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Child Development and Evolutionary Psychology

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Evolutionary developmental psychology involves the expression of evolved, epigenetic programs, as described by the developmental systems approach, over the course of ontogeny. There have been different selection pressures on organisms at different times in ontogeny, and some characteristics of infants and children were selected in evolution to serve an adaptive function at that time in their life history rather than to prepare individuals for later adulthood. Examples of such adaptive functions of immaturity are provided from infancy, play, and cognitive development. Most evolved psychological mechanisms are proposed to be domain specific in nature and have been identified for various aspects of children's cognitive and social development, most notably for the acquisition of language and for theory of mind. Differences in the quality and quantity of parental investment affect children's development and influence their subsequent reproductive and childcare strategies. Some sex differences observed in childhood, particularly as expressed during play, are seen as antecedents and preparations for adult sex differences. Because evolved mechanisms were adaptive to ancestral environments, they are not always adaptive for contemporary people, and this mismatch of evolved mechanisms with modern environments is seen in children's maladjustment to some aspects of formal schooling. We argue that an evolutionary perspective can be valuable for developing a better understanding of human ontogeny in contemporary society and that a developmental perspective is important for a better understanding of evolutionary psychology.

INTRODUCTION

The new field of evolutionary psychology has captured the attention of many in academic psychology (e.g., Buss, 1995; Daly & Wilson, 1988; Tooby & Cosmides, 1992). Evolutionary psychologists attempt to describe contemporary human functioning in terms of evolved psychological mechanisms. Not surprisingly, much evolutionary research and theorizing has focused on behaviors relating to mating (e.g., Buss, 1995) and social functioning among adults (e.g., Cosmides & Tooby, 1992). Less theorizing by people who identify themselves as evolutionary psychologists has focused on development. This is in part because it is mature members of a species who reproduce, the sine qua non of Darwinian explication. Yet, individuals must survive through infancy and childhood before reproducing, and there is every reason to believe that natural selection has acted as much upon the early portions of the lifespan to promote survival as it has upon adulthood. Our purposes here are to introduce the field of evolutionary developmental psychology and to apply evolutionary thinking to the study of human development, believing that an understanding of the "whys" of development will help us acquire a better understanding of the "hows" and "whats" of development (Geary & Bjorklund, 2000). Evolutionary developmental psychology involves the expression of evolved, epigenetic programs in interaction with an individual's physical and social environment over the course of ontogeny. Central to evolutionary developmental psychology is the idea that there are (and were in the environment of evolutionary adaptedness) different adaptive pressures on individuals at different times in ontogeny.

We further propose that an evolutionary account provides insight not only into developmental function, aspects of ontogeny that presumably characterize children universally and predictably, but also into individual differences. An evolutionary account suggests that there are alternative strategies to recurrent problems that human children faced in our evolutionary past. Such a perspective suggests that individual differences in developmental patterns are not necessarily the result of idiosyncratic experiences but rather are predictable, adaptive responses to environmental pressures.

In the sections below, we first outline some of the assumptions of the field of evolutionary psychology as they have been developed since the mid-1980s (e.g., Buss, 1995; Cosmides & Tooby, 1987; Daly & Wilson, 1988; Tooby & Cosmides, 1992). Our emphasis and our examples, however, will reflect evolutionary psychology as it relates to development. Next, we introduce concepts especially pertinent to evolutionary developmental psychology, specifically the developmental systems approach, the differential influence of natural selection at different points in ontogeny, and the development of evolved psychological mecha-

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nisms. We then examine selective areas of research in developmental psychology that have benefited from a specific evolutionary perspective, including the effects of parental investment on children's development and developmental antecedents of adult sex differences. We conclude by looking at the impact that an evolutionary perspective can have for establishing a better understanding of children's psychological functioning in contemporary culture.

EVOLUTIONARY PSYCHOLOGY

Darwin's (1859/1958) theory of evolution, as presented in the *Origin of Species*, is probably the best and most enduring general explanation we have of the human condition and our adaptation to the world. The basic principles behind Darwin's theory are relatively simple. First, there are many more members of a species born in each generation than will survive, termed *superfecundity.* Second, all members (at least in sexually reproducing species) have different combinations of traits; that is, there is *variation* in physical and behavioral characteristics among individuals within a species. Third, this variation is *heritable.* Fourth, characteristics that result in an individual surviving and reproducing tend to be *selected* as a result of an interaction between individuals and their environment and are thus passed down (via one's genes) to future generations, whereas the traits of nonsurvivors are not. That is, genetically based variations in physical or psychological features of an individual interact with the environment, and, over many generations, these features tend to change in frequency, resulting, eventually, in species-wide traits in the population as a whole. Thus, through the process of *natural selection*, adaptive changes in individuals, and eventually species, arise.

Darwin referred to the reproductive success of individuals as reflecting their *reproductive fitness*, which basically refers to the likelihood that an individual will become a parent and a grandparent. Contemporary evolutionary theorists, taking advantage of scientific advances that have occurred since Darwin's time (particularly in genetics), use the concept of *inclusive fitness* (Hamilton, 1964). Inclusive fitness includes Darwin's concept of reproductive fitness (in this case, having many offspring) but also considers the influence that an individual may have in getting other copies of his or her genes into subsequent generations. For example, by having one child, 50% of a woman's genes are passed on to the next generation. But by helping to rear her four nieces and nephews, each of whom shares, on average, 25% of her genes, a woman can further increase the copies of her genes in the next generation, thereby increasing her inclusive fitness.

Evolutionary psychology takes these basic tenets of Darwin's theory and the advancements made to it over the past 140 years (usually termed neoDarwinism) and applies them specifically to human psychological functioning. Although, as in any fertile area of intellectual inquiry, there are some healthy disagreements about specifics of evolutionary theory applied to humans, there are certain aspects of this new paradigm that, in one form or another, most practitioners of the field adhere to.

Evolved Psychological Mechanisms

Evolutionary psychologists have proposed that psychological mechanisms are the missing link in the evolution of human behavior. This is a position presented by Cosmides and Tooby (1987, p. 277), who proposed that cognitive processes "in interaction with environmental input, generate manifest behavior. The causal link between evolution and behavior is made through psychological mechanisms." According to Cosmides and Tooby, at least in humans, adaptive behavior is predicated on adaptive thought. Natural selection operates on the cognitive level—information-processing programs evolved to solve real-world problems. Moreover, mechanisms evolved to solve specific adaptive problems faced by our ancestors in the *environment of evolutionary adaptedness.* These are *domain-specific mechanisms*, what Cosmides and Tooby (1987) referred to as *Darwinian algorithms.* That is, rather than influencing general intelligence, for instance, Darwinian algorithms affect very specific cognitive operations, such as face recognition, language acquisition, or the processing of certain types of social interactions. Pinker (1997, p. 21) captured this perspective succinctly: "The mind is organized into modules or mental organs, each with a specialized design that makes it an expert in one area of interaction with the world. The modules' basic logic is specified by our genetic program. Their operation was shaped by natural selection to solve problems of the hunting and gathering life led by our ancestors in most of our evolutionary history."

If we possess domain-specific mechanisms for solving specific problems, the implication is that our mind is not a general-purpose problem solver and that some things will be very difficult or impossible to learn. Stated differently, this perspective proposes that there are *constraints* on learning (Gelman & Williams, 1998). Constraints imply restrictions, and restrictions are usually thought of negatively. The human mind is notable for its flexibility. We, more than any other species, live by our wits and have been able to adapt to the most varied range of environments of any large animal. But constraints, from this perspective, *enable* learning, rather than hamper it.

Children enter a world of sights, sounds, objects, language, and other people. If all types of learning were truly equiprobable, they would be overwhelmed by stimulation that bombards them from every direction. Instead, infants and young children are constrained to process certain information in "core domains" (such as the nature of objects, language) in certain ways. They come into the world with some idea of how the world is structured, and this leads to faster and more efficient processing of information within specific domains. According to Gelman and Williams (1998, p. 600): "From an evolutionary perspective, learning cannot be a process of arbitrary and completely flexible knowledge acquisition. In core domains, learning processes are the means to functionally defined ends: acquiring and storing the particular sorts of relevant information which are necessary for solving particular problems."

The evolved psychological mechanisms proposed by evolutionary psychologists have some things in common with the innate-releasing mechanisms, or fixed-action patterns, identified by ethologists to explain the often complex behaviors of animals in response to specific environmental conditions. There are also some differences, however. For example, Tinbergen (1951) described the aggressive behavior of male stickleback fish in response to the presence of the red belly of another male stickleback fish (the red belly being an indication of a readiness to mate). Stereotypic aggressive behavior was displayed to any red stimulus that closely resembled the underbelly of another male fish, and this is adaptive, in that it limits access of other males to a prospective mate. Such responses could be thought of as evolved psychological mechanisms; but most (if not all) such mechanisms possessed by humans are more flexible in nature, reflecting general propensities to respond in certain ways depending on the environmental conditions. It is not the case, for example, that human males act aggressively toward any male stranger who enters their territory (red belly or not). This pattern may be found in some cultures, however, and depending on the social organization of the group and the *developmental history of the individual*, how a person (male or female) responds to a stranger will vary. Nonetheless, according to evolutionary psychological theory, what underlies such responding are evolved psychological mechanisms, which find their expression as a result of interaction with the environment over the course of development.

