems obvious from the way theorists traditionally view development—from immaturity to maturity—with the adult as the product that "counts." But there are other ways to view development. For example, insects metamorphose: from caterpillar to butterfly (larva to adult or imago). The caterpillar has an integrity of its own; it often leads a complex and sometimes more active life than the sexually mature butterfly. Entomologists cannot view the caterpillar merely as an immature form of the butterfly but must view the caterpillar as an animal with its own organization and requirements that are adapted to its present environment, not to an environment it will live in as a butterfly. A butterfly is the inevitable product of a caterpillar, but the two are qualitatively distinct; the caterpillar is not just an immature version of the butterfly.

Mammals, of course, do not metamorphose. Yet, looking at the young—at infants and children as having an integrity of their own, as organisms with abilities specially adapted to the particular physical, social, and cognitive demands of their environment—provides a different picture of immaturity. Seen from this vantage, immaturity is not a necessary evil but possibly may play an adaptive role in a child's life and development. Some aspects of childhood are not specific preparations for adulthood. Rather, they are designed by evolution to adapt the child to its current environment but not necessarily to a future one. This is a very different view from the one implicitly assumed by most contemporary child developmental psychologists. Early accomplishments, and particularly early trauma, are seen to set the stage for later development. This is surely an accurate interpretation for many behaviors and characteristics, but believing that all psychological development progresses in such a way can be misleading and can distort one's view of ontogeny.

My colleagues and I have examined the argument for the adaptive nature of immaturity for cognition in general (Bjorklund & Green, 1992) and language and language remediation specifically (Bjorklund & Schwartz, 1996). We have argued that the immature child has a cognitive integrity of his or her own and that young children's thinking should not be viewed...

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solely from the perspective of what it is not and how close it is to what it will become; rather, theorists should ask what functions it might afford the child at that particular time in development. Although a similar point of view has reflected the canonical perspective of developmental psychobiologists (whose subjects are mainly infrahuman mammals and birds) since at least the early 1980s (e.g., Oppenheim, 1981; Spear, 1984; Turkewitz & Kenny, 1982), it is a novel perspective for cognitive developmentalists focusing on humans. I broaden our previous perspective in this article, arguing that developmental immaturity had an adaptive role in human phylogeny and that it continues to have an adaptive role in human cognitive and social ontogeny.

Consistent with the perspective of contemporary development mental psychobiologists, the theory implicitly underlying this review is Darwin’s. A number of social and cognitive developmental psychobiologists have recently recognized the significance of evolutionary theory to develop an understanding of normal human ontogeny (e.g., Bjorklund, 1997; Fernald, 1992; Geary, 1995; Siegler, 1996), although this perspective is not without controversy (e.g., Morris, 1990). With respect to the adaptive nature of developmental immaturity, I argue that some immature forms and behaviors may have been selected in evolution for either their immediate or eventual survival values. Of course, many aspects of immaturity, if not most, are maladaptive to the young organism and reflect necessary trade-offs for other contemporary or future adaptive functions. But immaturity should not immediately be associated with ineffectiveness. Rather, one should question whether some particular aspect of immaturity may afford the young organism some temporary advantage.

For instance, it has long been recognized that adaptations may be limited to a particular time in development, infancy, for example, facilitating the young organism’s chances of surviving to adulthood and eventually reproducing (e.g., Tooby & Cosmides, 1992). This is reflected by the concept of ontogenetic adaptations—neurobehavioral characteristics of young animals that serve specific adaptive functions for the developing animal. These are not simply incomplete versions of adult characteristics but have specific roles in survival during infancy or youth and disappear when they are no longer necessary. Oppenheim (1981) went so far as to suggest that “even the absence of adult capabilities may be developmentally adaptive... [and] should be considered in any comprehensive theory of ontogeny” (p. 92). Oppenheim discussed specializations of embryos that served to keep them alive but that disappear or are discarded once they serve their purpose, such as the yolk sac, embryonic excretory mechanisms, and hatching behaviors in embryonic birds.

Postnatal behaviors are also candidates for ontogenetic adaptations, including reflexes such as suckling and less well-defined behaviors such as play (Oppenheim, 1981). Some aspects of human infants’ cognitions may also serve a specific, short-term function rather than prepare the child for later accomplishments. For example, the imitation of facial expressions by newborns (e.g., Meltzoff & Moore, 1977, 1985) has been considered by some to be an example of an ontogenetic adaptation (Bjorklund, 1987). In about half of the experiments investigating neonatal imitation in humans (see Anisfeld, 1991), newborns are found to imitate adult facial gestures (usually tongue protrusion), although imitation of facial expressions decreases to chance levels by about 2 months (e.g., Abravanel & Sigafoos, 1984; Fontaine, 1984; S. W. Jacobson, 1979). This pattern, and that tongue protrusions can be elicited by other stimuli such as a red pen looming at an infant’s face (S. W. Jacobson, 1979), led some theorists to propose that the imitation seen during the first 2 months of life is qualitatively different from and unrelated to that observed in later infancy. Rather than serving to acquire new behaviors, which seems to be the primary function of imitation in later infancy and childhood, several theorists have speculated that neonatal imitation has a very different and specific function for the neonate. For example, S. W. Jacobson suggested that imitation of facial gestures is functional during nursing, Legert (1991) proposed that it serves as a form of prelinguistic communication, and Bjorklund (1987) suggested that it facilitates mother–infant social interaction at a time when infants cannot intentionally direct their gaze and control their head movements in response to social stimulation. Support for these latter interpretations was provided by Heimann (1989), who reported significant correlations between degree of neonatal imitation and later quality of mother–infant interaction at 3 months. Thus, early imitation appears to have a specific adaptive function for the infant (i.e., to facilitate communication and social interaction) that is presumably different from the function that imitation serves in the older infant and child (but see Meltzoff & Moore, 1992, for a different interpretation).

Also central to contemporary evolutionary psychology is the idea that adaptive behavior was selected, not for survival in modern culture, but rather in the environment of evolutionary adaptiveness, stretching back far into the Pleistocene Age. Thus, a behavioral characteristic that may have been adaptive for our ancestors may or may not continue to have adaptive value for contemporary humans. For example, our penchant for sweet and fatty foods, which signal a high-caloric meal, was surely adaptive for our nomadic ancestors. Such a penchant is less adaptive today and in fact is often maladaptive in societies where availability of high-caloric food is not a problem (Nesse & Williams, 1994). Also, remember that not all contemporary behaviors or forms were selected in evolution. Some are merely the by-products of other adaptations or the necessary consequences of physical growth. However, these behaviors and forms, although perhaps not selected in human evolution, were at least not sufficiently detrimental to human ontogeny to result in extinction. That is, their impact on evolution may have been neutral, in that they were not positively selected for but merely did not interfere with reproductive potential. An appreciation of evolutionary theory is not necessary for appreciating the potentially adaptive function of developmental immaturity, but it provides an overarching framework that, I believe, ties together well the research findings from diverse literatures.

In the sections below, I first examine the role of developmental retardation in human evolution, followed by a discussion of the consequences of humans’ prolonged period of youth and brain growth on behavioral plasticity and flexibility. I then examine the possibility that sensory and cognitive systems that limit the quantity of information an infant receives may facilitate sensory development, learning, and language acquisition. I then examine two aspects of cognitive immaturity—egocentrism and poor metacognition—that may have some adaptive advantages together with their obvious maladaptive ones. I conclude by pro-
posing that a view of ontogenetic immaturity as more than a handicap that needs to be overcome provides theorists with a different and important view of children, their development, and their education.

