

# Evolutionary Developmental Psychology

*David C. Geary and David F. Bjorklund*

Evolutionary developmental psychology is the study of the genetic and ecological mechanisms that govern the development of social and cognitive competencies common to all human beings and the epigenetic (gene–environment interactions) processes that adapt these competencies to local conditions. The basic assumptions and domains of this emerging field, as related to human life history and social and cognitive development, are outlined, as are implications for issues of importance in contemporary society.

## INTRODUCTION

Evolutionary developmental biology is the study of how genetic systems are expressed during development, how the ecology of the developing organism influences the expression of one genetic system or another, and how modifications in timing of developmental processes influence evolution (Gilbert, Opitz, & Raff, 1996; Waddington, 1942). Of particular importance is epigenetics, “the sum of the genetic and non-genetic factors acting on cells to selectively control the gene expression that produces increasing phenotypic complexity during development. The genotype is the starting point and the phenotype is the endpoint of epigenetic control” (Hall, 1992, p. 215). Genes provide the instructions for guiding the development of the core phenotypes, such as body structure and social behaviors, of the species. Sensitivity to internal (e.g., hormones) and external (e.g., population density) conditions ensures that the expression of the genotype is responsive to social and ecological factors such that the individual’s physical, behavioral, and psychological phenotypes are adapted, during the course of development, to these conditions (e.g., population density).

The development of most human phenotypes and associated individual variability among these phenotypes will be influenced by a mixture of genetic and ecological mechanisms, that is, by epigenetic processes (Hall, 1992; Scarr, 1992). These processes ensure commonality in the basic phenotypes of all humans and reflect the evolutionary history of our species but at the same time allow for the ontogenetic adaptation of these phenotypes to the local ecology. The goals of evolutionary developmental psychology, the sister discipline of evolutionary developmental biology, are to identify the social, psychological, cognitive, and neural phenotypes that are common to human beings, and to other species, and to identify the genetic and ecological mechanisms that shape the development of these phenotypes and ensure their adaptation to local conditions. The goal here is to provide the skeletal framework for the field of evolutionary developmen-

tal psychology, that is, to outline basic assumptions, define domains of study, and discuss future directions.

Among the fundamental issues that must be addressed by this emerging field are the function of development and evolutionary change in the developmental period, issues discussed in the first section below. The second and third sections focus on the two core areas of developmental psychology, social and cognitive development, respectively, and provide an evolutionary framework for conceptualizing empirical and theoretical work in these areas. The last section addresses the relationship between evolved phenotypes and their expression in contemporary society.

## EVOLUTION AND DEVELOPMENT

*Function of development.* A long developmental period has a clear risk, death before the age of reproduction, and thus would only evolve if there were benefits that outweighed this risk. Comparative studies suggest that one function and an important adaptive benefit of delayed maturation is the accompanying ability to refine the physical, social, and cognitive competencies that support survival and reproduction in adulthood (Mayr, 1974). For instance, an extended juvenile period is found in all social mammals and the length of this period increases with increases in the complexity of the species’ social system (Joffe, 1997). These patterns support the view that one function of delayed maturation is to allow juveniles to practice and refine the sociocognitive competencies associated with survival and reproduction (e.g., competing for mates) in adulthood. An extended developmental period is also related to enhanced tool use in some species and greater knowledge of the local ecology, both of which facilitate later foraging (Byrne, 1995; Geary, 1998).

For humans, play, social interactions, and exploration of the environment and objects appear to be the mechanisms through which these emerging competencies are practiced and refined during development (e.g., Pellegrini & Smith, 1998). In theory, these child-initiated activities provide experiences with the social, biological (e.g., prey species), and physical world that interact with underlying genetic systems to produce the physical, social, cognitive, and neural phenotypes associated with the survival and reproduction of our ancestors (Geary, 1998; Scarr & McCarthy, 1983). Child-initiated social play and exploration are intimately linked to cognitive and neural development in that these activities result in the environmental experiences that are an integral part of the epigenetic processes that result in adult phenotypes (Greenough, 1991; Hall, 1992). One resulting prediction is that the relationship between early play and social activities and later competencies will be activity specific. For instance, exploration of the wider ecology is associated with an improved ability to mentally represent and navigate in the physical world (Matthews, 1992), but is not necessarily associated with improved abilities in all spatial domains (e.g., remembering the location of objects).

*Evolutionary change.* In considering evolutionary change in the developmental period, it is useful to conceptualize human life history as being comprised of developmental stages (Charnov, 1993). These stages are useful for considering general social and development goals and changes in these goals at different points in the life span and do not, for instance, appear to map onto any developmental stages for the cognitive modules described later. Bogin (1997) provided one such framework and argued that human development can be understood in terms of five stages: infancy, childhood, juvenility, adolescence, and adulthood. The basic features of these stages, as found in humans in hunter-gatherer societies and in other mammals, are described in Table 1 (Bogin, 1997; Lancaster & Lancaster, 1983; Leigh, 1996). The stages are characterized by differing degrees of physical development, social dependence, and social goals.