Functional Analysis

Evolutionary psychological explanations focus on *adaptationist thinking*—stressing the function of a behavior or trait. For example, pregnancy sickness is quite common during the early months of pregnancy, occurring in the majority of women around the world (e.g., Tierson, Olson, & Hook, 1986). Symptoms include nausea, vomiting, and food aversions. Given these symptoms, pregnancy sickness is understandably considered an illness. Profet (1992), in an elegant review of the literature, however, showed that pregnancy sickness can be better understood as an adaptation to protect the health of the developing fetus. For example: (1) modern women acquire aversions to food that are highest in toxins and tend not to develop aversions to foods that are more apt to be toxin-free; (2) pregnancy sickness, including food aversions, corresponds to the time when an unborn child is most susceptible to the effects of teratogens; (3) pregnancy sickness appears to be universal; and (4) women who experience pregnancy sickness have lower levels of spontaneous abortions than women who do not become ill (Weigel & Weigel, 1989).

Profet's functional analysis of pregnancy sickness demonstrates the benefits that an evolutionary perspective can have. What has typically been viewed as a dysfunctional state, for which medication is frequently prescribed, is actually a well-adapted mechanism that serves to foster the development of the unborn child. Although the discomfort associated with pregnancy sickness is real, its consequence is an embryo/fetus protected from environmental toxins that would impair its development. It is ironic to note that thalidomide, the drug that led to serious deformations of children's limbs when taken early in pregnancy, was sometimes prescribed to alleviate pregnancy sickness.

Not all current aspects of cognition, behavior, or morphology are the result of adaptation. Evolution produces at least three products (Buss, Haselton, Shackelford, Bleske, & Wakefield, 1998): adaptations, by-products, and noise. *Adaptations* refer to reliably developing, inherited characteristics that came about as a result of natural selection and helped to solve some problems of reproduction or survival in the environment of evolutionary adaptedness. The umbilical cord would be an example of an adaptation. *By-products* are characteristics that did not solve some recurring problem and have not been shaped by natural selection but are a consequence of being associated with some adaptation. The belly button would be an example of a by-product. Finally, *noise* refers to random effects that may be attributed to mutations, changes in the environment, or aberrations of development, such as the shape of one's belly button. As this tripartite classification indicates, a characteristic may have evolved in a species but not have been designed by the forces of natural selection. The evolutionary psychologist's task is to identify and describe psychological mechanisms that may have served to solve survival or reproduction problems in our species' evolutionary past and to differentiate those mechanisms from characteristics that may be better classified as by-products or noise.

Furthermore, some adaptations may have negative effects (by-products) associated with them. For example, the enlarged skull of a human fetus is surely an adaptation (housing a large brain, associated with greater learning ability and behavioral flexibility); however, because of the size of the baby's head, birth is difficult (because of limits on the width of a woman's hips that result from constraints of bipedality), and many women and infants have died in childbirth. The cost/benefit trade-off, however, was such that the benefits of an enlarged brain outweighed the detriments of neonatal and maternal death.

It is worth commenting briefly here on the concept of cost–benefit analysis and its significance to evolutionary psychology. Cost–benefit analyses assume that behaviors have both benefits, or functions, and costs, or risks. Behaviors will be naturally selected if the benefits outweigh the costs: The benefits do not have to be absolutely high but only greater than associated costs (Krebs & McCleery, 1984). Also, from a developmental perspective, the benefits associated with costs/risks can be either immediate or delayed. For example, children's play, which will be discussed in greater detail below, can have substantial costs, sometimes resulting in injury or death (e.g., Cataldo et al., 1986; Peterson, Brezeal, Oliver, & Bull, 1997). Physical play also requires energy, and the energy demands of play must be considered in light of other caloric requirements (e.g., calories required for basic metabolism, growth, and more direct learning tutorials; see Pellegrini, Hovart, & Huberty, 1998). What benefits do children reap from taking such risks? Some appear to be immediate, such as the fostering of muscle and skeletal development, whereas others appear to be delayed, such as developing social skills that will be important in adult life. Regardless of when the benefit is realized, most adaptations have some risks associated with them and do not reflect "perfect" solutions to recurrent problems but rather trade-offs that have produced, on average, over evolutionary time, more benefits than costs.

The Role of the Environment

Counter to some common misconceptions, evolved psychological mechanisms exist in transactional relations with environmental factors. Believing that certain behaviors are under the influence of evolved psychological mechanisms does not imply that aspects of the physical and social environment do not play a critical role in the development or form of behavior. In fact, quite the opposite is true; most evolved mechanisms are quite sensitive to variations in environments and are expressed differently depending on one's surroundings (see Gottlieb, 1992, 1998). This point is critical, because humans live in a wide variety of environments and require flexible cognitive and behavioral systems to survive. Moreover, because evolved mechanisms will be expressed differently in different environments, evolutionary psychology can contribute to our understanding of individual differences. For the most part, evolutionary psychology has emphasized what is universal about the human species. The recognition, however, that genes are differentially activated by different experiences in development (see discussion of developmental systems approach below), coupled with the idea of natural selection, provides a model for predicting how different environmental conditions will result in different behavioral phenotypes.

EVOLUTIONARY DEVELOPMENTAL PSYCHOLOGY

The value of a behavior can be understood in terms of "ultimate" function (i.e., "fitness," or producing offspring, who, in turn, survive to reproduce) or in terms of beneficial consequences of that behavior to the organism during its lifespan (Hinde, 1980). Tinbergen (1963) stated the benefit of asking "four questions" to understand the value of behavior: What is the immediate benefit (internal and external to the organism)? What is the immediate consequence? How does it develop within the species (ontogeny)? How did it evolve across species (phylogeny)? To answer these questions, we must take a developmental perspective; we must appreciate the adaptive value of a particular behavior at a specific time in development. This implies that different behaviors or characteristics of an animal may be selected at different times in ontogeny. In other words, over the course of evolution, natural selection has functioned to adapt organisms to their current environments, and the environments and selective pressures experienced by our ancestors early in their ontogeny differed from the environments and selective pressures experienced by our ancestors later in their lifespan.

The Role of the Environment across Ontogeny in Evolutionary Psychological Perspective: The Developmental Systems Approach

If evolved psychological mechanisms underlie contemporary behaviors and thought patterns, what role can culture, or experience in general, play? A common misconception that was held by many psychologists until recently about evolutionary explication (and may still be held by some today) is that, if an ability is said to have "evolved" or to have an innate component, the result is one of biological, or genetic, determinism (see Charlesworth, 1992; Morss, 1990). If it is in the genes (which it must be if it evolved), it cannot be changed. This is not the case, and evolutionary psychologists are explicit about the role that the environment plays (and did play) in the expression of evolved psychological mechanisms.

Evolutionary psychologists assume that organisms adapt and evolve, through natural selection, by their transactions with the environment. Organisms affect their environment (e.g., by choosing and then "furnishing their niches"), and environments, in turn, affect the organism (e.g., by changing behaviors to meet the particular demands of a setting). Because of this transactional relation between organism and environment, we must study organisms interacting with their environments if we want to understand adaptation and development. This position rejects any simplistic biological determinism such as genetic endowment having a main effect on cognitive functioning (see Pellegrini & Horvat, 1995, for a discussion) or on social development (Pellegrini & Smith, 1998). More specifically, we believe that the *developmental systems approach* provides a proper appreciation of how biology and environment, at a variety of levels, interact to produce behavior and development and that such a model can be used to explain how evolved psychological mechanisms are translated into behavior.

The core concept of the developmental systems approach is that of *epigenesis*, which Gottlieb (1991a, p. 7) defined as "the emergence of new structures and functions during the course of development." Gottlieb (1991a, 1998; Gottlieb, Wahlsten, & Lickliter, 1998) stated that epigenesis reflects a bidirectional relation between all levels of biological and experiential factors, such that genetic activity both influences and is influenced by structural maturation, which is bidirectionally related to function and activity. This relation can be expressed as follows:

genetic activity (DNA ↔ RNA ↔ proteins) ↔
structural maturation ↔ function, activity.