The Role of Retardation in Human Evolution

A simple, and now discredited, idea about evolution that was popular among biologists in the 19th century is the seductive idea of progress. Evolution was seen as leading ever upward and onward, with Homo sapiens as being the ineluctable conclusion—the "Great Chain of Being." Evolution was seen as purposive and always leading to increased complexity. This was captured by the principle of orthogenesis. Orthogenesis is based on the assumption that an inherent perfecting force in all of organic life makes evolution directional and always moving "forward." More "advanced" species, such as humans, relative to less advanced species, such as chimpanzees (or, more properly, the human apelike ancestors), evolved by the addition of something to the adult stages of their ancestors. So, for example, humans evolved "more" brain.

This idea was reflected in Haeckel's famous biogenetic law (see Gottlieb, 1992; Gould, 1977; and Mayr, 1982, for historical reviews). The biogenetic law is captured by the phrase, "ontogeny recapitulates phylogeny," meaning that the development of the individual (ontogenetic development) goes through, or repeats, the same sequences as the evolutionary development of the species (phylogenetic development) and that modifications to a species are in the form of additions or accelerations to the adult stage. (Variations of recapitulation theory found their way into psychology through the work of G. Stanley Hall [1904], the first child development theorist of modern psychology. Hall proposed that postnatal ontogenetic development goes through the same behavioral—psychological stages as did the species in phylogenetic time. Hall's ideas were widely regarded, but his recapitulation theory met debilitating criticism based on both logical arguments [e.g., Thorndike, 1913] and embryological data [e.g., Davidson, 1914].)

Neoteny

Contemporary evolutionary theorists no longer see evolution as progressive in the sense of developing toward ever-increasing levels of complexity (see Gould, 1989); nor is the biogenetic law taken seriously. Many aspects of evolution can be seen as additions or accelerations of a developmental trend but certainly not all and perhaps not even most. In many cases, important evolutionary changes are brought about by retardation of development, not by acceleration. This is reflected by the concept of neoteny, which means literally "holding youth" or the retention of embryonic or juvenile characteristics by a retardation of development. Neoteny is an example of the process of heterochrony—genetic-based differences in developmental timing. de Beer (1958) proposed that changes in the timing of ontogeny are the driving force of evolution, and many evolutionary biologists over the course of this century have concurred. For example, Thomson (1988) stated that heterochrony can "readily lead to qualitative shifts" (p. 131) in the morphology of a species. More specific to the retardation of development, Wesson (1991) has suggested that neoteny seems to be a good strategy for evolutionary innovation, permitting "a new beginning and relatively rapid change as the organism backs up evolutionarily to get a better start" (p. 205). Many other theorists over the course of the century have concurred with and extended de Beer's perspective, believing that humans' retarded rate of development contributed significantly to the human species's morphological and behavioral characteristics (e.g., Bolk, 1926; Garstang, 1922; Gould, 1977; Groves, 1989; Montagu, 1989; Wesson, 1991; Wilson, 1980). Groves, for example, has done a careful analysis of the characteristics of hominid skeletons, from Australopithecines through Homo sapiens, and concluded that the line that eventually lead to modern humans did so by becoming increasingly neotenuous.

Theorists of human evolution, such as Bolk (1926), Gould (1977), and Montagu (1962, 1989), have listed a number of physical and functional neotenuous features of humans. These include the shape of the head and face, a late eruption of teeth, the size and orientation of the pelvis, a delicate (or gracile) skeleton, and a nonopposable big toe, among others. Although one could speculate on the potential adaptive value of the maintenance of immature facial features, for example, other neotenuous characteristics have seemingly played a central role in human evolution. For example, the angle at which the human spine connects to the skull permits bipedality (locomoting on two feet). The first great step to humanness was the upright stance, achieved 4.5 to 5.0 million years ago by Australopithecines. Bipedality freed the hands, which was possibly important for using tools and carrying things; it changed the structure of the pelvis, making birth more difficult by requiring that infants be born prematurely so that more brain development could occur postnatally; it changed the structure of the neck and the supralaryngeal airway, resulting in the ability to make sounds and contributing, perhaps, to the evolution of spoken language.

Bipedality requires a change in the angle at which the spine connects with the skull. The opening in the skull where the spine connects to the skull is referred to as the foramen magnum. In all embryonic mammals, the foramen magnum is located at the bottom of the skull, so that the spine enters the skull at a right angle to the top of the skull and parallel to the plane of the face. During prenatal development, the location of the foramen magnum shifts toward the back of the skull, so that in most species of mammals the spine is essentially parallel to the top of the skull and perpendicular to the plane of the face. During prenatal development, the location of the foramen magnum shifts toward the back of the skull, so that in most species of mammals the spine is essentially parallel to the top of the skull and perpendicular to the plane of the face. However, in humans, the position of the foramen magnum does not change appreciably beyond this embryonic stage. Development is retarded, so that at birth and into adulthood the sharp angle of the spine to the skull is maintained. That is, the foramen magnum maintains its embryonic position, with the result being that the skull sits atop the spine, thus permitting one to look forward while standing upright. Because the foramen magnum shifts toward the back of the skull in other mammals, forward sight is more easily accomplished when the animal is on all four feet. Thus, bipedality results from retention of an embryonic characteristic—development is retarded, setting the stage for major evolutionary change (see Gould, 1977; and Montagu, 1989).

Although bipedality is clearly a characteristic central to the definition of human, perhaps the species's most outstanding trait...
is intelligence. Here, people have clearly developed beyond their evolutionary ancestors rather than having development retarded to some earlier embryonic or infantile state (Byrne, 1995). When one is looking at mammals as a group, human brains are far larger than expected for their body size (Jerison, 1973). This increased brain size in humans is selective, with some areas of the brain having evolved at a faster pace than others, most notably the neocortex, the area of the brain most centrally involved in higher cognitive activities (see Eccles, 1989).

This enlargement of the brain was achieved, in part, however, by maintaining the rapid rate of prenatal brain growth into postnatal life. The rate of prenatal brain development is remarkably similar for all primates, including humans (see Bonner, 1988). The brain develops rapidly in comparison with the overall size of the body. Brain growth slows down quickly after birth for chimpanzees, macaque monkeys, and other primates but not for humans. The pace of human brain development begins prenatally continues through the second year of postnatal life (see Gould, 1977). By 6 months, the human brain weighs 50% of what it will in adulthood; at 2 years, about 75%; at 5 years, 90%; and at 10 years, 95% (Tanner, 1978). In contrast, total body weight is about 20% of eventual adult weight at 2 years and only 50% at 10 years. So the brain, which grows rapidly before birth, continues its rapid development postnatally by retaining the rate of growth characteristic of the prenatal period.

The retention of the embryonic growth rate for the brain into the first 2 years of postnatal life is necessitated in part by some physical limitations of women. If a species is going to have a big brain in relation to its body, it will also, of course, have a big skull. But the skull that houses a 2-year-old human brain is far too large to pass through the birth canal of a woman. The evolutionary pressures that resulted in an enlarged brain required that gestation be relatively short. If humans were as well developed bodily at birth as their simian cousins, their heads would never fit through the birth canal, which is limited in width because of the constraints of bipedality. The result is a physically immature infant, motorically and perceptually far behind the sophistication of other primate infants but with a brain that will continue to grow and eventually be able to process language and think symbolically.