Based on evidence derived from the fossil record (e.g., adult size), it has been estimated that the age of maturation for *Australopithecus afarensis*, *A. africanus*, and *Homo habilis* was similar to that found in the modern chimpanzee (*Pan troglodytes*), that is, nine to eleven years (Bogin, 1997; McHenry, 1994). In other words, two to four million years ago, our ancestors were sexually mature at around 10 years and probably began to reproduce a few years later. The estimated age of maturation of our most recent ancestor, *H. erectus*, was between 12 and 13 years, whereas that of modern humans is in the late teens to early twenties (Tanner, 1990).

**Table 1 Stages of Human Life History**

<p>Infancy</p> <p><i>Defining feature:</i> For mammals, this is the time of breast-feeding.</p> <p><i>Human characteristics:</i> In hunter-gatherer societies, infants are typically breastfed until the age of 3 years. The age of weaning in humans is shorter than that found in a close relative, the chimpanzee, where infants are weaned between 4 and 5 years of age.</p>
<p>Childhood</p> <p><i>Defining feature:</i> The period between weaning and the ability to eat adult foods.</p> <p><i>Human characteristics:</i> This period is longer in humans than in other primates and appears to be associated with a relatively short infancy. In hunter-gatherer societies, childhood encompasses the ages of 3 to 7 years, 7 years being the age at which the first adult molars appear and dependence on adults decreases. During this time, the responsibility for feeding children often shifts from the mother to the wider community (e.g., older siblings), although social and psychological dependence on parents continues.</p>
<p>Juvenility</p> <p><i>Defining feature:</i> Period between weaning or childhood and sexual maturation and social independence. This period is common to social mammals and is characterized by social and other forms of play.</p> <p><i>Human characteristics:</i> In hunter-gatherer societies this period ranges between 7 years and the mid teens. As with other social mammals, this is often a time of social and other forms of play, as well as a time during which parental dependency decreases and peer influences increase.</p>
<p>Adolescence</p> <p><i>Defining feature:</i> Encompasses the process of physical, social, and personal maturation. In many primates, the transition between juvenility and adulthood is not marked by an obvious period of adolescence (e.g., no growth spurt).</p> <p><i>Human characteristics:</i> Clear growth spurt, and prolonged period of physical maturation. This is generally a time to explore adult social and sexual roles and refine reproduction-related social strategies (e.g., those associated with competing for mates). During this time, the social activities common to juvenility become increasingly adult-like (e.g., play fighting gradually escalates to real fighting). Early physical maturation and prolonged dependence on parents (e.g., to complete schooling) has increased the length of this period in industrial, compared to hunter-gatherer, societies.</p>
<p>Adulthood</p> <p><i>Defining features:</i> Period of mature reproductive activities, which involve finding a mate or mates (e.g., competing for mates or choosing mates) and investment in offspring. For 95% to 97% of mammalian species, there are large sex differences in these activities, with males focusing most of their reproductive energies on mating and females on parenting.</p> <p><i>Human characteristics:</i> As with other mammals, the finding of a mate and investing in any resulting offspring are the focus of this period in hunter-gatherer, and other, societies. Humans are atypical among mammals, in that men invest in the well-being of children, though less so than women do, and women, like men, compete for mates.</p>

Thus, the length of the developmental period has nearly doubled since the emergence of *A. afarensis*. All of the stages described in Table 1 are longer in humans than in other primates and almost certainly longer than in our hominid ancestors (Bogin, 1997; Leigh, 1996).

The substantial increase in the length of the developmental period suggests that our ancestors were more successful at keeping their offspring alive than were other primates; child mortality rates in hunter-gatherer societies are about 50% compared with 67% to nearly 90% in other primates (Lancaster & Lancaster, 1983). Moreover, the lengthening of the developmental period, along with a threefold increase in brain volume since *A. afarensis*, suggests a substantial increase in the complexity of hominid social systems and in the ability to exploit biological and physical resources (e.g., through tool use). An extended developmental period, along with the increased social play and exploratory behavior, would enable the refinement of increasingly sophisticated physical, social, and cognitive competencies.

*Adaptive value of immaturity.* Not all features of the developmental period are a preparation for adult survival and reproduction. A basic assumption of evolutionary developmental psychology is that natural selection has resulted in cognitive and social traits that support survival of individuals at all stages of development, and that infants, children, juveniles, and adolescents may have evolved specific adaptive behaviors to deal with their developmentally defined niches (Bjorklund, 1997). When such a perspective is applied to human cognitive and social development, one sees cognitive or social immaturity in a different light. Seemingly “immature” behavior may have been selected as a way young organisms can negotiate the preadult years (Pellegrini & Smith, 1998). As an example, Turkewitz and Kenny (1982) argued that the immature sensory abilities of infants (e.g., poor eye sight) may serve as a form of protection from overstimulation (see Bjorklund, 1997, for a review). Aspects of cognitive immaturity, such as an egocentric perspective and poor metacognition (see Bjorklund, 1997), may have an adaptive role for children as well. For instance, their short auditory memory span may serve to reduce the amount of language processed and thus aid in comprehension.