From this perspective, functioning at one level influences functioning at adjacent levels. For example, genes code for the production of protein molecules, which in turn determine the formation of structures, such as muscle or nerve cells. But activity of these and surrounding cells can serve to turn on or off a particular gene, thereby causing the commencement or cessation of genetic activity. Also, self-produced activity or stimulation from external sources can alter the development of sets of cells. From this viewpoint, there are no simple genetic or experiential causes of behavior; all development is the product of epigenesis, with complex interactions occurring among multiple levels (see also Johnson, 1998).

Evolved psychological mechanisms can be thought of as genetically coded "messages" that, following epigenetic rules, interact with the environment to produce behavior. The experiences of each individual, however, are unique, beginning before birth, and if the developmental system's account of ontogeny closely mirrors reality, there should be substantial plasticity in development. Yet, despite the fact that genes will be expressed differently in different environments, almost all members of a species (human or otherwise) develop in a species-typical pattern. How can this be so and the developmental systems perspective still be valid?

The answer lies in the fact that humans (or chimpanzees or ducks) inherit not only a species-typical genome but also a species-typical environment. According to Lickliter (1996, pp. 90–91), ". . . the organism-environment relationship is one that is structured on both sides. That is, it is a relation between a structured organism *and* a structured environment. The organism inherits not only its genetic complement, but also the structured organization of the environment into which it is born." To the extent that an organism grows up under conditions similar to that in which its species evolved, development will follow a species-typical pattern. Tooby and Cosmides (1992) have argued that complex, psychological mechanisms evolve only under circumstances when the environments are relatively stable over many generations. Thus, over long periods of time, members of a species could "expect" certain types of environments, and they evolved species-typical solutions to deal with such stable environments. For example, in the wild, a mother duck will lay several eggs together in a nest and stay close by the eggs until they hatch. While in the egg, the ducklings begin to vocalize and so hear themselves, the vocalizations of their brood mates, and those of their mother. How might these "experiences" influence later species-typical behavior?

In a procedure developed by Gottlieb (1976, 1991b), ducklings, while still in the egg, were isolated from other eggs and their mother so that they could not hear the vocalizations of other animals. Their vocal chords were also treated so that they could not produce any sound (a condition that wears off several days after hatching). Following hatching, these animals were placed in a large container and heard the maternal call of two species—their own and another—played through speakers on opposite sides of the container. Most untreated birds in this situation approached the call of their own species, seeming to know "instinctively" which call is that of their species and which is not. However, ducklings who were prevented from hearing any duck vocalizations, either their mothers, those of other ducklings still in their eggs, or their own, failed to make this discrimination and were just as likely to approach the call of an alien species as that of their own. Thus, prehatching experience plays a critical role in posthatching species-typical behavior. The reason that nearly all ducks approach the species-typical call after hatching is that nearly all ducks inherit not only the genetic disposition to make such a selection but also the species-typical environment that provides the necessary experiences for such a pattern to develop.

A related example demonstrates how providing an animal with species-atypical experience (rather than depriving it of experience as in the Gottlieb studies) can disrupt development. Lickliter (1990) removed part of the eggshell 2 to 3 days before hatching of bobwhite quail and provided visual experience (patterned light) to these animals. Following hatching, the quail chicks were tested in a situation similar to that used by Gottlieb, with the maternal call of a quail coming from one speaker and that of a chicken coming from another. A group of control animals that had the egg shell removed but did not receive any additional visual experience displayed the species-typical pattern: They approached the maternal call of their own species on most occasions. In contrast, most of the experimental animals showed no preference or approached the maternal call of the chicken. The animals that received extra visual stimulation showed enhanced visual discrimination abilities relative to control animals, thus demonstrating a facilitory effect of the early visual stimulation; but this came at a cost to auditory discrimination abilities. Other research, using ducks, quail, and rats as subjects, has demonstrated that providing young animals with stimulation that is outside the species norm has negative consequences for development (e.g., Gottlieb, Tomlinson, & Radell, 1989; Kenny & Turkewitz, 1986; Lickliter & Lewkowitz, 1995; Spear, 1984). What results such as these demonstrate is that behaviors (here related to infant–mother attachment) that are found in almost all normal members of a species are influenced by often subtle characteristics of the environment. Evolved psychological mechanisms at the human level can be similarly viewed. Strong species-wide biases may exist for certain behaviors, but how any particular evolved mechanism is expressed will vary with environmental conditions experienced at certain times in development.

The substantial plasticity characteristic of early development provides a behavioral route for evolutionary change (Bateson, 1988; Gottlieb, 1992). For example, Gottlieb (1992) proposed that large-brained animals with extended juvenile periods display substantial behavioral and cognitive malleability and that this malleability can result in drastic changes in a phenotype when a young animal is exposed to a species-atypical environment. In this way, changes in developmental rate or expressions of novel behavior, brought about by changes in environmental conditions, can serve as the fodder for natural selection, and lead, eventually, to species-wide changes in a phenotype.

Some examples of how modified early environments can alter species-typical behavior that are particularly pertinent to human evolution come from observations of human-reared (*enculturated*) great apes. Great apes (mostly common chimpanzees) who have been raised by humans, much as human children, often display more human-like cognitive abilities than those displayed by mother-reared animals (see Call & Tomasello, 1996). For example, the most successful of the "language-trained" apes have been enculturated (e.g., Gardner & Gardner, 1969; Savage-Rumbaugh et al., 1993). Similarly, mother-reared apes rarely demonstrate imitation of tool use, particularly *deferred imitation* (i.e., imitating a behavior following a significant delay). In contrast, enculturated common chimpanzees, bonobos, and orangutans have all been shown to display above-chance levels of deferred imitation of object manipulation (Bering, Bjorklund, & Ragan, in press; Bjorklund, Bering, & Ragan, 2000; Tomasello, Savage-Rumbaugh, & Kruger, 1993). Deferred imitation has traditionally been interpreted as requiring symbolic representation (e.g., Meltzoff, 1995; Piaget, 1962), and aspects of these apes' atypical, human-like rearing history apparently prompted the emergence of representational skills, at least in limited contexts, which are absent from their mother-reared conspecifics.

It is not possible at this time to say what aspects of the apes' experiences are responsible for the change in their cognitive abilities and behavior toward more human-like thinking. One attractive candidate, however, has been joint-attentional strategies, whereby adults draw the attention of the young animal to an object (Call & Tomasello, 1996). An important aspect of this research is that it provides an experiential vehicle by which our hominid ancestors (using contemporary great apes as a model) could have begun to modify their cognition in the direction that resulted in *Homo sapiens.*

The Influence of Natural Selection at Different Times in Ontogeny

Ontogenetic adaptations and adaptive immaturity. In keeping with the basic argument that there are different selection pressures on organisms at different times in development is the idea that some aspects of infancy and childhood are not preparations for later adulthood but were selected in evolution to serve an adaptive value for that specific time in development (Bjorklund, 1997a; Oppenheim, 1981). As a result, certain immature aspects of a young animal often have adaptive value. They were selected in evolution to help keep the animal alive at that time in ontogeny. This perspective has long been held by developmental psychobiologists, whose typical subjects are birds or infrahuman mammals (e.g., Gottlieb et al., 1998; Spear, 1984; Turkewitz & Kenny, 1982), but has been less popular with developmental psychologists who study human ontogeny and whose focus has often been to find behaviors or traits early in life that are predictive of later development.

Many adaptations are limited to a particular time in development; they facilitate the young organism's chances of surviving to adulthood and eventually reproducing. This is reflected by the concept of *ontogenetic adaptations*—neurobehavioral characteristics that serve specific adaptive functions for the developing animal (see Oppenheim, 1981). 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. For example, embryos of most species have specializations that serve 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 (Oppenheim, 1981).

Ontogenetic adaptations in human infancy. Such adaptations are not limited to prenatal behaviors. Infant reflexes, such as the sucking reflex in mammals, are obvious postnatal behaviors that serve a specific function and then disappear. Some aspects of human infants' cognition have also been interpreted as serving a specific function, only to disappear or to become reorganized later in life. For example, the imitation of facial gestures by newborns (e.g., Meltzoff & Moore, 1985) has been characterized by some as an ontogenetic adaptation (e.g., Bjorklund, 1987). Under the appropriate conditions, newborn infants will imitate a range of facial gestures, although imitation of facial expressions decreases to chance levels by about 2 months of life (e.g., Abravanel & Sigafoos, 1984; Jacobson, 1979). Rather than serving to acquire new behaviors, which seems to be the primary function of imitation in later infancy and childhood, several researchers have speculated that imitation has a very different and specific function for the neonate. For example, Jacobson (1979) suggested that imitation of facial gestures is functional in nursing; Legerstee (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. Heimann (1989) provided support for these latter interpretations by reporting significant correlations between degree of neonatal imitation and subsequent 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 will serve in the older infant and child (but see Meltzoff & Moore, 1992, for a different interpretation). Presumably, these different functions for similar behavior at different times in ontogeny were selected over evolutionary time.