The Slow Rate of Growing Up: Consequence to Human Evolution

One of the most important neotenuous aspects of human development is a human's prolonged period of immaturity and dependency; this has important implications for how people live as a species. Compared with other primates, humans take a disproportionate amount of time to reach reproductive maturity. The closer a species's common ancestor is with Homo sapiens, the longer the period of immaturity: in lemurs approximately 2 years, in macaques approximately 4 years, in chimps approximately 8 years, and in humans approximately 15 years (Poirier & Smith, 1974).

Slow growth clearly has its disadvantages, mainly, the likelihood that an individual may die before reproducing. However, there are more obvious advantages to humans' extended immaturity. Although Homo sapiens have seemingly evolved many domain-specific "programs" for dealing with specific problems and with other members of the species (what Cosmides & Tooby, 1987, refer to as Darwinian algorithms), humans, more than any other species, depend on learning and behavioral flexibility for their success. The complexities of human societies are enormous and highly variable, and it takes an extended childhood to acquire all that must be learned to succeed. Because brain growth continues well into adolescence, neuronal connections are created and modified long after they have become fixed in other species (M. Jacobson, 1969). The result is a more "flexible" brain (in terms of what neural connections can be made), which means more flexible thinking and behavior. Additionally, an extended youth provides the opportunity to practice complex adult roles, which, because of their cultural variability and complexity, cannot be hard wired into the brain.

One argument for the importance of delayed development to human evolution centers around the foundation of the human family and social structures (e.g., Gould, 1977; Wesson, 1991). The human infant is totally dependent at birth and will remain dependent on adults for well over 1 decade. Pair bonding and some division of labor (both within and between family members) may be a necessary adaptation to the pressures presented by the slow growth of offspring, increasing the likelihood that children would survive to sexual maturity. The long period of dependency also means that the man's genetic success could not be measured just by how many women he inseminated or by how many children he sired. His inclusive fitness would depend on how many of his offspring reached sexual maturity, thus assuring him of becoming a grandfather. To increase the odds of this happening, his help in the rearing of his children would be needed. A prolonged maturation rate may have contributed to some phylogenetic changes in the human species over the past 4 or 5 million years, but their extended physical immaturity also has a contemporary impact on development. Perhaps the most important aspect of prolonged growth for humans today is related to the plasticity, or modifiability, of the brain and the consequences that has on one's behavior. The human brain continues to gain weight well into the third decade of life. The process of myelination—the insulation of neurons to yield faster signal transmission with less interference—is a slow one in human development.
physical dependence is accompanied by weaker and less persistence. As a result, Mason (1968a) stated, "..."

Behavioral Neoteny

Although humans' slow rate of brain growth may be the proximal cause for the plasticity and flexibility of human cognition, it is accompanied by an extended period of physical and behavioral development. Several theorists have written of behavioral neoteny as the extended juvenile character of human behavior (Cairns, 1976; Lorenz, 1971; Mason, 1968a, 1968b). Cairns (1976) and Mason (1968a) have postulated, for example, that important aspects of human social behavior such as attachment are influenced by behavioral neoteny (see also Cairns, Galeney, & Hood, 1990; and Montagu, 1989), and, according to Lorenz, such juvenile characteristics as curiosity are responsible for human's behavioral flexibility.

Behavioral Neoteny and Flexibility

With respect to behavioral flexibility, Mason (1968a, 1968b) argued that neoteny is a general primate characteristic, both in terms of physical development—as was discussed briefly previously—and in terms of behavior. Mason noted that the prolongation of infancy is greater in chimpanzees than monkeys and greater yet in humans. This extension of infancy and its physical dependence is accompanied by weaker and less persistence of primitive infantile responses (e.g., reflexive grasp, rooting, and oral grasping) and a "loosening" of behavioral organization. As a result, Mason (1968a) stated, "..."

Making similar arguments, Cairns (1976) pointed out that both the instability of individual differences and the high malleability of social behavior over infancy, which are found in all social mammals, are extended in human children and may be due to neoteny. Thus, the behavioral plasticity that characterizes the human species may be due, in large part, to an extended period of immaturity. From this perspective, prolonged infancy and childhood not only provide more time to learn but also when accompanied by a reduced reliance on "instinctive" behaviors may in fact require a greater need for learning.

As all historical sciences, evolutionary theory suffers from the inability to test empirically some of its hypotheses. One cannot turn back the clock and manipulate some factors to determine the phylogenetic outcomes. However, experimental evidence does exist, demonstrating the effects of changes in developmental timing on social behavior across several generations. For example, in a series of experiments, Cairns and his colleagues (Cairns et al., 1990; Cairns, MacCombie, & Hood, 1983) observed that aggressive behavior in mice, measured by latency to attack, increased with age and experience. Mice were selectively bred for latency to attack; one line was selected for high aggression, and another line was selected for low aggression. Cairns and his colleagues noted that later generations of low-aggressive animals exhibited a gradual reduction in asymptotic levels of aggression compared with the foundational generation. More specifically, later generations of low-aggressive animals did not display the typical age-related increases in aggression observed in the first generation. Cairns et al. (1990) described this pattern as an example of neoteny, "..."

Play

Play, which is found in many animals, is extended into adulthood in humans and can be rightfully considered an example of behavioral neoteny (Lorenz, 1971). Many theorists believe that it is primarily through play that children's cognition develops (e.g., Dansky, 1980; Piaget, 1962), and it can be viewed as a vehicle by which neoteny affects development.

There is no doubt of the widespread occurrence of play during the immature stages of many animals. Like the extended period of youth and, in fact, correlated with it, play is most frequently found in species that are behaviorally flexible and particularly in neotenized organisms (Beckoff, 1972; Poirier & Smith, 1974; Vandenberg, 1981). In an early review of animals' play, Groos (1967) stated that "..."
The benefits of play are numerous. For example, play provides the juvenile animal with, among other things, the opportunity to develop motor skills, practice mastery of social behaviors, and learn by experimenting in a situation of minimum consequences (Bruner, 1972; Dollinow & Bishop, 1970). Play, like genetic mutations, provides a source of creativity that may eventually help produce cultural diversity by discovering new ways to solve old problems (Oppenheim, 1981; Vandenberg, 1981); because of the youthful tendency toward play and curiosity in animals, it is likely that new innovations will be introduced by the young rather than the adult. This was demonstrated in the acquisition of the skill of potato washing in Japanese macaque monkeys (Kawai, 1965). A monkey troop was living in the wild but was observed and fed by Japanese scientists. The monkeys were given sweet potatoes, which were often sandy. One juvenile monkey “learned” to wash potatoes in sea water before eating them. Other juveniles subsequently learned, and then so did some adult females; this innovation was then passed on to infants as part of the culture. Few adult males ever learned this, however. Admittedly, it is unlikely that important cultural innovations will be made through the play of human children. Nevertheless, the discoveries children make through play may serve as the basis of later innovations or true creativity, which become important later in life.

Play is observed in the adults of many mammals, although usually in the context of courtship or parent–child interaction (Fagen, 1981). There is no other species that demonstrates curiosity and play into adulthood to the extent that Homo sapiens do. This orientation toward play caused the historian Huizinga (1950) to refer to humans as Homo ludens, “playful man.” Novelty and the unknown are typically avoided in adult animals, with the notable exception of humans. In fact, what academics do for a living is often termed as playing with ideas. Intellectual curiosity, or play, is a hallmark of the human species and likely a necessary component for invention.