## SOCIAL DEVELOPMENT

Sociocognitive competencies, such as the ability to produce and respond to communicative behaviors (e.g., vocalizations), are a requisite feature of survival and reproduction in all primates (Hauser, 1996). Development not only enables the refinement of these sociocognitive competencies through social play, it also re-

flects changes in the nature of social relationships. Social relationships in infancy and childhood are largely survival related, whereas those during juvenility appear to involve a preparation for adult reproduction. The nature of social relationships changes again during adolescence and adulthood, when they are focused more directly on reproductive issues.

*Infancy and childhood.* There is little question that the primary relationship in infancy and childhood is between the child and his or her parents (Bowlby, 1969). The associated attachment-related behaviors, such as stranger anxiety and separation anxiety, emerge at about the same age in all human societies and at about the same age in the chimpanzee, suggesting a long evolutionary history (Bard, 1995). Some form of attachment is, in fact, common to primates and appears to function to reduce infant mortality risks by keeping the infant in close proximity to its parent or parents and by increasing the level of parental investment (Bard, 1995; Bowlby, 1969; MacDonald, 1992); the latter refers to resources, such as time and food, provided to offspring at a cost to the parent (e.g., delayed birth of the next offspring, see Geary, 2000; Trivers, 1974). There are, however, individual differences in the nature or quality of the attachment relationship across dyads of parents and children (Ainsworth & Bell, 1970), suggesting that attachment emerges through an epigenetic process. In other words, the attachment process is biologically driven, but the nuances of this relationship—the measurable phenotype—are shaped by the nature of the parent-child relationship.

One implication, and an important conceptual framework for future studies, is that different forms of attachment reflect an adaptation to different social contexts (MacDonald, 1992). In theory, these adaptations would reflect behavioral and psychological adjustments to maintain or increase levels of parental investment (Trivers, 1974), although empirical research on attachment generally has not approached these individual differences from this perspective. A related issue is whether early attachment patterns influence later reproductive strategies (Belsky, Steinberg, & Draper, 1991). There is indeed a correlation between receiving low or inconsistent levels of parental investment in childhood, an insecure attachment to parents, and later instability in marital relationships and thus lower levels of investment in any resulting children. However, it is not clear if this correlation is caused by early attachment patterns or reflects heritable traits, that is, genes that influence both marital instability and low levels of parental investment (MacDonald, 1997). Future studies of potential social and genetic influences on attachment and later parenting might

follow the approach recently used by Rowe and his colleagues to study genetic and social influences on individual differences in social aggression (Rowe, Almeida, & Jacobson, 1999).

*Juvenility.* During juvenility, the focus of human social relationships shifts from parents to peers, as is found in other social mammals (Bogin, 1997; Harris, 1995). Across primate species, a long juvenile period is associated with a larger neocortex and a complex social system (Barton, 1996; Joffe, 1997), suggesting, as noted earlier, that one goal of juvenility is to practice and refine sociocognitive competencies. An intriguing feature of human social behavior during juvenility is the tendency of children to segregate themselves into same-sex groups and to engage in different forms of social play within these groups, although these differences begin to emerge in childhood (Maccoby, 1988, 1998). From an evolutionary perspective, these sex differences are predicted to be a reflection of and a preparation for sex differences in adult reproductive activities, at least in hunter-gatherer societies and presumably during the course of human evolution (see Bjorklund & Shackelford, 1999; Geary, 1998, 1999, 2000).

As with juvenile males in most other mammals, boys' play is largely focused on the achievement of social status and social dominance and includes rough-and-tumble play (e.g., play wrestling) and group-level competition (e.g., team sports, Pellegrini & Smith, 1998; Smith, 1982). These activities are a preparation for the physical and often deadly forms of male-on-male aggression in adulthood that is common in preindustrial societies and related to striving for social dominance and mate acquisition (Geary, 1998; Keeley, 1996). The social activities of girls are more communal than those of boys and are focused on the development and maintenance of a small number of intimate and reciprocal relationships with other girls. In adulthood, these networks appear to provide a system of social support and stability. The achievement of a stable social network in turn is associated with reduced morbidity risks for children and thus appears to be an evolved parenting strategy (Flinn & England, 1995; Geary, 1998). This does not mean that girls do not compete with one another—they do: they back bite, shun, and gossip, the goal of which appears to be to disrupt the social networks of their competitors (termed "relational aggression," Crick & Bigbee, 1998). Although it is not certain, girls' relational aggression during juvenility might provide practice for later competition over mates and other resources, just as boys' rough-and-tumble play provides practice for later male-male competition. In any case, the evolutionary perspective will provide a broader context for conceptualizing and studying aggression among girls and women.