Play as an ontogenetic adaptation. There are similar examples from social development, of which play is perhaps the most obvious. Play is in many ways a quintessential developmental construct. For instance, it has been used to define, relationally, a developmental period: The juvenile/childhood period is often defined as the period during which playful behavior is dominant. Correspondingly, play is sometimes defined as that behavior which is exhibited by juveniles (Martin & Caro, 1985). Thus, play has been considered to be an integral and important part of childhood and one which accounts for a substantial portion of children's time and energy budgets (Hinde, 1974). The ubiquity of play in juveniles' lives has led many scholars to assume that play serves a very important developmental function. For example, some scholars have listed over 30 possible functions of play (Baldwin & Baldwin, 1977).

More exact definitions of play have been proffered by both ethologists (e.g., Martin & Caro, 1985) and child developmentalists (Rubin, Fein, & Vandenberg, 1983), and they agree on a common consequential definition of play: It is behavior that appears to have no apparent function or where the means of a behavior are more important than the ends. In the ethological literature, this sort of "purposeless" behavior has typically been divided into object play, social play, and physical play (Fagen, 1981; Martin & Caro, 1985).

Specifically, play can occur with objects, as in the case of Piaget's (1962) sensorimotor play where very young children and juveniles from a number of primate species (e.g., Kohler, 1925) perform a variety of novel behavioral routines with objects. Play can be solitary, as in cases where individuals play with materials, or social, where they play with an adult or a peer. Physical play is vigorous and can be either solitary (e.g., swinging) or social (e.g., wrestling with a peer or parent). For children, the paradigmatic case of play is social-fantasy play, a uniquely human variety of play (McCune-Nicholich & Fenson, 1984; Smith & Vollstedt, 1985), although "symbolic play" has been inferred in nonhuman primates reared by humans (i.e., enculturated; see Tomasello & Call, 1997).

Some students of both animals' and children's play have seen it as a source of creativity that may eventually lead to discovering new ways to solve old problems (Biben, 1998; Oppenheim, 1981); and, because of the youthful tendency toward play and curiosity in animals, it is likely that innovations will be introduced by the young rather than by adults. Support for this contention comes from observations of the skill of potato washing in Japanese macaque monkeys (Kawai, 1965). A group of Japanese scientists provisioned a troop of wild monkeys with sweet potatoes, which were often sandy. One juvenile monkey learned to wash potatoes in sea water before eating them, and this was subsequently learned by other juveniles, and then some adult females. (Few adult males ever learned this.) This innovation was then passed on to infants as part of the culture. Although it is unlikely that important cultural innovations will be made through the play of human children, the discoveries children make through play may serve as the basis of later innovations or true creativity, which become important later in life.

The functional question of play is particularly interesting in light of its most common definitional attribute—serving no apparent purpose. How can a behavior be both developmentally important yet serve no apparent purpose? Most theories, especially those in the child development literature, assume that the benefits of play are deferred until after the period of childhood (Groos, 1898, 1901; Vygotsky, 1978). As Kagan (1996) notes, this assumption may be due to the bias toward the importance of early experience in human development. In these theories, children's play is a way in which to learn skills important in adulthood. Consequently, play is viewed as an imperfect version of adult behavior. In Bateson's (1976) terms, this is the *scaffolding view* of play: Play functions in the assembly of skills and is disassembled when the skills are complete (e.g., Bruner, 1972). The classic example of play serving deferred benefits is where the play-fighting characteristic of juvenile males is seen as practice for adult hunting and fighting skills (Smith, 1982).

An alternative view of play, labeled the *metamorphic view* by Bateson (1976), holds that play is not an incomplete or imperfect version of adult behavior but is beneficial immediately and specialized to the niche of childhood. In this way, play can be considered a specific adjustment to the context of childhood (Bateson, 1976; Bjorklund, 1997a; Gomendio, 1988; Pellegrini & Bjorklund, 1997; Pellegrini & Smith, 1998). This view is also consistent with the perspective that natural selection exerts functional pressure during the period of childhood. An example of play serving an immediate function holds that the sense of mastery and self-efficacy associated with play probably relates to children experimenting with new and different activities and roles. Once activities are chosen, they should be sustained, which in turn affords opportunities for learning specific skills (Bjorklund & Green, 1992). In a similar vein, boys' rough-and-tumble play may serve as a way in which to learn and practice social signaling (Martin & Caro, 1985), with exaggerated movements and a play face communicating playful intent. Furthermore, it is used as a way in which boys establish leadership in their peer group and assess others' strength (Pellegrini & Smith, 1998). Rough-and-tumble play also has immediate nonsocial benefits; it provides opportunities for the vigorous physical exercise that is important for skeletal and muscle development (Bruner, 1972; Dolhinow & Bishop, 1970).

The adaptive nature of cognitive immaturity. Infants' and young children's immature cognition may also provide some adaptive value that is often overlooked by developmental psychologists and educators (see Bjorklund, 1997a; Bjorklund & Green, 1992; Bjorklund & Schwartz, 1996). For example, young children's poor metacognition, particularly their poor ability to judge the competency of their own performance, may be adaptive in some contexts. Children who overestimate their own abilities may attempt a wider range of activities and not perceive their less-than-perfect performance as failure (e.g., Bjorklund, Gaultney, & Green, 1993).

Other researchers have speculated that young children's limited working-memory capacity may facilitate language acquisition. For example, Newport (1991) and Elman (1994) have each proposed that children initially perceive and store only component parts of complex stimuli. They start with single morphemes (usually a single syllable) and gradually increase the complexity and the number of units they can control. This results in a simplified corpus that actually makes the job of analyzing language easier. With success and time, maturationally paced abilities gradually increase, as does language learning. Both Newport (1991) and Elman (1994) performed computer simulations in which they restricted the amount of information the simulations could process at any one time (equivalent to restricting how much children can hold in working memory). They each reported that aspects of language were more easily acquired when the input was initially limited (either by presenting a reduced corpus or by limiting the working memory of the system). These researchers concluded that young children's limited working-memory capacity restricts how much language information can be processed, which simplifies what is analyzed, thereby making the task of language acquisition easier. Preliminary support for the "less is more" position also comes from evidence that adults learn an artificial grammar faster when presented with smaller units of the language (Kersten & Earles, in press). (See Bjorklund & Schwartz, 1996, for a discussion of these ideas applied to remediation of language disabilities in children.)

Issues of accelerating cognitive development. Research on these and other topics of cognitive development (see Bjorklund, 1997a) indicates that certain aspects of immaturity may be adaptive. This raises the question about the wisdom of attempts to accelerate intellectual development, frequently advocated in the United States (see Bjorklund & Schwartz, 1996; Goodman, 1992), as well as the potential negative side effects of early medical interventions. For example, Als (1995) has suggested that preterm human infants have experiences similar in nature to those of Lickliter's bobwhite quail. In an extensive review of research examining factors that influence preterm infants' brain development, Als suggested that the unexpected stimulation that preterm infants often receive in hospitals disrupts brain development (particularly the frontal cortex) during sensitive periods and frequently causes impairments resulting in lowered IQ, attention deficits, eye-hand coordination difficulties, impulsivity, and speech problems. These deficits, however, are often accompanied by accelerated or enhanced abilities in other areas, such as mathematics. Als's interpretation is similar to that of Lickliter's for bobwhite quail: Stimulation outside the species-typical range can have unforeseen consequences on brain and behavior development. Als (1995, p. 452) writes: "Social contexts evolved in the course of human phylogeny are surprisingly fine-tuned in specificity to provide good-enough environments for the human cortex to unfold, initially intrauterinely, then extrauterinely. . . . With the advances in medical technology, that is, material culture, even very immature nervous systems exist and develop outside the womb. However, the social contexts of traditional special care nurseries bring with them less than adequate support for immature nervous systems . . . leading to maladaptations and disabilities, yet also to accelerations and extraordinary abilities."

In research with rhesus monkeys, Harlow (1959) reported that animals who began discrimination training at 155 days of age or younger actually performed more poorly on the learning tasks later in life than animals who did not begin training until 190 days of age or older. This was true despite the fact that the younger animals had more experience on the task than the older animals. Harlow (p. 472) 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."

These and other findings (see Bjorklund, 1997a) suggest that infants and young children respond to experiences differently than older children and adults and may be adapted for receiving particular amounts and types of stimulation at different points in development. This interpretation, we argue, is consistent with an evolutionary developmental psychological perspective and is apt to be missed or interpreted otherwise without such a perspective. This viewpoint can be worthwhile for evaluating the benefits *and* the costs of early education and intervention programs for infants and young children (e.g., Hyson, Hirsh-Pasek, & Rescorla, 1990) and for children with special needs (e.g., Goodman, 1992).