Immaturity as a Form of Protection From Overstimulation

Humans’ slow brain development not only permits an extension of behavioral plasticity but may also protect the young organism from overstimulation. Turkewitz and Kenny (1982) proposed that, similar to the arguments cited earlier made by Oppenheim (1981), the immaturity of sensory and motor systems may play adaptive roles early in development. The limited motor capacities of altricial animals (i.e., those who are physically immature and helpless at birth and need substantial parental care) prevents them from wandering far from their mother, thus enhancing their chances of survival. Of greater interest, however, was their proposal that sensory limitations of many young animals are adaptive because they serve to reduce the amount of information infants have to deal with, which facilitates their constructing a simplified and comprehensible world. In the next section, this proposal is assessed by examining the consequences of stimulation in excess of a species’s norms on the subsequent perception and learning of young animals. It is followed by a section examining the consequences of early learning experiences on later learning by infant animals and humans. In the third section, I discuss the possibility that limitations of young children’s working memory may make the process of language acquisition easier. Most of the research I present in the next two sections was conducted with animals. Although one must be cautious in generalizing research findings across species, infancy is a time when such comparisons are most apt to be informative, and I believe that, given the similarities of perceptual development across a wide range of species (see Gottlieb, 1971), mechanisms found to underlie the development of infrahuman animals can gainfully inform the psychologist interested in human development, especially considering the dearth of evidence from testing human participants.

Adaptive Value of Immature Sensory Systems

Turkewitz and Kenny (1982) proposed that early maturing senses may not develop properly if other senses were “competing” with them for neurons and that limited sensory functioning reduces sensory input and serves to decrease competition between developing senses. From this perspective, immature sensory systems are not handicaps that must be overcome but are adaptive and necessary for proper sensory development and sensory learning.

Evidence in support of Turkewitz and Kenny’s (1982) proposal has been reported for a number of species, with most research conducted with precocial birds (i.e., ducks and bobwhite quail), in which—as with all vertebrates—hearing develops before vision (Gottlieb, 1971). Like other precocial birds, ducks and bobwhite quails show a preference for the maternal species call, which is important in attachment. Working with quails, Lickliter and his colleagues (Lickliter, 1990, 1993; Lickliter & Hellewell, 1992; Lickliter & Lewkowitz, 1995) used a procedure to provide quails with visual exposure while still in the egg. The procedure involved cutting a hole in the egg near the head and providing patterned light 2 to 3 days prior to hatching. In one series of experiments (Lickliter, 1990), quail chicks were placed in the middle of a round tub 1 or 2 days after hatching. The maternal call of a quail was played from a speaker on one side of the tub and the maternal call of a chicken was played from a speaker on the opposite side. Quail chicks in the control group (egg opened and no premature visual experience) showed the species–typical pattern: Most approached the speaker emitting the maternal bobwhite quail call (29 of 32 animals). However, most of the experimental animals showed no preference (25 of 44 animals), and some (14 of 44 animals) even preferred the call of the chicken. Similar results of interference of early visual exposure on later approach behavior have been found with ducks (Gottlieb, Tomlinson, & Radell, 1989). Other research has shown that specific types of auditory stimulation can interfere with subsequent visual development in bobwhite quails (McBride & Lickliter, 1994) and that extra visual stimulation can interfere with olfaction in rats (Kenny & Turkewitz, 1986). The extension of the idea that limited sensory abilities might be adaptive in altricial mammals was made explicitly by Spear (1984) in reference to neonatal rats, which are functionally deaf and blind: “If this animal could be made to see and hear, it seems at least as likely that severely maladaptive behavior would result due to distraction from the more conventional events (e.g., odors) upon which its survival depends” (p. 335).
It should be noted that, in the Lickliter (1990) study, the prehatching visual stimulation did result in the acceleration of visual development in the chicks. However, this acceleration was at the expense of the development of the auditory system, which seriously hindered species-typical attachment behavior. It is also worth noting that attenuated prehatching stimulation results in a slowing of sensory systems (Lickliter & Lewkowitz, 1995). In general, developmental changes in sensory systems appear to be timed to correspond to species-typical experiences. When an animal receives stimulation that varies substantially from the species-typical pattern, postnatal sensory development is impaired.

Because the auditory system develops before hatching, there is the opportunity for some prenatal learning to occur. For example, quail and duck chicks recognize the call of their mothers versus the calls of other females birds shortly after hatching (e.g., Gottlieb, 1988). Lickliter and Hellewell (1992) assessed the effects of extra-pre-hatching stimulation on such auditory learning. Quail embryos heard a specific maternal call, some with and some without additional visual stimulation, while still in the egg (Experiment 4A). Twenty-four hours after hatching, the quail chicks were put in a choice situation, where they heard the previous, familiar maternal call versus the maternal call of another bobwhite quail (a novel call). Preference for the familiar maternal call was the key dependent measure. Replicating their earlier findings (e.g., Lickliter & Hellewell, 1992, Experiment 1A), Lickliter and Hellewell reported that the bobwhite quail chicks exposed only to the maternal call showed a significant preference for that call. In contrast, the chicks that received the additional visual stimulation showed no such preference, making no distinction between the familiar and novel calls. That is, extra visual stimulation interfered with auditory learning. These findings are consistent with the position that the species-typical pattern, in which one system receives stimulation and develops before another, is adaptive. Hastened development in one system can interfere with development in a second system.

The findings of Lickliter and Hellewell (1992) are consistent with Türkewitz and Kenny’s (1982) proposal that the differential rates of maturation of sensory systems minimize intersensory competition. Accelerating development of a late developing system interferes with the development of the normally early developing system. A related hypothesis is that intersensory interference can occur even when a fully developed sensory system (e.g., the vestibular system), which should not be competing for neurons with an immature system, receives extra stimulation. That is, stimulation that exceeds the species-typical range can interfere with development, regardless of whether the stimulated system is fully developed or still immature.

This possibility was investigated in a series of auditory-learning experiments by Radell and Gottlieb (1992). As in the Lickliter and Hellewell (1992) experiments, mallard duck embryos heard a specific maternal call. Some prehatchlings also received extra levels of vestibular, proprioceptive, and tactile stimulation, delivered by placing eggs on a rocking waterbed. Four to 8 hr after hatching, the ducklings were put in a choice situation where they heard simultaneously the familiar and novel maternal duck calls. When low and species-typical levels of motion were experienced (Experiment 4), no differences in choice behavior were observed between the control (no motion) and experimental animals. However, when the waterbed motion was substantially greater than would normally be experienced by the duck embryos, significant differences between control and experimental animals were found. Whereas 91% of the ducklings in the no-motion condition approached the familiar maternal call ( Experiment 1), only 42% of the ducklings in the high-motion condition did so (Experiment 2A). Thus, it appears as if stimulation in excess of the species-typical range in any sense modality can interfere with ontogeny of a still-developing sense. These findings, although suggesting a modification of the Türkewitz and Kenny (1982) hypothesis, are consistent with the idea that slow developing and immature systems provide opportunities for earlier developing systems to develop properly. What these data indicate, however, is that the type of excessive sensory stimulation that can interfere with development extends beyond that associated with still-developing systems.

I know of no experiments comparable with those performed on precocial birds that assess the effects of excessive levels of stimulation on perceptual development in human infants. However, experiments in the early days of infant-perception research indicate that infants’ preference for visual complexity increases with age, with younger infants preferring to look at less complex stimuli (usually stimuli with less contour) than do older infants (e.g., Greenberg & O’Donnell, 1972; Hershenson, Munsinger, & Kessen, 1965; H. Thomas, 1965), suggesting that there is an optimal level of perceptual stimulation for infants that increases with age. Also an equally venerable literature indicates that enriched visual, tactile, kinesthetic, or all of the above stimulations for premature or low-birth-weight infants (Scarr-Salapatek & Williams, 1973; Solkoff, Yaffee, Weintraub, & Blase, 1969; J. L. White & LaBarba, 1976) or for orphanage-reared infants (B. L. White & Held, 1966) results in enhanced perceptual, physical, or intellectual development. There is every reason to believe that providing human infants with a perceptually varied and stimulating environment positively fosters development. However, animal research informs theorists that stimulation should be within the species-typical range and that stimulation that exceeds this range early in development may have unintended maladaptive consequences.