*Adolescence and adulthood.* Adolescence is defined by the physical changes that prepare individuals for adult reproductive activities, such as giving birth or physical competition for social status, an increasing interest in members of the opposite sex, and an escalation of the forms of social competition described above (Tanner, 1990). As an example, in mammals, including humans, the play fighting of males becomes increasingly intense and adult-like during adolescence. For humans, early courtship and presexual (sometimes sexual) heterosexual relationships emerge, and appear to provide the experiences needed to establish and maintain the more stable relationships of adulthood (Bogin, 1997; Maccoby, 1998).

Early adulthood is the reproductive period and in hunter-gatherer societies usually begins in the late teens for girls and a few years later for boys (Bogin, 1997). Although there are similarities in the reproductive activities of men and women, there are differences as well. For instance, men engage in more physical, coalition-based intrasexual aggression for the establishment of social dominance than do women, and women spend more time in parenting activities than do men (Bjorklund & Shackelford, 1999; Geary, 1998). In hunter-gatherer and other preindustrial societies, women continue having children until menopause and spend their post-menopausal years raising their youngest children and investing in their grandchildren. Older men, in contrast, often attempt to continue their reproductive activities by marrying younger wives (Bogin, 1997; Lancaster & Lancaster, 1983). These patterns suggest different life histories for women and men during human evolution and, as a result, developmental sex differences in social goals, behaviors, and motivations are expected, and found (Geary, 1998, 1999).

Finally, natural selection does not eliminate the many deleterious changes associated with adult aging but rather, under some conditions, can operate to delay the onset of these changes (Charnov, 1993). During hominid evolution there has been a clear increase in the length of the lifespan, suggesting that a slowed rate of maturation and the associated extension of adulthood has resulted in reproductive advantages. The advantages associated with a longer developmental period, as described earlier, could only be supported by a corresponding increase in the lifespan of parents, given the dependency of human children. The increase in the length of adulthood is thus likely to be related in part to increases in the level of parental investment, which in turn would result in reproductive benefits, specifically reductions in child mortality rates and potential improvements—through an

extended childhood and thus greater opportunity to refine social and cognitive competencies—in the later social and thereby reproductive competitiveness of children (Geary, 2000; Lancaster & Lancaster, 1983).

Nonetheless, the power of natural selection wanes with age, and “the benefits resulting from evolutionary selection evince a negative age correlation” (Baltes, 1997, p. 367). This is because traits that are expressed only after an individual has reproduced and successfully reared offspring are not subject to the same degree of selection pressure as traits that directly influence survival to reproductive age and successful reproduction. As a result, there are no strong selection pressures against deleterious genes that have their influence in old age (such as those that contribute to Alzheimer’s dementia). In fact, many of these genes or other factors (e.g., hormones) that provide adaptive benefits early in life may have more deleterious effects later in life.

## COGNITIVE DEVELOPMENT

The first of two central issues for evolutionary developmental psychology is to identify the evolved domains of mind, that is, the constellations of cognitive competencies that appear to have been shaped during evolution (Cosmides & Tooby, 1994; Pinker, 1997). The second issue concerns the mechanisms that govern the development of the associated competencies and their adaptation to local ecologies (Gelman, 1990; Siegler, 1996).

*Domains of mind.* Geary (1998) recently proposed that evolved domains of mind be conceptualized as constellations of hierarchically organized modules for processing information in the social, biological, and physical worlds, as shown in Figure 1, although there appear to be other modules that are not represented in the figure (e.g., for numerical processing). Socio-cognitive modules are further divided into individ-

ual- and group-level systems (see also Caporael, 1997). Individual-level systems are designed for the on-line monitoring of dyadic interactions and for establishing and maintaining interpersonal relationships. The associated submodules include those that support the reading of nonverbal behavior and facial expressions, language, and theory of mind (Baron-Cohen, 1995; Pinker, 1994). The group-level modules parse the social universe into kin, friends (in-group), and competitors (out-group).

Sensitivity to nonverbal behaviors, facial expressions, and other communicative behaviors (e.g., vocalizations) of conspecifics, as well as the preferential treatment of kin and the formation of favored and disfavored social groups, are found in many other species (Goodall, 1986; Hauser, 1996). A rudimentary theory of mind might be evident in chimpanzees, although this is currently debated (e.g., Povinelli & Eddy, 1996; Premack & Woodruff, 1978). Either way, it is clear that humans have the unique ability to form in-groups and out-groups on the basis of social ideologies (e.g., nationality).

In addition to managing social relationships, our ancestors had to secure food and other resources from the natural environment, which in turn almost certainly resulted in the evolution of modules for processing biological and physical information. Biological modules are for categorizing and representing the behavior or growth patterns of flora and fauna in the local ecology, especially species used as food, medicines, or in social rituals (e.g., Berlin, Breedlove, & Raven, 1973). Physical modules are for guiding movement in three-dimensional physical space, mentally representing this space, and using physical materials (e.g., stones, metals) for making tools (Pinker, 1997; Shepard, 1994).