The Ontogeny of Evolved Psychological Mechanisms

As we mentioned earlier, foremost in evolutionary psychology is the idea that psychological mechanisms underlie important social and intellectual behaviors and that these mechanisms have evolved (Buss, 1995; Tooby & Cosmides, 1992). These are domain-specific, modular-like mechanisms that evolved in the environment of evolutionary adaptedness, when our ancestors survived as hunters and gatherers, and may not be associated with greater reproductive fitness today.

It would be extreme to claim, of course, that all adaptive behaviors or thought processes have been explicitly selected for their fitness value; some may have been associated with another adaptive trait (by-product) and not selected for themselves, and others may simply have not been sufficiently maladaptive to result in extinction. But a core assumption of evolutionary psychology is that psychological mechanisms evolved to solve specific problems and are modular in nature. They also did not evolve to deal with the problems of contemporary humans; our species has only recently abandoned a nomadic lifestyle for one of villages, towns, and cities. Rather, these mechanisms evolved over the past several million years to handle the problems faced by our hominid ancestors.

An important point here is that evolved mechanisms themselves develop. Evolved epigenetic programs are expressed by means of interaction with the child's physical and social environment. Because of the commonalities of human environments throughout the world and across time, many aspects of the human mind and behavior will develop in a species-typical way. Yet, these programs also reveal a substantial degree of flexibility, which permits individuals to adapt to the specific features of their environments. For example, children acquire language over the course of 4 or 5 years. For adults, learning a second language is often very difficult, and the ease with which children learn a first language seems at odds with (i.e., independent of) their other more general cognitive abilities. A number of specific evolved psychological mechanisms have been proposed to explain children's acquisition of language (see Pinker, 1994), although other evolutionary-friendly proposals that posit a domain-general mechanism have also been suggested (see Elman et al., 1996).

Similarly, aspects of children's understanding of social functioning has been hypothesized to be modular in nature (e.g., Baron-Cohen, 1995; Leslie, 1994). For example, by age 4, most children understand that other people have beliefs and desires, sometimes different from their own, that motivate their behavior. This knowledge that peoples' behavior is motivated by their beliefs and desires (belief-desire reasoning; Wellman, 1990) has been referred to as a *theory of mind*, and it is difficult to imagine how any person could survive in human culture without such a theory. Being able to think about others' thoughts is crucial to detecting deception and other social strategies that might handicap individuals. Although social intelligence, broadly defined, continues to develop into adulthood, most children by the age of 4 have developed a belief-desire theory of mind. Most children much younger than 4 years of age, however, seem to lack the requisite knowledge or conceptual ability characteristic of belief-desire reasoning.

Theory of mind is illustrated by false-belief tasks. In the standard false-belief task (e.g., Wimmer & Perner, 1983), children watch as a treat is hidden in a specific location (in a box, for example). Another person (Maxi) is present when the treat is hidden but then leaves the room, at which time the treat is moved to a new location. Children are then asked where Maxi will look for the treat when he returns. Most 4-year-old children can solve the problem, stating that Maxi will look where the treat was originally hidden, whereas most younger children state that Maxi will look for the treat in the new hiding place, apparently not realizing that Maxi's knowledge is different from their own.

Having a belief-desire theory of mind is required for everyday exchanges of resources between two people. For instance, in research by Peskin (1992), 3-year-old children play a game with "mean monkey," who always wants the toy that the child wants most. When children are asked to tell "mean monkey" which of several toys they "really" want and which one they "really don't want," "mean monkey" (a hand puppet controlled by the experimenter) always takes the most desired toy, leaving the child with the least desired one. Four-year-old children catch on very quickly to the trick to deceive "mean monkey" by pretending that the least-wanted toy is really their favorite, thus foiling "mean monkey's" evil plan. Most 3-year-olds, in contrast, never catch on and spend the entire game being honest with "mean monkey" and never getting the toys they most desire. They fail either to monitor their own thinking or to realize that "mean monkey" has a different goal in mind than they do.

Some have argued that primate intelligence evolved in response to detecting others' cheating and cooperation (e.g., Humphrey, 1976), but a fully developed theory of mind, based on belief-desire reasoning, is found only in *Homo sapiens.* Although primatologists have observed monkeys and apes engaging in tactical deception, reflecting a suite of advanced cognitive abilities (see Whiten & Byrne, 1988), such deception does not necessarily require the ability to read the mind of another individual (see Bjorklund & Kipp, in press). For example, using nonverbal false-belief tasks, Call and Tomasello (1999) found no evidence of belief-desire reasoning, comparable to that of a human 4-year old, for chimpanzees and orangutans. In other research, Povinelli and Eddy (1996) demonstrated that chimpanzees do not understand "seeing." In their experiments, chimpanzees were just as likely to request food from a naive observer or one who was blindfolded as they were from an observer who knew or could see the location of the desired treat. Thus, although deception is an important social skill, it does not necessarily imply a highly developed theory of mind. Humans obviously evolved a theory of mind since our species last shared a common ancestor with chimpanzees, and researchers have speculated how other cognitive abilities, including language (e.g., Smith, 1998) and cognitive inhibition (Bjorklund & Kipp, in press), might have co-evolved, or been prerequisite for, this uniquely human ability.

Consistent with an evolutionary developmental psychological perspective, research has indicated that this ability may be composed of a small set of modular-like skills. For example, Baron-Cohen (1995) has proposed four separate, interacting modules involved in mindreading that develop over infancy and early childhood. The earliest developing module is the *Intentionality Detector* (*ID*), which interprets moving objects as having some volition or intention. For example, an object that is moving toward an individual may be perceived as an agent with some *intention* toward that individual (for instance, it wishes to harm me, to be near me). This is a very primitive skill, likely possessed by all animals with a nervous system. The second module is the *Eye-Direction Detector* (*EDD*), which has three related functions: It detects the presence of eyes or eye-like stimuli, determines whether the eyes are looking toward it or toward something else, and infers that if an organism's eyes are looking at something then that organism sees that thing. In other words, this module is responsible for our belief that knowledge is gained through the eyes (both ours and the eyes of others). According to Baron-Cohen, these first two modules develop between birth and 9 months of age. The third module is the *Shared-Attention Mechanisms* (*SAM*). Whereas the ID and EDD involve only two objects/individuals (that is, dyadic interactions/representations), the SAM involves triadic interactions/representations. For example, if person A is looking at object B, and person C can see the eyes of person A and can see object B, person C can come to the conclusion that "You (person A) and I (person C) are looking at the same thing." This module develops between 9 and 18 months. Finally, the *Theory-Of-Mind Module* (*TOMM*) is roughly equivalent to the belief-desire reasoning described earlier and is reflected by passing false-belief tasks. This module develops between the ages of about 18 to 48 months.

Possessing a theory of mind is central to any understanding of what it means to be human; and although monkeys and apes seem not to have a human-like theory of mind, social primates do possess the rudiments of an understanding of other conspecifics as social beings, and these animals serve as models for what the mind of our hominid ancestors may have been like (see Byrne & Whiten, 1988; Russon, Bard, & Parker, 1996). Moreover, researchers have used models similar to those of Baron-Cohen (1995) described above to explain primate behavior (e.g., Hauser & Carey, 1998; Tomasello & Call, 1997) in an attempt not only to understand the mind of primates but also to get a glimpse at the evolution of the human mind.

Evidence for the modularity of the various components of Baron-Cohen's model comes from studies of children with autism. Baron-Cohen (1995) reviewed research from his laboratory and those of other scientists suggesting that the more advanced forms of mindreading (SAM and TOMM) are typically absent in children with autism. Autistic children (and later adults) often seem to be in a world of their own and have a difficult time in most forms of social interaction. Baron-Cohen claims that the primary deficit of these children is an inability to read minds, or what he calls *mindblindness*. Evidence for this conclusion comes from studies in which autistic children are presented with false-belief and other theory-of-mind tasks and consistently fail them, despite performing well on other, nonsocial tasks (e.g., Baron-Cohen, 1989; Baron-Cohen, Leslie, & Frith, 1985; Perner, Frith, Leslie, & Leekam, 1989). This is in contrast to children with mental retardation, such as Down syndrome, who perform theory-of-mind tasks easily, despite often doing poorly on other tasks that assess more general intelligence (e.g., Baron-Cohen et al., 1985). Most autistic children are able to perform well on the simpler tasks requiring the ID or EDD modules, but fail tasks involving the SAM and especially the TOMM modules. According to Baron-Cohen, autistic children are unable to understand other people's different beliefs, even those children who are functioning at a relatively high intellectual level.