**Consequences of Early Learning on Later Learning**

The findings of Lickliter and Hellewell (1992) and of Gottlieb and his colleagues (Gottlieb et al., 1989; Radell & Gottlieb, 1992) indicate that extra-pre-natal stimulation in one sensory system (vision or vestibular) can adversely affect later learning in another system. Related to this issue is the question of whether an early learning experience in infancy can interfere with later learning. Relatively little research focused directly on this question, although relevant research does exist for at least three species, rats, monkeys, and humans.

Using rat pups, Rudy, Vogt, and Hyson (1984) reported a classical conditioning study in which animals were trained to make mouthing activity (which was initially elicited by the unconditioned stimulus of a 10% sucrose solution) to auditory stimuli (e.g., a 2,000 Hz, 9 dB tone SPL). Conditioning began when the pups were 10, 12, or 14 days old, and testing continued until they were 16 days old. Despite the greater experience on the conditioning task, performance on Days 14 and 15 was
worse for the animals that began training at 10 days old than for those that began training at 12 days old. Moreover, these pups never performed better than the pups who began training at 14 days old, leading Rudy et al. to conclude that the early training had a detrimental effect on the pups' ability to benefit from later training.

Spear and Hyatt (1993) discussed the results of two unpublished studies from their laboratory on conditioning in infant rats that similarly show impairment of later learning as a result of earlier learning experiences. In one study, rat pups that were given active avoidance training at 15 days old took more trials to reach the criterion on the same task at 75 days old than rats that were exposed to the tasks for the first time at 75 days old (p. 188). In a second study cited by Spear and Hyatt (an unpublished dissertation by N. Lariviere, 1990), rat pups, beginning as early as 12 days old, were exposed to some or all of the components of a classical conditioning task involving lights, tones, or both. Pups were given a criterion test at postnatal Days 17 and 18—the earliest time that conditioning with flashing lights paired with foot shock is usually observed. Spear and Hyatt reported that animals that had previously been exposed to the conditioned and the unconditioned stimuli demonstrated substantially impaired conditioning on Days 17 and 18. They concluded that “apparently, if experience with an episode to be learned later is given too early in life, learning of that episode in later ontogeny is impaired” (p. 189).

Similar evidence of a detrimental effect of early learning on later learning was provided by Harlow (1959), who studied object-discrimination learning in rhesus monkeys. Infant monkeys were given single discrimination tasks (e.g., triangle vs. circle) with three-dimensional stimuli that varied on multiple dimensions, such as color, form, size, and material. They were given 25 trials per day, 5 days per week for 4 weeks. Testing began when animals were either 60, 90, 120, 150, or 366 days old. Beginning at 120 days old (or later), these monkeys were given new sets of more complicated learning-set problems, using the same set of stimuli as on single-discrimination problems. Monkeys were tested on 4 problems per day, 5 days per week, 6 trials per problem, for a total of between 400 and 600 problems. Performance on these problems, beginning at 120 days old, is shown in Figure 1 as a function of the age at which the monkeys began training.

Performance of the two youngest groups of monkeys never stayed far from chance levels (50%), despite the fact that they were 10 and 11 months old at the conclusion of training. From 260 days old and onward, these early trained monkeys' performance was inferior to that of the other groups with less experience but matched for age. This suggests that early training was detrimental to later learning for these young monkeys. Harlow (1959) concluded that

there is a tendency to think of learning or training as intrinsically good and necessarily valuable to the organism. It is entirely possible, however, that training can either be helpful or harmful, depending upon the nature of the training and the organism's stage of development. (p. 472)

Research with human infants pertinent to this question was conducted by Papousek and initially reported in the late 1960s (see Papousek, 1977; and Sameroff, 1971). Infants were conditioned to turn their heads in response to auditory stimuli—turn one way to the sound of a bell and the other way to the sound of a buzzer. Training began either at birth, Day 31, or Day 44. The older infants had had some training on simpler discrimination tasks, whereas this complex learning task was the first experience for the newborns.

The younger the children started the training, the more trials it took them to attain criterion (M no. of trials to reach the criterion: newborns = 814; 31-day-olds = 278; 44-day-olds = 224). This makes sense if age of maturation is the critical factor. But note that, whereas the difference between the 31- and 44-day-old infants is consistent with such a maturation hypothesis, the data from the newborns are not. They required many more trials than would be predicted based on age (i.e., maturation) alone. This is made clear when one examines the age at which infants reached the criterion (M age in days at which infants reached the criterion: newborns = 128; 31-day-olds = 71; 44-day-olds = 72). Infants who began training at birth took nearly twice as long to master the discrimination-learning problem as infants who began at 31 and 44 days old. Because infants apparently had a variety of testing experiences between the time of their first and final exposures on this task and because control groups that did not experience retroactive interference were not tested, one must be cautious when interpreting these results (C. Rovee-Collier, personal communication, September 30, 1996).

But these data are suggestive of the possibility that not all learning experiences are necessarily good for infants—sometimes, learning experiences are not only useless for infants who lack the requisite cognitive abilities but sometimes may actually be detrimental to later learning and development.

Despite the long history of research in infant learning, there appear to be few other studies designed to assess the consequences of early learning experiences on later learning. The only other relevant study I am aware of was performed by Little, Lipsitt, and Rovee-Collier (1984). In this study, separate groups of 10-, 20-, and 30-day-old infants were subjected to classical eyelid conditioning procedures and then tested again with the same procedures 10 days later. For infants whose initial testing was at 20 days old, there was a savings effect: Their performance 10 days later was greater than that of 30-day-old infants tested for the first time. There was no such savings effect 10 days later for infants whose initial testing began at 10 days old, but there was also no decrement in performance, as might be expected given the findings of Papousek (1977).

There is a paucity of research on the topic of the effects of early learning experience on later learning. There is no question that infants begin learning at birth and before (e.g., DeCasper & Spence, 1986), and I find it unlikely that learning experiences early in life will have long-term negative consequences. However, the meager evidence suggests that some specific learning experiences can adversely affect later specific learning experiences (e.g., Harlow, 1959; Papousek, 1977) and that there may be no benefit in terms of savings to begin a learning task very early in infancy (Little et al., 1984). This is clearly an area in which further research on well-trodden topics is warranted.

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2 I wish to thank Carolyn Rovee-Collier for pointing out this study to me.
**Language Acquisition: When Less Is More**

From a phylogenetic perspective, language is clearly an "addition." If the great apes are any indication of what human's common ancestors may have been like, they were not language users. No other primate engages in anything that even closely resembles human language in their natural habitat; although enculturated chimpanzees can presumably learn several hundred words and a limited syntax, they seem unable to advance beyond the language competence of an average 2-year-old human child (Savage-Rumbaugh et al., 1993). From this perspective, language would not seem to be a good candidate to look for adaptive immaturity. Yet, much as an immature nervous system reduces the amount of stimulation the infant receives and thus facilitates the development of the various sensory systems, so too might certain immature characteristics of children's information-processing abilities set the stage for the rapid process of first- and second-language acquisition observed in young children.