An important developmental prediction is that the skeletal competencies—the neural systems that guide attention to and processing of the associated infor-

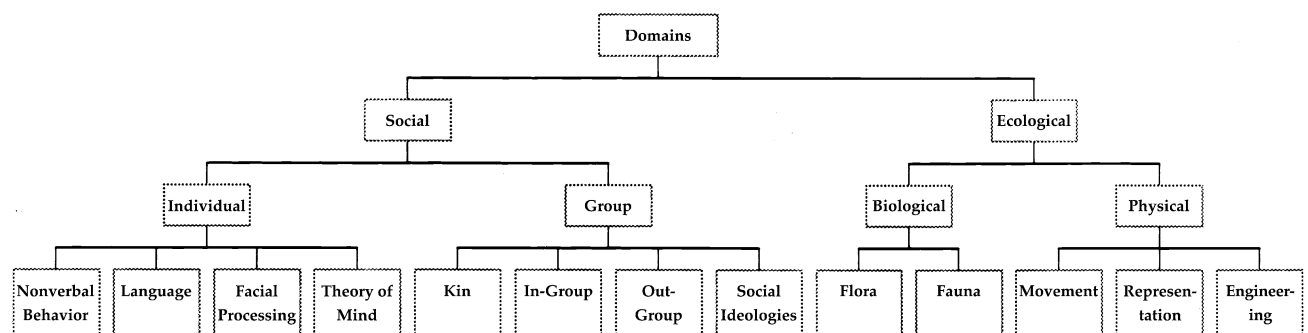


Figure 1 Proposed domains of mind. From *Male, female: The evolution of human sex differences* (p. 180), by D. C. Geary, 1998, Washington, DC: American Psychological Association. Reprinted with permission.

mation—of these modules are inherent but are fleshed out as children engage in social discourse, play, and exploration (Gelman, 1990; see Elman et al., 1996, for an alternative view). The prediction is that natural child-initiated activities are centered on learning about people and developing social competencies, learning about other living things, and learning how the physical world is organized, that is, gaining competencies in the areas of folk psychology, folk biology, and intuitive physics. The associated activities would include, for instance, sociodramatic play, exploring the environment, and object-oriented play. An outline of the predicted developmental features of evolved cognitive modules is presented in Table 2 (Geary, 1998; Gelman, 1990). These predictions may provide a useful framework for guiding future cognitive developmental research and for linking this research to parallel studies in the fields of ethnobiology and cognitive anthropology (Atran, 1998).

*Mechanisms of development.* The long developmental period of humans argues against the position that any inherent features of these cognitive modules and associated behaviors are immutable (Mayr, 1974). Rather, there is a core set of cognitive competencies, but the associated phenotypes are modifiable by experiences, that is, these competencies emerge by means of epigenetic processes. For instance, it appears that children in all cultures are biologically prepared to process and respond to the sounds of all human languages, but the phenotype that eventually emerges is the specific language to which they are exposed (Kuhl et al., 1997). Another prediction is that these modules will not be fully elaborated unless children are exposed to and engage in the relevant activities. For instance, Western children have a rudimentary understanding of folk biology but, presumably due to a lack of extensive exposure to flora and fauna, they do not develop the same degree of folk biological knowledge as is found with individuals in hunter-gatherer and other preindustrial societies (Atran, 1998; Kiel, 1992).

The mechanisms that contribute to this epigenetic process are not well understood but, like natural selection, appear to involve the generation of variability and experiences acting on this variability (Siegler, 1996). The brain and mind appear to generate multiple representations and strategies for processing and acting on social, biological, and physical information. Experience results in one or a few of these representations or behavioral strategies being selected over others. The relative success of one approach or the other for achieving the desired goal (e.g., influencing other people) appears to be the selective process. However, the underlying cognitive and neural mechanisms that generate