PARENTAL INVESTMENT: EVOLUTIONARY EFFECTS ON CHILDREARING

When thinking of evolutionary (i.e., selective) influences on infancy and childhood, one naturally thinks of direct genetic effects. What characteristics of children's behavior have been selected to promote their survival? There are, however, important factors external to children that may also influence their survival and reproductive success and that have also been influenced by a long history of natural selection. More specifically, we refer to the quantity and quality of parenting, or *parental investment*, that children receive.

Within evolutionary psychology, the concept of parental investment (Trivers, 1972) has been used primarily to explain differences in behaviors related to mating and parenting among men and women (see Bjorklund & Shackelford, 1999). Because ancestral men and women faced different adaptive problems surrounding the amount of time, effort, and resources required to rear an offspring to maturity, they evolved different adaptive mechanisms. In mammals, fertilization and gestation occur within the female, and after birth, mothers provide the primary nutritional support for their offspring until they are weaned. In contrast, the male's investment in the next generation may be as little as the sperm he contributes. For a slow-developing species such as *Homo sapiens*, however, paternal investment, in the form of providing food and protection for the offspring and mother as well as child care, increases the likelihood that a man's offspring will survive and attain relatively high status in the social group (see Geary, 1998). To the extent that parenting influences children's behavior and development (see Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000), aspects of parental investment theory can and have been applied to child development.

There is no doubt that the presence and investment of parents, particularly in high-stressed environments, is crucial to a child's survival and eventual social status. For example, Geary (1998) summarized research from traditional societies, as well as historical data from Western cultures, indicating that father absence is associated with higher childhood mortality and, for those children reaching adulthood, lower social status than for children who have a father present. The death rate is even greater when a mother is absent. What are the factors that contribute to parents investing their time and resources in a child? How might factors in the home environment influence the reproductive strategies of the children as they grow up? Are there evolutionarily sound principles to predict under what conditions children will be neglected, abused, and even killed by a parent (see Daly & Wilson, 1988)?

In light of the diverse social ecological niches that individuals inhabit, that successful adaptation depends on the ability to choose from a variety of alternative strategies is not surprising. Most basically, childrearing involves a balance between the caregivers and the offspring. Human newborns, of course, are helpless, and caregivers must invest heavily in infants to maximize their survival. In terms of a cost–benefit ratio, this can be expressed as high costs (e.g., providing food, protection, and thermoregulative support) and high benefits (nurturing the survival of one's progeny) to caregivers and low cost and high benefits to infants. Of course this ratio changes with development, with benefits to children decreasing with increasing age.

One aspect of parent–child relationships that has important consequences for survival is attachment. Bowlby (1969) integrated Freudian and ethological concepts of attachment and proposed that mother–infant attachment is a human universal that evolved to increase the likelihood of survival. Fernald (1992) has even speculated that the infant-directed speech that parents around the world use when speaking to their babies evolved out of the attachment relationship. Infant-directed speech regulates infants' emotions, behavior, and attention and also conveys a mother's own emotional state to her infant, all factors important to establishing an attachment relationship.

Although all infants become attached, the quality of those attachment relations varies. Typically, securely attached infants are viewed as being better adjusted, both in infancy and in later childhood, than insecurely attached infants. Although such a characterization may have some validity from the perspective of mainstream Western society, differences in the quality of attachment may reflect different adaptive solutions to different physical and social environments, and insecure attachments, for example, should not automatically be viewed as less optimal than secure attachments. For instance, children reared in homes characterized by inadequate resources, high stress, marital discord/father absence, and harsh and inconsistent childcare reach puberty early, form short-term and unstable pair bonds, and invest relatively little in their own offspring (e.g., Belsky, Steinberg, & Draper, 1991; Chisholm, 1999); male children tend to be noncompliant and aggressive (Draper & Harpending, 1987). In stressful and uncertain environments, there is a tendency to invest more in mating (for both sexes) than in parenting. In contrast, children from home environments characterized by adequate resources and spousal harmony/father present mature later, postpone sexual activity, and show greater investment in the fewer number of children they produce (e.g., Belsky et al. 1991; Graber, Brooks-Gunn, & Warren, 1995; Kim, Smith, & Palermiti, 1997; Moffitt, Caspi, Belsky, & Silva, 1992; Surbey, 1998). Thus, depending on the availability of resources, which is related to paternal investment and spousal harmony, different patterns of socialization occur that result in differential investment in the next generation.

Research examining the effects of environmental conditions on reproductive maturity generally report a greater effect for females than for males (e.g., Kim et al., 1997). This sex difference makes sense, given the differential investment in offspring by males and females. Because females' investment in any conception is greater than males', they should be more sensitive to environmental factors that may affect the rearing of offspring (such as malnutrition, stress, lack of resources) than males (Surbey, 1998).

As children grow, they are less dependent on mothers for their basic needs; thus conflicts between mothers' and children's interests surface, usually at the time of weaning (Hinde, 1987). Caregivers must balance the costs associated with providing protection, food, and guidance to their offspring with the resources needed for their own survival and future reproductive needs. Consistent with this argument, caregivers would expend more resources on only/last born children. In certain extreme cases (e.g., where caregivers' resources are limited or where the potential for offspring survival is low) infanticide can result (Daly & Wilson, 1984). Fathers' investment in offspring often varies with the degree of paternal certainty (e.g., Daly & Wilson, 1988). These environmental variations and their effects on parents, in turn, translate into differential treatment, and outcomes, for different children in the same family.

Other individual differences are associated with children's relationships with their parents, and these differences may be related to a specific dimension of the affectional system, "warmth." Warmth has been conceptualized as a reward system, distinct from the attachment system, that may have evolved to promote cohesive family relationships and parental investment in their children (MacDonald, 1992). Individual differences in the warmth system may underlie parent–child relationships and subsequent personality. Specifically, the affectional system of which warmth is a component may have evolved in such a way as to shape our motivation to engage in certain behaviors (e.g., opioid systems underlie the emotions of social support and separation; Panksepp, cited in MacDonald, 1992). This reward system may provide the basis for parents to invest (by providing warmth) in the prolonged care of their offspring.

Individual differences in the amount and quality of investment parents provide for their children, as well as other important aspects of children's social and physical environment, can be addressed in terms of evolutionary developmental psychology. Placing such emphasis on "environmental" factors may, upon initial inspection, seem at odds with a theory based on the expression of evolved, genetically based, epigenetic programs over the course of ontogeny. But to the contrary, evolutionary developmental psychology has much to say about the conditions in which children are reared and the consequences of their rearing environment on their later development.

The effects that parents have on the personality development and socialization of their children is complicated and not always direct (see Collins et al., 2000). In fact, other theorists taking an evolutionary perspective have suggested that forces outside of the family exert a far greater role on children's socialization than had previously been believed (e.g., Harris, 1995; Scarr, 1992). For example, Scarr (1992) proposed that "super parenting" is not necessary to rear a successful child. Rather, children can tolerate a wide range of parenting styles and still grow up to be successful (i.e., reproductive) adults. Scarr proposed that patterns of child development are robust to variations in parenting, with children seeking environments that are compatible with their genotype, and it is these genotype-compatible environments that are chiefly responsible for shaping children's behaviors and minds.

There is no single evolutionary account for the role of parents and other cultural agents on the socialization of children. Taking an evolutionary developmental perspective can, however, provide insight for understanding the different ways parents treat their children; it can also help identify and illuminate alternative strategies that children and adolescents use to deal with adaptive problems (e.g., mating). For example, viewing early physical maturation and sexual activity by some teens as an adaptive reproductive strategy in response to stressful and uncertain environments may cause policymakers to see the problem of teenage pregnancy in a different light and propose different alternatives for its solution.

DEVELOPMENTAL ANTECEDENTS OF ADULT SEX DIFFERENCES

Evolutionary psychologists have understandably been interested in sex differences in adults. In particular, evolutionary social psychologists have focused on sex differences in reproductive strategies, most as they relate to parental investment theory (e.g., Buss, 1989; Shackelford & Larsen, 1997). Sex differences have also been a favorite topic of developmental psychologists. Although some cognitive sex differences are now typically attributed to an interaction of biological and social factors (e.g., Casey, 1996), differences in social behavior between boys and girls are most typically attributed to the adoption of culturally imposed gender roles (e.g., Eagly, 1987). Although one's culture, a proximal mechanism, undeniably exerts a profound effect on one's gender-specific behaviors and roles, evolutionary psychology proposes that males and females have evolved different "strategies" relating to mating and childrearing and that these different evolved strategies, or distal mechanisms, underlie sex differences in associated behaviors across all human cultures (e.g., Bjorklund & Shackelford, 1999; Geary, 1998). This, of course, does not imply that adult sex differences arise fully formed but rather that they emerge over the course of development and follow the precepts of the developmental systems approach discussed earlier.