Most scholars of language development have adhered to the idea that there is a critical or sensitive period for the acquisition of a first and second language (e.g., Hurford, 1990; Lenneberg, 1967; Locke, 1993; Newport, 1991). There are at least four sources of evidence for this assertion (see Locke, 1993): (a) People who were socially deprived or isolated during infancy and early childhood typically demonstrate only a tenuous mastery of language (e.g., Curtiss, 1977), (b) eventual proficiency of a second language is greater the younger one is when exposed to that language (e.g., Johnson & Newport, 1989), (c) the eventual proficiency of sign language by deaf people—their first language—is greater the younger one is when exposed to that language (e.g., Newport, 1990), and (d) recovery of language function from brain damage is greater when the damage occurs earlier rather than later (e.g., Witelson, 1987). From this and other evidence, it appears that, as the brain matures, it loses its plasticity to acquire language.

There has been some interesting speculation that young children's fantastic language-acquisition ability may be accompanied by a set of immature cognitive skills. Recall the research with ducks and bobwhite quails indicating that sensory immaturity in one system was associated with enhanced development in another system (e.g., Lickliter, 1990). A similar relation may exist between young children's limited information-processing skills and language acquisition.

Newport (1991) has developed a model of language acquisition based on what she calls the "less is more" hypothesis. Her proposal is that cognitive limitations reduce competition, thus simplifying the language corpus the infant and young child must process and making it easier to learn language. With success...
and time, maturationally paced abilities gradually increase, as
does language learning. Young children in the early stages of
language learning start out slowly—actually more slowly than
do adults learning a second language. They perceive and store
only component parts of complex stimuli. They start with single
morphemes (usually a single syllable) and gradually increase
complexity and the number of units they can control. They are
able to extract only limited pieces of the speech stream. But
this results in a simplified corpus that actually makes the job of
analyzing language easier. Adults, in contrast, start out learning
a second language faster than children; they are more competent
initially, producing more complex words and sentences. They
more readily perceive and remember the whole complex stimu-
lus. But this advantage is short lived. Adults extract more of
the input but are then faced with a more difficult problem of analyzing
everything all at once.

Newport (1991) conducted a computer simulation, varying
the amount of information that would be processed in the
computer’s “working memory” at one time. A restricted input filter
(i.e., limited working-memory store) yielded (a) some loss of
data for morphology learning, thus making learning initially
more difficult; (b) greater loss of data at the whole-word level
than the morphology level; and (c) an improvement in the sig-
nal-to-noise ratio, such that there is greater loss of data from
accidental co-occurrences than from systematic co-occurrences
of form and meaning. Overall, a restricted filter (i.e., limited
working memory) was more successful at acquiring morphology
than was a less restricted filter or no filter at all. The latter
“entertained” too many alternatives and could not uniquely
determine which was the better one.

A similar interpretation has been derived from experiments
with connectionist networks by Elman (1994). Elman used a
specific type of connectionist network called a simple recurrent
network (Elman, 1990). In his simulation, Elman (1994) pro-
vided the network with sentences involving subject–verb agree-
ment for number and the potential for multiple relative clause
embeddings. The network had to “learn” both local and long-
distance subject–verb agreement (e.g., “The zebras who the
lion chases find the hiding place”). In this example, there is
local agreement between lion and chase. However, the agree-
ment between zebras and find is long distance, dependent on
the hierarchical structure of the sentence.

Initial attempts, in which the entire corpus was presented to
the network in a random order, failed to yield evidence of lan-
guage acquisition. The network did not learn correct long-
distance subject–verb agreement (i.e., the wrong form of the
verb was selected by the network). Following these initial fail-
ures, Elman (1994) simplified the corpus that the network re-
ceived, beginning with only simple sentences and gradually in-
creasing the percentage of complex sentences presented to the
network. Under these conditions, the network was correct in its
selecting grammatically correct forms of verbs (i.e., verbs that
agree with the appropriate subjects) for all of the different sen-
tence types. In a subsequent simulation, Elman varied the net-
work’s memory for words, beginning with a limited memory
of three to four words and increasing memory at subsequent
stages in the simulation. Now when the entire corpus, including
both simple and complex sentences, was presented to the net-
work, learning occurred, much as it did in the earlier simulation
(i.e., when sentence complexity increased in stages). In both
situations, limitations in what the network could process, deter-
mined either by the simplicity of the sentences presented or the
limitation of how much the network could keep in its memory
at any one time, produced language learning. Elman used the
metaphor, “the importance of starting small,” to describe his
findings and suggested the critical period for language acquisi-
tion reflects the developmental delay of certain abilities rather
than the loss of some language-specific capacities. Thus, young
children’s limited working-memory capacity restricts how much
language information can be processed. This simplifies what is
analyzed, making the task of language acquisition easier.

Adaptive Value of Cognitive Immaturity

Immature sensory systems or limited working-memory ca-
pacity are proposed to be adaptive because they reduce the
amount of stimulation an organism receives, thus making the
process of sensory or language development easier. Other as-
pects of immaturity, rather than fostering the development of
specific systems by simplifying input, may provide some imme-
diate benefits to the organism, although these benefits may be
coupled with some handicaps.

Certain aspects of young children’s cognitive functioning can
be seen in this light. The cognitive limitations of preschool
children are well documented. This theme was central in Piaget’s
theory, as reflected by his description of the stimulus-bound,
ecocentric, and intuitive preoperational child in contrast to the
decentered, nonecocentric, and logical concrete-operational
child. One need not be a Piagetian or an advocate of any stage
theory to believe in the immaturity of preschool thought. The
5- to 7-year shift (e.g., S. H. White, 1965; 4- to 7-year shift,
Nelson, in press; or the 3.5- to 4.0-year shift, Perner, 1991) has
been noted by a variety of theorists, who have provided a variety
of explanations to account for the mental deficiencies of pre-
school children.

Such cognitive immaturity, although real, may reflect defi-
ciences only in relation to the cognition of older children. Some
aspects of young children’s immature cognition may have an
adaptive role for them at that particular time in development. It
is deficient in terms of what it is to become, but it may be quite
efficient in terms of what problems it helps the child to solve
at this particular point in development.

In a previous article, Bjorklund and Green (1992) introduced
the possibility that some aspects of young children’s immature
cognition—especially egocentricity and poor metacognition—
could, under some circumstances, be adaptive. It was not argued
then, nor is it argued here, that such immature characteristics
were always adaptive; in fact, it seems obvious that an overly
self-centered perspective and the state of being out of touch with
one’s cognitive abilities is generally maladaptive. However, these
detrimental to good cognition may have associated with them
some occasional benefits. In other words, looking only at the
negative side of young children’s limitations provides an incom-
plete and overly pessimistic picture of these children’s cognitive
functioning. In this section, I review briefly the findings that led
Bjorklund and Green to their earlier interpretation, and I present
new data and theory to bolster the position that young children’s
immature cognition can have some positive consequences.
Egocentricity

It is well established that people of all ages tend to remember more information when they relate the target information specifically to themselves at time of encoding, later at retrieval, or both (e.g., Kail & Levine, 1976; Lord, 1980; Nadelman, 1974; Pratkanis & Greenwald, 1985). One implication of self-referencing memory experiments is that young children’s egocentric tendencies may bias them to encode events in terms of themselves more so than older children would, thus enhancing their retention (see Mood, 1979).