**Table 2 Predicted Developmental Features of Evolved Cognitive Modules**

Hierarchical Organization
<ol style="list-style-type: none"> <li>1. The modules shown in Figure 1 are very likely to be comprised of a hierarchy of submodules. For instance, the language system includes specialized systems for the comprehension and production of speech. These, in turn, are supported by sensory and motor systems for processing and articulating language sounds.</li> <li>2. The degree to which submodules are specialized is likely to be inversely related to their level in the hierarchy. The most basic submodules are likely to be highly specialized, designed to process a restricted range of stimuli, such as specific language sounds. Modules at the highest level receive information from many lower-level modules and may show moderate to high levels of flexibility in the range of stimuli that can be processed and in their output. An example is the apparently infinite number of utterances that can be generated by the language production system.</li> </ol>
Sensitive Periods and Child-Initiated Activity
<ol style="list-style-type: none"> <li>1. If cognitive modules emerge by means of an epigenetic process, then the development of the associated neural and cognitive systems will be dependent on exposure to domain-specific information (e.g., language sounds). Experiences interact with the inherent skeletal features of these modules to produce the phenotypic competencies.</li> <li>2. A bias in children's activities and the types of information to which they attend is expected. These activities are expected to correspond to the domains shown in Figure 1 (e.g., orienting to people, exploring the environment) and provide the experiences that are an intimate feature of the epigenetic development of the modules.</li> <li>3. Sensitivity to environmental input is expected to be time-limited to some degree; that is, sensitive periods are expected. The length of the sensitive period may be related to the submodules' level in the hierarchy. Because the functioning of higher level submodules may depend on input from lower level modules, the sensitive period for lower-level modules is expected to be shorter and occur earlier in life than that for higher level modules. In short, the length of the sensitive period may be directly related to the complexity of the information processed by the module.</li> </ol>
Implicit Knowledge
<ol style="list-style-type: none"> <li>1. The skeletal structure of evolved modules reflects the organization of the underlying neural systems and the types of information to which these systems respond.</li> <li>2. Knowledge is built into the organization of these cognitive and neural systems, that is, they respond to appropriate ecological information and produce intelligent responses to this information. The functioning of many of these systems is likely to be automatic and largely outside of the realm of conscious control.</li> <li>3. The degree to which the functioning of modules is relatively automatic and the associated knowledge implicit may be inversely related to the modules' level in the hierarchy. Lower-level modules are likely to be characterized by automatic processing (assuming adequate attention to this information) and a high degree of implicit knowledge. Individuals are more likely to gain explicit awareness of the output of higher-level modules, and the functioning of these modules may be more open to top-down control by the individual.</li> </ol>

variability and ensure the selection of successful over less successful strategies are not well understood (see Shrager & Siegler, 1998, for related discussion) and thus should be one focus of future cognitive developmental and developmental neuroscientific research.

## EVOLUTION AND CONTEMPORARY SOCIETY

A basic tenet of evolutionary psychology is that modern humans evolved domain-specific cognitive abilities and behavioral strategies to deal with recurring conditions in the environments of our ancestors (Cosmides & Tooby, 1994), but these abilities and strategies may not always be well suited to contemporary conditions. Thus, in addition to studying epigenetic processes that guide the development of evolved social and cognitive systems, the goal of evolutionary developmental psychology is to understand how these evolved biases and constraints influence the expression and development of social and cognitive competencies that are important in modern society.

As an example, much of formal education is “unnatural” in that much of what children are taught involves tasks never encountered by our ancestors (Brown & Bjorklund, 1998; Geary, 1995). Although humans apparently have been using language for thousands of years, it is only in this century that the majority of people on the planet are literate. Geary (1995) referred to language and other evolved forms of cognition, such as those represented in Figure 1, as *biologically primary abilities*, and skills that build upon these primary abilities but are principally cultural inventions, such as reading, as *biologically secondary abilities*. Biologically primary abilities are acquired universally and children typically have high motivation to perform tasks involving them. In contrast, biologically secondary abilities are culturally determined, and often tedious repetition and external motivation are necessary for their mastery. From this perspective, it is understandable that many children have difficulty with reading and higher mathematics.

Similarly, an understanding of evolved social biases has profound implications for understanding and addressing other pressing social issues, such as individual differences in parenting styles, child neglect and abuse, the sharp increase in male-on-male violence during adolescence and early adulthood, divorce, and prejudice (e.g., Daly & Wilson, 1988). Without an appreciation of the evolutionary and biological contributions to the epigenetic processes that shape the development of these phenomena, psychology as a discipline will never address these issues to its fullest potential. As an example, the tendency of adolescent males to engage in

sometimes life-threatening risk-taking (e.g., reckless driving) and deadly forms of male-on-male violence is readily understood in terms of competition for social status, which in turn often influences mating opportunities (Daly & Wilson, 1988; Geary, 1998). By understanding the goal of these behaviors and the contexts that are likely to elicit them (e.g., “saving face” when confronted by a male peer), psychologists should be in a position to reduce the frequency of these behaviors. One potential strategy is to provide multiple opportunities for young men to achieve status in one domain (e.g., athletics) or another (e.g., academics). For instance, in this view, athletic competition is a culturally regulated expression of intrasexual competition, and this competition can be modified (e.g., through rules) and channeled through athletics such that it does not escalate into deadly violence.

## CONCLUSION

A complete understanding of human social and cognitive development, and any associated sex differences, requires an understanding of human evolution and the associated epigenetic processes that guide the development of evolved social and cognitive phenotypes. To argue otherwise is to ignore the vast empirical literature supporting Darwin’s (1859) theory of evolution (e.g., Weiner, 1995) and to deny the core theoretical foundation of the biological sciences. The goal here was to provide a skeletal framework for linking the extant empirical and theoretical literatures in developmental psychology to the wider field of evolutionary biology and, in particular, to evolutionary developmental biology (e.g., Hall, 1992). This emerging interdisciplinary field of evolutionary developmental psychology seeks to explain not only the evolutionary and biological influences on human development, but also to understand the social and ecological conditions that will necessarily affect the development and expression of social and cognitive competencies. In other words, an evolutionary perspective should provide a useful framework for conceptualizing and guiding future research across many of the developmental specialties (e.g., social, cognitive, and neuroscientific).