From a developmental perspective, many behaviors that reflect sex differences between adults should have their origins in childhood. Thus, differences in the social behaviors between boys and girls may reflect preparations for important reproductively related behaviors observed in adulthood. Although we have emphasized earlier that many adaptive characteristics of infancy and childhood are selected for this time in development only and are not (necessarily) preparations for later life, other aspects of childhood *do* serve to prepare the way for adulthood, of which sex differences in social and cognitive abilities are good examples.

Adult sex differences should be found in mating strategies, in the degree males and females invest in the well-being of their offspring, and in intrasexual competition (see Geary, 1998, 1999). Following the tenets of parental investment theory (Trivers, 1972), women, because of the greater potential investment they have in any potential copulation (i.e., pregnancy and the principal job of nurturing the resulting child), should adopt a more conservative mating strategy than men. They should also be more oriented toward childcare. With regard to intrasexual competition, men in all cultures compete with one another for control of resources (e.g., money or cattle) and attainment of social status. Such competition often involves physical contests and often results in injury or death (e.g., Cairns & Cairns, 1994; Daly & Wilson, 1988).

Of course, females also compete with one another for mates. Our knowledge, however, of the ways in which females accomplish this goal is extremely limited in both the human and animal literatures. Ethologists who have studied this (Gowaty, 1992; Smuts, 1985, 1995) have found that female primates use alliances with conspecifics for both defense against unwanted sexual overtures and access to desired males. In gaining access to males, females often compete, through alliances and deception, with other females as well. We also know that human females use different forms of aggression than males, specifically "relational aggression" (Crick & Bigbee, 1998), which involves gossiping, backbiting, and shunning other women, the goal of which appears to be to disrupt the social networks of their competitors. In short, and consistent with Darwin's original formulations, there is both within- and between-sex competition for mates.

From this view, it is important to explore further females' use of "relational aggression" or aggression used in the service of social relations. Knowing the goal of within- and between-sex relational aggression would be helpful. That is, relational aggression is used to manipulate social relations, but we do not know what these relationships are the vehicle for. Is it used by preschool girls against both boys and girls to gain access to favored resources, similar to the way preschool boys use physical aggression? Is it used in adolescence against other girls in the service of gaining access to potential mates?

Competition and Aggression

Although females compete with one another and use aggression, the intensity of that competition is not as fierce as it traditionally has been for males and rarely leads to serious physical injury or death. This pattern of sex differences is particularly critical in a species, such as humans, that is marginally polygamous, with some males being able to monopolize more than one female and other males having access to no females or only to less desirable females (i.e., those with low reproductive value). Most mammalian females will find a mate, even if not a highly desirable one; in contrast, the fitness variance is larger for mammalian males, with many males being totally excluded from mating. As a result, selection favored a male psychology in which competitive risk taking was favored (Daly & Wilson, 1988; Wilson & Daly, 1985). Such risk taking, and the violence that can accompany it, is universal and peaks when males are entering the reproductive market, which in humans is in adolescence (Cairns & Cairns, 1994; Daly & Wilson, 1988).

Risk taking and accidents are frequently the result of competitive or "show-off" (display) behaviors, with the purpose being to compete with other members of the same sex or to impress members of the opposite sex. Data from the United States indicate that death from accidents and injuries resulting from violence are higher in males than females and rise rapidly for males in the late teens and continue to increase into the mid-20s before declining (see Cairns & Cairns, 1994; Daly & Wilson, 1990). Similar patterns are observed both for being the victim and the perpetrator of homicide (Cairns & Cairns, 1994; Daly & Wilson, 1988; Wilson & Daly, 1985).

Despite the societal penalties and presumed maladaptiveness of much of this behavior in contemporary culture, human males have inherited a psychology that was adapted to different conditions in which risky competition during adolescence and young adulthood, on the average, resulted in increased inclusive fitness. Such behaviors are not, of course, "programmed" or "inevitable" but rather are shaped by experience over development and are more likely to be expressed in some environments than others. For example, when a young male has limited access to important cultural resources and when life expectancy is low, competing vigorously for mates and what resources one can attain makes more sense than taking a more cautious, long-term approach. Under such conditions, which typify impoverished communities in affluent nations, males can be expected to engage in elevated levels of risk taking and violence against other males. This is exactly the pattern one sees in the United States for homicide rates of African American males (see Cairns & Cairns, 1994). The age pattern is similar to that of Whites, but the absolute rate is higher and is associated with reduced access to educational and economic opportunities for many inner-city African American males in comparison with Whites.

Judging Ideal Mates

One interesting sex difference that is apparent in adolescence is concerned with sexual attractiveness. In all cultures, women (including teenage girls) state that the ideal mate is someone several years older than they are (Buss, 1989; Kenrick & Keefe, 1992), and this corresponds to actual marriage practices (Kenrick & Keefe, 1992). Similarly, males in all cultures state that the ideal mate is someone several years younger than themselves, and the age discrepancy in an ideal mate actually increases as men age (i.e., older men prefer increasingly younger women, whereas women's preferences shown no such change; Kenrick & Keefe, 1992). Males' preference for younger mates has been interpreted as reflecting an evolved psychological mechanism for recognizing reproductive value. Reproductive value, the number of children a woman can potentially have in a lifetime, cannot be measured directly but can be inferred from other characteristics, and age is perhaps the best single predictor. Thus, older men's ideal mate is not someone just a few years younger than themselves but someone who has high reproductive value. The only group not to show this pattern is adolescent boys. Rather, teenage males' ideal mate is a woman several years older than themselves (Kenrick, Keefe, Gabrielidis, & Cornelius, 1996). According to Kenrick and his colleagues (1996), the reason for this anomaly is that adolescent males are making their decision on the basis of physical cues of reproductive value and not age, per se. Women in their late teens and early 20s are the most fertile and thus are selected by adolescent males as most desirable, despite the fact that such women express no interest in dating younger males (Kenrick et al., 1996).

Play as Preparation for Adulthood

Precursors to adult sex differences are readily found in childhood. Perhaps the most obvious differences are observed in the ways in which boys and girls segregate themselves. This segregation has implications for the ways in which children interact and play. For example, as early as 3 years of age, boys engage in more rigorous rough-and-tumble play, particularly in situations not monitored by adults (e.g., see Pellegrini & Smith, 1998). In fact, there is some suggestion that girls actively avoid contact with boys because of their roughness (e.g., Haskett, 1971), thus contributing to the universal formation of the same-sex play groups that dominate the early school years (e.g., Edwards & Whiting, 1988). Segregation in play groups and males' play being rougher than females are also typical of nonhuman primate play (Biben, 1998). Males' greater propensity toward rough-and-tumble play has been associated with prenatal exposure to male hormones (Collaer & Hines, 1995).

The most common preparatory function proposed for rough-and-tumble play in the animal literature relates to fighting and hunting in males (Biben, 1998; Smith, 1982). This argument is based on the similarity in design features; for example, both playing and fighting involve hitting movements. In humans, rough-and-tumble play mirrors the activities associated with male–male competition (i.e., primitive warfare) in hunter-gatherer societies (Keeley, 1996). Further, experiencing both superordinate and subordinate role characteristics of rough-and-tumble play probably relates to social competence. Evidence from nonhuman primates, for example, suggests that juvenile squirrel monkeys, *Saimiri Sciureus*, deprived of opportunities to engage in play fighting where they are in superordinate (pinner) and subordinate (being pinned) roles, are later bullies and "sissies," respectively (Biben, 1989). Thus, although boys' rough-and-tumble play may have some immediate benefits, such as establishing social hierarchies and facilitating skeletal and muscle development, it also appears to teach boys something about aggression, fighting, and social competition. Further, by engaging in the role alternation characteristic of playfighting, boys are gaining experience in superordinate and subordinate roles (Biben, 1998), something that is useful in competitive interactions of all sorts but especially useful in their encounters with other males on matters of dominance and eventual mating choices.

Girls' play is also influenced by matters associated with fitness and mating but in different ways. Girls engage in more play parenting (i.e., doll play) than boys, a sex difference that is found even in some primates (Pryce, 1995). Further, there is a relative absence of dominance-related themes in the play of human and nonhuman female primates (Biben, 1998). That is, females' play is less often centered around roles where physically based dominance relationships are publically exhibited. This sex differences has been viewed as an evolved tendency that relates to the fact that females take primary responsibility for parenting their offspring (e.g., Biben, 1998; Geary, 1998).

Sex Differences in Inhibition

Childhood sex differences are also found for some forms of behavioral and social inhibition that may be related to mating and childcare strategies. For example, Bjorklund and Kipp (1996) proposed that, because of the greater potential investment women have in any sexual encounter, it would be in their best interest to have greater inhibitory control of sexual and social behaviors relative to men. Thus, compared to men, women should be better at hiding their true emotions (so as not to reveal prematurely an interest in a potential mate). In a literature review, Bjorklund and Kipp (1996) reported that females displayed greater inhibitory abilities on tasks potentially related to mating strategies, such as concealing emotions. (This is true despite greater female emotional expression.) When sex differences were found consistently in a domain, they were found for children as well as for adults. For example, in research in which people are to display a positive emotion after a negative experience (for example, pretending that a foul-tasting drink tastes good) or vice versa, females from the age of 4 years are better able to control their emotional expressions (that is, fool a judge watching their reactions) than are males (e.g., Cole, 1986; Saarni, 1984).