More recent research in source monitoring similarly has suggested that young children’s bias toward self-referencing may contribute to enhanced cognition rather than as solely a detriment to thought. Source monitoring refers to people’s ability to ascertain the origins of some information. In one type of source monitoring, people must determine whether they themselves had performed an action or if they had observed someone else perform it. In a series of experiments, Foley, Ratner, and their colleagues (Foley & Ratner, 1996; Foley, Ratner, & Passalacqua, 1993) asked 4-, 6-, and 8-year-old children to make a collage with an adult. Children were later unexpectedly asked to tell the experimenter who had put each of the objects on the collage, themselves or the adult. What Foley, Ratner, and their colleagues were interested in was attribution errors: To what extent would children falsely attribute an action (putting objects on the collage) of their own to an adult (“You did it”) attribution) versus falsely attribute an action done by an adult to themselves (“I did it” false attribution)?

Six- and 8-year-old children were no more likely to make “I did it” false attributions as “You did it” false attributions (Foley et al., 1993). In contrast, 4-year-olds were consistently more likely to attribute an action performed by an adult to themselves (“I did it”) than the reverse (Foley & Ratner, 1996, in press; Foley et al., 1993; Ratner & Foley, 1997). Young children’s pattern of responding can be attributed to an egocentric perspective (i.e., when in doubt, take personal credit for an action). Foley, Ratner, and their colleagues suggested that this bias may result in better learning of the actions of others, in part because misattributing the actions of another to oneself may result in children linking the actions to a common source (themselves), thus producing a more integrated and easily retrievable event memory. According to Foley and Ratner (1996),

if the bias we report is a reflection of children’s more frequent anticipations or subsequent re-creations of the actions of another person, increasing confusion between self and others, actions themselves may be better understood and better remembered when these anticipations occur. Thus, children who actually display a pronounced source monitoring bias may subsequently perform quite well on their own after guided participation in a similar joint activity. Thus, taking the other “into the self may be an important mechanism for promoting children’s learning and remembering. (pp. 19–20)

Ratner and Foley (1997) have recently collected data to test this hypothesis. Five-year-old children were asked to place six pieces of furniture in the rooms of a doll house (cf. Freund, 1990). One group did this in collaboration with an adult, alternating turns with the adult. For children in the no-collaboration group, half of the items had already been placed in the house by the adult before the child entered the room and the adult asked the child to place the remaining items in the rooms. When the children were later asked questions about who had placed each item in each room, those in the collaboration group made significantly more “I did it” attribution errors than those in the no-collaboration group. Moreover, when the children were later given the furniture and asked to place each piece in the room where they had been placed before, those in the collaboration group were correct more often and also made more planning–explanatory statements while recategorizing than did those in the no-collaboration condition. Thus, as Ratner and Foley predicted, collaboration led to both more self-attribution errors and better learning than did no collaboration. Although other interpretations are possible (e.g., a greater depth of processing for children in the collaboration group from watching the adults place items), this is consistent with the claim made here: that is, in some circumstances, an egocentric bias can have a positive effect on learning.

The results of these experiments should not be interpreted as reflecting that egocentricism in young children is not sometimes a hindrance to good cognition. It is an expression of an immature cognitive system and may hamper more “mature” thought in many situations. Social responding is especially hampered by an egocentric attitude, and children must overcome their generally self-centered perspective if they are to interact comfortably in the adult world. However, the findings of the various studies cited above do indicate that a focus on only the detrimental aspects of young children’s egocentricism without considering the possible adaptive functions yields an incomplete picture of children’s development.

Metacognition

Another area in which young children’s immature cognition may sometimes be a blessing in disguise is metacognition, particularly as it relates to how competent children see themselves. Metacognition refers to the knowledge people have about the workings of their own minds—their mental weak and strong points, skills they possess, and ability to evaluate and monitor their own problem solving. For most forms of cognition, one can think of a corresponding form of metacognition. The developmental relation between cognition and metacognition is a bidirectional one, with changes in one factor influencing changes in the other (see Schneider, 1985). Although both cognition and metacognition within a domain typically improve with age, the relation between the two is not always strong (e.g., Cavanaugh & Borkowski, 1980). However, that good metacognition is usually associated with good cognition is illustrated by studies with school-aged children that show a positive correlation between metacognition and intelligence (e.g., Schneider, Körkel, & Weinert, 1987). That is, as one would expect, school-aged children with good metacognition are, on average, brighter than school-aged children with poor metacognition.

Prediction—performance relations. One aspect of metacognition that is particularly relevant for my purpose is the relation between children’s predictions of their abilities and their actual performance. On the other side of the coin is posttask evaluation (postdiction), how well children think they have performed
some task. Prediction and postdiction are important factors in both cognitive and social development. Bandura (1989) has concluded that the confidence people have in their competence in a particular domain influences what tasks they choose to perform and how long they persist at those tasks. Thus, a child's degree of confidence influences which tasks he or she attempts and how long he or she persists at a task before quitting. This, in turn, determines to a significant extent what is learned.

There is abundant evidence that preschool and early school-aged children overestimate their own abilities on a broad range of cognitive tasks (e.g., Bjorklund, Gaultney, & Green, 1993; Schneider, 1991; Stipek & Mac Iver, 1989; Yussen & Levy, 1975), and in general think they are "smarter" than others think they are (e.g., Stipek, 1981, 1984; Stipek & Hoffman, 1980; Stipek, Roberts, & Sanborn, 1984). Stipek (1981, 1984) reported that young children's assessments of their school-related abilities are quite high. Most children in the first grade and before think of themselves as being "one of the smartest kids in my class." It is only at the second and third grades that children begin to have a more realistic estimate of their academic standing. Beginning about this time, children's assessments of their school abilities are consistent with the assessments of their teachers and peers. Stipek (1984) has stated that children's tendencies to overestimate their skills may provide them with basic confidence in their own competence. Rather than trying to make young children's judgments of their abilities more accurate, she believes that theorists should "try harder to design educational environments which maintain their optimism and eagerness" (p. 53).

There seems to be no single reason for young children's overly optimistic bias in their abilities. When given specific feedback, preschool children can make more accurate assessments of their abilities (e.g., Clifford, 1978; Stipek & Daniels, 1988), and they are able to make accurate assessments of other children's abilities, arguing that they have the cognitive competence to make accurate predictions. Young children seem to have different, more lenient criteria for evaluating success and failure for themselves than for others (e.g., Schneider, 1991; Stipek, 1981), do not differentiate effort from ability (e.g., Harter & Pile, 1984), and may have a difficult time distinguishing their wishes (how they wish to perform) from their actual expectations (e.g., Stipek, 1984).

Regardless of the reasons for young children's inaccurate predictions of their performance, such overestimation of one's ability would seem to be a detriment to skilled performance. As noted earlier, in school-aged children, IQ and metacognition are usually positively related (e.g., Schneider et al., 1987). Nonetheless, Bjorklund and Green (1992) have argued that being out of touch with one's physical and mental abilities has benefits for young children, those who are at the low end of the physical- and mental-ability scales. When children have poor metacognitive skills, they believe that they are capable of more than they really are. This encourages exploration of new territories and reduces fear of failure in young learners. This was demonstrated in a study of meta-imitation (the knowledge of one's own imitative abilities; Bjorklund et al., 1993). In the study, 5-year-old children who were more accurate in predicting and postdicing their imitative abilities (i.e., who overestimated less) had higher IQs than did the less accurate children. In contrast, 3- and 4-year-old children with higher IQs were those who most overestimated their imitative abilities (see Figure 2; because almost all children overestimated, lower scores represent less overestimation [and thus greater accuracy] and higher scores represent more overestimation [and thus greater inaccuracy]).

Bjorklund et al.'s (1993) interpretation of these results was that immature metacognition allows young children to imitate a broad range of behaviors without the knowledge that their attempts are inadequate. Without this negative feedback, bright young children continue to try their hand at many behaviors, thus permitting them to practice and improve their skills at a time when trial-and-error learning is so important. As their motor skills improve, so do their metacognitive skills, which later in development are associated with more advanced thinking abilities.