## ACKNOWLEDGMENTS

We thank Todd Shackelford and three anonymous reviewers for helpful comments on an earlier draft. The preparation of this article was supported, in part, by a Summer Research Fellowship awarded to the first author by the Research Council of the University of Missouri at Columbia.

## ADDRESSES AND AFFILIATIONS

Corresponding author: David C. Geary, Department of Psychology, 210 McAlester Hall, University of Missouri at Columbia, Columbia, MO 65211-2500; e-mail: GearyD@Missouri.edu. David F. Bjorklund is at Florida Atlantic University, Boca Raton, FL.

## REFERENCES

- Ainsworth, M. D. S., & Bell, S. M. (1970). Attachment, exploration and separation: Illustrated by the behavior of one-year-olds in a strange situation. *Child Development, 41*, 49–67.
- Atran, S. (1998). Folk biology and the anthropology of science: Cognitive universals and cultural particulars. *Behavioral and Brain Sciences, 21*, 547–609.
- Baltes, P. B. (1997). On the incomplete architecture of human ontogeny: Selection, optimization, and compensation as foundation of developmental theory. *American Psychologist, 52*, 366–380.
- Bard, K. A. (1995). Parenting in primates. In M. H. Bornstein (Ed.), *Handbook of parenting: Vol. 2. Biology and ecology of parenting* (pp. 27–58). Mahwah, NJ: Erlbaum.
- Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Cambridge, MA: MIT Press/Bradford Books.
- Barton, R. A. (1996). Neocortex size and behavioural ecology in primates. *Proceedings of the Royal Society of London B, 263*, 173–177.
- Belsky, J., Steinberg, L., & Draper, P. (1991). Childhood experience, interpersonal development, and reproductive strategy: An evolutionary theory of socialization. *Child Development, 62*, 647–670.
- Berlin, B., Breedlove, D. E., & Raven, P. H. (1973). General principles of classification and nomenclature in folk biology. *American Anthropologist, 75*, 214–242.
- Bjorklund, D. F. (1997). The role of immaturity in human development. *Psychological Bulletin, 122*, 153–169.
- Bjorklund, D. F., & Shackelford, T. K. (1999). Differences in parental investment contribute to important differences between men and women. *Current Directions in Psychological Science, 8*, 86–89.
- Bogin, B. (1997). Evolutionary hypotheses for human childhood. *Yearbook of Physical Anthropology, 40*, 63–89.
- Bowlby, J. (1969). *Attachment and loss: Vol. 1. Attachment*. New York: Basic Books.
- Brown, R. D., & Bjorklund, D. F. (1998). The biologizing of cognition, development, and education: Approach with cautious enthusiasm. *Educational Psychology Review, 10*, 355–373.
- Byrne, R. (1995). *The thinking ape: Evolutionary origins of intelligence*. New York: Oxford University Press.
- Caporael, L. R. (1997). The evolution of truly social cognition: The core configurations model. *Personality & Social Psychology Review, 1*, 276–298.
- Charnov, E. L. (1993). *Life history invariants: Some explorations of symmetry in evolutionary ecology*. New York: Oxford University Press.
- Cosmides, L., & Tooby, J. (1994). Origins of domain specificity: The evolution of functional organization. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 85–116). New York: Cambridge University Press.
- Crick, N. R., & Bigbee, M. A. (1998). Relational and overt forms of peer victimization: A multiinformant approach. *Journal of Consulting and Clinical Psychology, 66*, 337–347.
- Daly, M., & Wilson, M. (1988). *Homicide*. New York: Aldine de Gruyter.
- Darwin, C. (1859). *On the origin of species by means of natural selection*. London: John Murray.
- Elman, J. L., Bates, E. A., Johnson, M. H., Karmiloff-Smith, A., Parisi, D., & Plunkett, K. (1996). *Rethinking innateness: A connectionist perspective on development*. Cambridge, MA: MIT Press/Bradford Books.
- Flinn, M. V., & England, B. (1995). Childhood stress and family environment. *Current Anthropology, 36*, 854–866.
- Geary, D. C. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *American Psychologist, 50*, 24–37.
- Geary, D. C. (1998). *Male, female: The evolution of human sex differences*. Washington, DC: American Psychological Association.
- Geary, D. C. (1999). Evolution and developmental sex differences. *Current Directions in Psychological Science, 8*, 115–120.
- Geary, D. C. (2000). Evolution and proximate expression of human paternal investment. *Psychological Bulletin, 126*, 55–77.
- Gelman, R. (1990). First principles organize attention to and learning about relevant data: Number and animate-inanimate distinction as examples. *Cognitive Science, 14*, 79–106.
- Gilbert, S. F., Opitz, J. M., & Raff, R. A. (1996). Resynthesizing evolutionary and developmental biology. *Developmental Biology, 173*, 357–372.
- Goodall, J. (1986). *The chimpanzees of Gombe: Patterns of behavior*. Cambridge, MA: The Belknap Press.
- Greenough, W. T. (1991). Experience as a component of normal development: Evolutionary considerations. *Developmental Psychology, 27*, 14–17.
- Hall, B. K. (1992). *Evolutionary developmental biology*. London: Chapman & Hall.
- Harris, J. R. (1995). Where is the child's environment? A group socialization theory of development. *Psychological Review, 102*, 458–489.
- Hauser, M. D. (1996). *The evolution of communication*. Cambridge, MA: MIT Press/Bradford Books.
- Joffe, T. H. (1997). Social pressures have selected for an extended juvenile period in primates. *Journal of Human Evolution, 32*, 593–605.
- Keeley, L. H. (1996). *War before civilization: The myth of the peaceful savage*. New York: Oxford University Press.
- Keil, F. C. (1992). The origins of an autonomous biology. In M. R. Gunnar & M. Maratsos (Eds.), *Modularity and constraints in language and cognition: The Minnesota symposia on child psychology* (Vol. 25, pp. 103–137). Hillsdale, NJ: Erlbaum.