Bjorklund and Kipp (1996) also reported sex differences in inhibition abilities, favoring females, on tasks requiring delay of gratification and resisting temptation, again at all ages tested (e.g., Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Slaby & Park, 1971). These differences may relate to the greater inhibition skills that women need as principal caregivers for their children. Effective parents must put the needs of their infants first, delay their own gratification, resist distractions that would take them away from their infants, and inhibit many aggressive "reflex" responses to an often difficult and aversive infant. The pattern of sex differences in inhibition abilities found in both children and adults is consistent with the pattern that one would predict if pressures associated with taking care of young children were greater on hominid females than males (see Bjorklund & Kipp, 1996). No consistent sex differences were found, at any age, for tasks assessing cognitive inhibition, which suggests that the sex differences that are observed are relatively domain-specific in nature and relate to the different mating and childcare strategies of ancient men and women.

An evolutionary account of sex differences, either in adulthood or childhood, does not minimize the contribution of culture in affecting the roles that men and women adopt. Rather, the proposal here is that adult sex differences, in all cultures, are built upon evolved, epigenetic programs, based on the differential self-interest of ancestral men and women. Moreover, these abilities develop, with differences observed in adulthood being influenced by experiences over the juvenile period.

Evolutionary theory provides a reason for assessing sex differences on a wide range of social and cognitive tasks. Evaluating sex differences in our studies for their own sake rarely seemed worthwhile. But having an overarching theory that proposes that males and females have evolved different strategies for maximizing their inclusive fitness and that these strategies develop in interaction with a child's social and physical environment affords a motivation for thinking that, sometimes, sex differences are something substantially more than error variance.

EVOLUTIONARY DEVELOPMENTAL PSYCHOLOGY AND CONTEMPORARY CULTURE

Despite the many differences of lifestyle between contemporary humans and their Pleistocene ancestors, there has been too little time for evolved psychological mechanisms to have changed since the advent of civilization 10,000 to 12,000 years ago. As a result, mechanisms evolved to adapt ancient humans to their environments may not always be beneficial to modern people.

This insight is relevant to formal educational practices. Given that the modern human mind evolved to solve problems faced by small groups of nomadic hunters and gatherers, it is no wonder that many children balk at attending school. From the perspective of evolutionary psychology, much of what we teach children in school is "unnatural" in that teaching involves tasks never encountered by our ancestors (e.g., Jensen et al., 1997; Pellegrini & Bjorklund, 1997). For example, although our species has apparently been using language for tens of thousands of years, reading is a skill that goes back only a few thousands of years, and it is only in this century that a majority of people on the planet are literate. Geary (1995) has referred to cognitive abilities that were selected in evolution, such as language, as *biologically primary abilities* and to skills that build upon these primary abilities but that are principally cultural inventions, such are reading, as *biologically secondary abilities.* Biologically primary abilities are acquired universally and children typically have high motivation to perform tasks involving them.

Biologically secondary abilities, on the other hand, are culturally determined, and often tedious repetition and external motivation are necessary for their mastery. It is little wonder that reading, a supposed "language art," and higher mathematics give many children substantial difficulty.

On a related issue, Jensen and his colleagues (1997) have proposed that a common childhood disorder that impacts formal schooling, attention-deficit/hyperactivity disorder (ADHD), may, in fact, reflect an adaptational problem, for at least some afflicted children. Impulsivity, rapid scanning, and hyperactivity may have been advantageous traits to early *Homo sapiens*. For example, high levels of motor activity may have served (and still do) to gain information about the immediate environment, which can be of benefit to foraging, anticipating dangers, and spotting new opportunities. Rapid scanning, as opposed to the highly focused scanning useful in modern schools, may have served to monitor threats and changing environmental conditions, particularly in stressful or highly varied environments. And quick responses without the benefit of reflection (impulsivity) may have been favored when the likelihood of a delayed response would have resulted in losing food or becoming the victim of a predator. Jensen et al. (1997) proposed that the relatively high incidence of ADHD today (3% to 5%) suggests that it has been maintained by natural selection. Rather than all cases of ADHD being a "disorder," many cases may reflect normal variation in a suite of cognitive/behavioral characteristics or developed responses to early environmental conditions (e.g., high-threat or highly novel environments yielding rapid scanning). Modern schools, with their emphasis on highly focused instruction, provide a poor fit to what were once adaptive evolved mechanisms. Similarly, Panksepp (1998) and Pellegrini and Horvat (1995) have suggested that most children diagnosed with ADHD may simply be highly active and playful youngsters who have a difficult time adjusting to the demands of school. The widespread use of psychostimulant drugs to reduce the hyperactivity and increase the attentional focusing of children with ADHD may reduce the desire and opportunity to play, which may, in turn, reduce neural and behavioral plasticity.

An evolutionary perspective to developmental psychology may also provide insights into some contemporary social issues, such as male-on-male violence during adolescence and young adulthood (e.g., Daly & Wilson, 1988), teenage pregnancy (e.g., Weisfeld & Billings, 1988), the effects of different parenting styles on later behavior (e.g., Belsky et al., 1991), parent–child conflict (e.g., Surbey, 1998; Trivers, 1974), sibling rivalry (Sulloway, 1996), changing patterns of social dominance over childhood (Hawley, 1999), and child abuse (e.g., Daly & Wilson, 1996), among others. For example, cases of child abuse and child homicide are much more frequent in stepfamilies, with the abuse often perpetrated by the stepfather (see Daly & Wilson, 1988, 1996). In fact, Daly and Wilson (1996, p. 79) state that the "step relationship itself is the single most important risk factor for severe child maltreatment yet discovered." Because stepparents have no genetic investment in their stepchildren, from a strictly inclusive-fitness perspective, stepparents should seek to invest few of their resources on their stepchildren. In many animal species, males will kill the offspring of a new mate, thereby bringing the female into estrus sooner and eliminating the investment of resources he would have had to devote to his mate's offspring from a previous male. Humans, in fact, are exceptional in the nurturing that stepparents do provide for stepchildren. Yet, differential patterns of child abuse and expressed motivations for child homicides between genetic parents and stepparents suggest that much of the violence against children is rooted in ancient evolved adaptations, and knowing this can result in societal solutions to a pervasive problem.

CONCLUSION

An evolutionary perspective provides a common ground for interpreting all aspects of human behavior—social, emotional, cognitive—and may serve to integrate the often disparate subfields of psychology. As developmental psychologists, we have long believed that the best way to understand any aspect of human functioning is to look at its ontogeny. But developmental psychology has been as fractionated as its parent discipline. Many developmental scientists often talk past one another because they fail to share a common view of what is important about development (see Bjorklund, 1997b). Evolutionary psychology, we believe, provides a metatheory for developmentalists assessing a wide range of topics and ages (Baltes, 1997; Bjorklund, 1997b; Fishbein, 1976). As evolutionary theory is the foundation for modern biology, we believe that it needs to be the foundation for modern psychology (see Daly & Wilson, 1988; Tooby & Cosmides, 1992; Wilson, 1998).

We also believe that an explicitly developmental perspective can have a positive influence on the field of evolutionary psychology. Much of evolutionary psychology has been concerned with the natural selection of "mature" behaviors. Given this perspective, it is easy to see why some evolutionary psychologists have not looked at child development for interesting phenomena. Evolution proceeds when successful individuals reproduce. These are the most *progressed* members of the species, and factors that promote their reproduction obviously characterize adulthood and not infancy and childhood.

We must admit that, on the surface, this seems to be a reasonable argument, and, quite obviously, much of what does contribute to individual success at reproduction, both today and in our evolutionary past, is found in the adult. But our ancestors also developed, and before organisms can reproduce to get their genes into the next generation, they must first reach adulthood. For a slow-developing species such as humans, that can be a long and treacherous path. How people develop is important to eventual reproductive success, and, as we have noted previously, we have every reason to believe that evolution has worked to select characteristics of infancy and childhood that are adaptive to surviving to adulthood, just as it has worked to make adults responsive to the appropriate social and sexual cues that are so important in getting one's genes into the next generation. Moreover, important characteristics of adulthood, such as different "sexual strategies" of men and women, should not be seen as preformed, springing into existence with the first blast of pubertal hormones. Rather, even these characteristics have a developmental history, which can alter the expected course of adult behavior. We believe that an evolutionary perspective is important for a new science of developmental psychology.

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