Seligman (1991) has proposed that children's overly positive view of their abilities, and of the world in general, is not something limited to upper-middle-class children who can afford to be optimistic about the future but is characteristic of the species and was selected in evolution:

"The child carries the seed of the future, and nature's primary interest in children is that they reach puberty safely and produce the next generation of children. Nature has buffered our children not only physically—prepubescent children have the lowest death rate from all causes—but psychologically as well, by endowing them with hope, abundant and irrational. (p. 126)"

Metacognition and strategy development. Another area in which children's poor metacognition may occasionally provide some benefit is strategy development. Typically, children's metacognitive knowledge about strategy use and task performance is positively related, although such positive relations are not always found and are often constrained by context (see Bjorklund & Douglas, 1997; Schneider & Bjorklund, in press; and Schneider & Pressley, 1997).

Recent research has shown that, when children use strategies, they sometimes do not experience substantial benefits in task performance compared with their performance when not using a strategy or to that of older children who are comparably strategic. Miller (1990, 1994) has identified this pattern as a utilization deficiency. It has been investigated most frequently in the area of memory development; although it is a relatively recent discovery, partial or strong evidence of utilization deficiencies has been found in over 90% of developmental studies involving spontaneous strategy implementation (see Miller & Seier, 1994) and in more than half of memory training studies (see Bjorklund, Miller, Coyle, & Slawinski, in press) published over the past 20 years. Utilization deficiencies are not limited to the use of memory strategies but have been found for strategies of selective attention (e.g., Miller, Haynes, DeMarie-Dreblow, & Woody-Ramsey, 1986), reading (e.g., Gaultney, 1995), and analogical reasoning (e.g., Munn-Broadus, 1995), among others (see Bjorklund & Coyle, 1995; Miller, 1994; and Miller & Seier, 1994, for reviews). It is precisely when children demonstrate utilization deficiencies that poor metacognition may facilitate rather than hinder performance.

In a series of experiments from our laboratory, my colleagues and I assessed utilization deficiencies in children between Ages
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Figure 2. Correlation between IQ scores and prediction and postdiction imitation scores by age (note that negative correlations imply that children with higher IQs overestimated less, i.e., were more accurate, than did children with lower IQs). Data from Bjorklund, Green, and Gaultney (1993).

6 and 13 for the memory strategy of organization (grouping and recalling sets of categorically related items together). Children were given different sets of categorized items over a series of trials. A utilization deficiency is defined as occurring when measures of strategy use increase significantly between consecutive trials in the absence of a corresponding increase in recall (Bjorklund, Coyle, & Gaultney, 1992; Bjorklund, Schneider, Cassel, & Ashley, 1994; Coyle & Bjorklund, 1996). Utilization deficiencies were rarely observed for the youngest children (6-year-olds), most of whom were not yet using strategies, or for the oldest children (13-year-olds), most of whom were using strategies effectively. Utilization deficiencies were observed, however, in about $\frac{1}{2}$ of the 7- to 9-year-old children tested, both for spontaneous strategy use (Bjorklund et al., 1992; Coyle & Bjorklund, 1996) and for generalization of a trained strategy (Bjorklund et al., 1994).

Why should children use an effort-consuming strategy to guide their behavior when it has no positive impact on their task performance? One speculation is that utilization deficiencies may be related to children's poor metacognition and a belief that problem solving requires hard work (Bjorklund & Coyle, 1995; Bjorklund et al., in press). Perhaps children believe that performance may be enhanced by using a systematic approach to a problem, but they do not have the metacognitive knowledge to realize that this approach does not (as yet) yield benefits. Children may know, from informal instructions by adults or their own spontaneous problem solving, that doing something or thinking about how to solve a problem is in general more advantageous than doing nothing or not thinking about a problem. If this is the case, children may adopt a strategic approach to a problem when one is discovered, leading eventually to the efficient use of that and other strategies. This is similar to the argument made by Wellman (1988) in describing preschool children's use of faulty strategies—effortful, goal-directed activities that do not help performance. Discussing preschoolers' possible motivations for using faulty strategies, Wellman (1988) asserted that "young children may simply come to prefer a strategic or intelligent approach to problem solving, regardless of immediate payoffs . . . [and that] . . . faulty approaches are generated by coherent but mistaken notions of what will work" (p. 26).

Siegler (1996) has speculated that utilization deficiencies may play an important role in children's adaptive strategy choices. In discussing the phenomenon of utilization deficiencies, he stated that the cognitive system may operate as if it knew the law of practice. With practice, any new procedure is likely to become faster, easier, and more accurate. If a new approach is even approximately as useful as an established one, it makes sense from a long-term perspective to use the new procedure, because substantial improvement in its effectiveness is more likely. (p. 141)

Although I know of no evidence that utilization deficiencies result in long-term strategic benefits, there is evidence that a
utilization deficiency may lead to more effective strategy use relatively quickly. In the experiment by Bjorklund et al. (1992), 44% of the third-grade children who were classified as utilizationally deficient demonstrated increases in recall on subsequent trials. That is, for these children, the utilization deficiency was short lived, with children eventually experiencing the benefit of strategy use. Microgenetic and short-term longitudinal studies will be necessary to evaluate the long-term benefits of utilization deficiencies on children's cognition.

Thus, young children's poor metacognition may provide them an advantage (cf. Bjorklund et al., 1993); a child with better metacognitive skills may realize quickly that the extra effort being put into the task is not resulting in improved performance and thus resort to a nonstrategic approach. In contrast, by being out of touch with the relationship between strategy use and task performance, utilizationally deficient children may persist in using a strategy until it becomes sufficiently efficient to result in improved task performance. In this case, children's immature cognition is adaptive, leading to eventual (though not immediate) benefits.

Concluding Remarks

In this article, I have attempted to place the concept of developmental immaturity in the perspective of evolutionary theory and to demonstrate how the concept can be applied to achieve a better understanding of human development. The principal premise of this article is that developmental immaturity can sometimes be adaptive and has been selected in evolution for the survival value it afforded the young organism. Some, but not all, aspects of developmental immaturity may still be adaptive to modern humans. When one considers the nature of the physical world in which a child at any particular age lives and the tasks he or she must master, some immature qualities may afford more advantages than disadvantages. I do not wish to imply, however, that all aspects of developmental immaturity are adaptive. Many aspects of a prolonged youth may be necessary correlates of other adaptive changes and may themselves have no adaptive function. In fact, they may be maladaptive, just not so maladaptive as to cause extinction.

In proposing that psychologists and educators view children's immature behavior and forms for their possible advantages, I do not intend this perspective as praise for immaturity or to suggest that children's immature thinking and behavior should be extended. Although it is tempting to take a romanticized view of childhood—as a time of carefree play and innocence—I am not arguing for the artificial prolongation of youth by "babying" children. Adults of a society must see to it that children grow up to be independent and responsible people. Prolongation of immaturity is deleterious, and maturity is still the goal of development. Instead, I suggested that there may be some adaptive functions for immaturity that co-exist with the maladaptive ones—at least at certain times in development.

This view of development provides a strikingly different perspective than the one traditionally taken by contemporary psychologists, educators, and parents. How we view development affects how we see children develop. It influences what questions we ask about development, how we educate children, and our perspective toward remediation. The current perspective should not turn any major theory of development on its head, but it should provide a new respect for the immature cognitions and behaviors of infants and young children.

References

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