- Kuhl, P. K., Andruski, J. E., Chistovich, I. A., Chistovich, L. A., Kozhevnikova, E. V., Ryskina, V. L., Stolyarova, E. I., Sundberg, U., & Lacerda, F. (1997). Cross-language analysis of phonetic units in language addressed to infants. *Science*, *277*, 684–686.
- Lancaster, J. B., & Lancaster, C. S. (1983). Parental investment: The hominid adaptation. In D. J. Ortner (Ed.), *How humans adapt: A biocultural odyssey* (pp. 33–56). Washington, DC: Smithsonian Institution Press.
- Leigh, S. R. (1996). Evolution of human growth spurts. *American Journal of Physical Anthropology*, *101*, 455–474.
- Maccoby, E. E. (1988). Gender as a social category. *Developmental Psychology*, *24*, 755–765.
- Maccoby, E. E. (1998). *The two sexes: Growing up apart, coming together*. Cambridge, MA: Belknap Press.
- MacDonald, K. (1992). Warmth as a developmental construct: An evolutionary analysis. *Child Development*, *63*, 753–773.
- MacDonald, K. (1997). Life history theory and human reproductive behavior: Environmental/contextual influences and heritable variation. *Human Nature*, *8*, 327–359.
- Matthews, M. H. (1992). *Making sense of place: Children's understanding of large-scale environments*. Savage, MD: Barnes & Noble Books.
- Mayr, E. (1974). Behavior programs and evolutionary strategies. *American Scientist*, *62*, 650–659.
- McHenry, H. M. (1994). Behavioral ecological implications of early hominid body size. *Journal of Human Evolution*, *27*, 77–87.
- Pellegrini, A. D., & Smith, P. K. (1998). Physical activity play: The nature and function of a neglected aspect of play. *Child Development*, *69*, 577–598.
- Pinker, S. (1994). *The language instinct*. New York: William Morrow.
- Pinker, S. (1997). *How the mind works*. New York: W. W. Norton & Co.
- Povinelli, D. J., & Eddy, T. J. (1996). What young chimpanzees know about seeing. *Monographs of the Society for Research in Child Development*, *61*(3, Serial No. 247).
- Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*, 515–526.
- Rowe, D. C., Almeida, D. M., & Jacobson, K. C. (1999). School context and genetic influences on aggression in adolescence. *Psychological Science*, *10*, 277–280.
- Scarr, S. (1992). Developmental theories of the 1990s: Developmental and individual differences. *Child Development*, *63*, 1–19.
- Scarr, S., & McCarthy, K. (1983). How people make their own environments: A theory of genotype→environment effects. *Child Development*, *54*, 424–435.
- Shepard, R. N. (1994). Perceptual-cognitive universals as reflections of the world. *Psychonomic Bulletin and Review*, *1*, 2–28.
- Shrager, J., & Siegler, R. S. (1998). SCADS: A model of children's strategy choices and strategy discoveries. *Psychological Science*, *9*, 405–410.
- Siegler, R. S. (1996). *Emerging minds: The process of change in children's thinking*. New York: Oxford University Press.
- Smith, P. K. (1982). Does play matter? Functional and evolutionary aspects of animal and human play. *Behavioral and Brain Sciences*, *5*, 139–184.
- Tanner, J. M. (1990). *Foetus into man: Physical growth from conception to maturity*. Cambridge, MA: Harvard University Press.
- Trivers, R. L. (1974). Parent-offspring conflict. *American Zoologist*, *14*, 249–264.
- Turkewitz, G., & Kenny, P. (1982). Limitations on input as a basis for neural organization and perceptual development: A preliminary theoretical statement. *Developmental Psychobiology*, *15*, 357–368.
- Waddington, C. H. (1942). Canalization of development and the inheritance of acquired characteristics. *Nature*, *150*, 563–565.
- Weiner, J. (1995). *The beak of the finch*. New York: Vintage Books.