Evolutionary Functions of Social Play
Life Histories, Sex Differences, and Emotion Regulation

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Many research findings about animal play apply to children's play, revealing structural and functional similarities with mammals in general and primates in particular. After an introduction to life-history theory, and before turning to humans, the author reviews research about the two mammals in which play has been studied the most extensively: laboratory rats and monkeys. He looks at the development of play, deprivation studies, gender segregation, and the functions of gender-differentiated forms of play. The gender segregation and sex differences in play parenting and rough-and-tumble play observed in many primates are also evident in children. Vigorous social-play benefits all children physically by developing strong bones and muscles, by promoting cardiovascular fitness, and by encouraging exercise habits that help prevent obesity. Unsupervised play also helps hone the skills of communication, perspective taking, and emotion regulation. For boys especially, rough-and-tumble play in early childhood provides a scaffold for learning emotion-regulation skills related to managing anger and aggression. **Key words**: emotion regulation; life-history theory; play deprivation; play of mammals; play of primates; play parenting; rough-and-tumble play; social play

This article explores the adaptive functions of the forms of play that have been shaped by natural selection to insure the organism's survival and reproduction. Contemporary evolutionary biologists think evolved patterns of play help children develop strong bones and fit bodies, acquire and practice a culture's skills and values, learn to establish friendships and get along with peers, and control impulses and emotions. The positive emotions play invokes encourage children to explore the environment, to try out new behaviors, and to learn with more flexibility— all of which helps prepare them for the unexpected (Panksepp 1993; Spinka, Newberry, and Beckoff 2001). However, in the United States and in much of the rest of the developed world, we have witnessed a dramatic decline in the opportunities for children to engage in vigorous social play away from adult control (Gray 2011). Thus, questions about possible functions

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of free social play with respect to the physical and emotional health of children seem especially urgent.

In this article, I examine the possible benefits derived from vigorous social play—running, jumping, chasing, and wrestling. Mothers and teachers often frown on all of these, especially when played indoors. I begin with an introduction to life-history theory because each species has its own unique social ecology and historical development. We need an understanding of the challenges and opportunities a particular species faces to understand why play evolved in the particular form it did in that species. Because similar patterns of vigorous social play appear in many species, we can use comparative analyses to explore its adaptive functions in relation to species differences in social ecology and life history, as well as in age and gender within species. I precede my discussion of play in children with an overview of the mammals for which play has been studied most extensively: rats and monkeys. I review the development of play and experimental deprivation studies in which the potential benefits of play are inferred from animals deprived of it, for which there is no close parallel in human research. I also examine gender segregation and sex differences in play in relation to the specific functions that gender-differentiated forms of play serve in monkeys. I then describe developmental and cross-cultural patterns of play in children with particular attention to gender segregation and sex differences. Finally, I review evidence for adaptive functions of play in children and conclude with a discussion of the specific function of emotion regulation.

An Evolutionary Perspective

From evolutionary biology, we know that the impulse to play in certain ways and at certain points in the life cycle is common to a variety of mammals. Because play is so ubiquitous in young mammals and combines the expenditure of great energy with apparently pointless risk, its evolutionary origins and functions have long intrigued evolutionary biologists. Evolutionary biologists specializing in the study of animal behavior (hereafter, ethologists) generally regard play as having been shaped in our species by natural selection to provide delayed benefits to the individual. In other words, through play a child develops and practices skills critical to survival and reproduction as an adult (Smith 2010). However, play may also confer immediate benefits to a child, and contemporary ethologists recognize that natural selection acts upon all periods of the life cycle, a view now called life-history theory.

Life-history theory proposes an analytical framework widely used in biology and evolutionary psychology since the 1970s. It postulates that species-typical characteristics have evolved to guide somatic and reproductive efforts over the course of life. The basic insight of life-history theory is that, with respect to its evolution, it is best to consider an organism as an ever-changing life cycle, not as a static adult. Because individuals have a finite amount of time, energy, and resources, they must make basic decisions regarding behavioral priorities and the allocation of resources with respect to developmental periods and life goals appropriate to those periods (Bogin 1999; Levins 1968). Despite its obvious costs, play takes priority during the early-juvenile period in all social primates, and social play occupies much of the time not spent eating and sleeping. Ethnologists consider this fact important as the primary basis for inferring an adaptive function of play, because natural selection favors only behaviors whose benefits clearly outweigh associated costs. The basic cost of such play is the time and energy devoted to it, since playing necessarily diminishes the time, effort, and energy spent on other activities. Under benign circumstance, the costs of play are greatly reduced, but playing can be costly under less favorable circumstances involving uncertainty, danger, or resource shortage, and other environmental risks. For example, it is well known that food shortages diminish juvenile play. This makes sense given the expenditure of high energy associated with play, which can increase food requirements in at least some species by as much as 10 percent over a metabolism at rest (Martin 1984; Siviy and Atrens 1992). Animals play less in very hot climates, when they fall ill, and when they fear predators. For example, cat odors and other predator odors have been shown to decrease play in rats (Siviy, Harrison, et al. 2006). All this makes sense, too, because the additional costs of play involve the possible neglect of predator danger, as well as the heightened risk of injury, especially in play fighting and other risky behaviors (Smith 2010).

Despite such costs and strategic trade offs, the natural propensity of young mammals is to engage in play as long and as often as ecological constraints and opportunities afford. Play is so ubiquitous in primates that Mason (1965) notes "playfulness . . . is rightly regarded as a useful index of the physical and psychological well-being of the young primate. Its prolonged absence raises the suspicion of retardation, illness or distress" (530). Play is so strongly part of the natural motivation of the young that attempts to suppress or deprive the animal of it are followed by sharp rebound effects. This surge in play after deprivation, the amount of time and energy devoted to play despite well-documented

costs, and the universality of play throughout the mammalian order leads to the conclusion that play serves multiple functions and is indispensable to the development of a healthy, well-functioning adult. I take this principle as the starting point for my analysis.

Laboratory Rats at Play

Researchers have studied rat pups extensively to determine what functions play serves in their development, both socially and at the neural level. Classified as rough-and-tumble, the play of rat pups, includes charging, pinning, chasing, rolling, wrestling, and inhibited biting as well as surprise attacks. This behavior appears to be largely instinctive because it requires no evident learning on the part of the animal and appears early in life, even in socially isolated animals (Panksepp 1993). The developmental course of play behavior in rats follows the typical inverted U curve seen in other species, increasing rapidly from eighteen days of age and peaking at between thirty-two and forty days then declining as rats approach sexual maturity (approximately eighty to ninety days). Play fighting also becomes rougher and more complex during this period with an increase in asymmetry associated with dominance struggles. Such play fighting differs from the more serious fighting of somewhat older rats by its lesser severity and the reduced risk of its causing injury (Pellis and Pellis 1987). Panksepp (1980, 1993) insists that rat pups do not become aggressive when playing in this manner and never progress beyond a playful state. They initiate play bouts by pouncing on each other followed by chasing and pinning. After a period of playing, the animals stop and engage in grooming. The surprise attack often comes during this grooming phase. Usually, one animal suddenly pounces onto the seemingly unaware playmate, and the playing again commences.

Social Deprivation Experiments with Rats

Researchers have found that the play of rat pups increases considerably after the animals are deprived of social interaction. The short-term effects of social deprivation, as well as more specific play deprivation (animals housed with nonplayful adult rats), clearly reveal a rebound effect. Of greater interest to developmental psychologists are findings regarding the long-term effects of play deprivation.

Research has demonstrated that depriving juvenile rats of play opportunities during their normative play period with peers (twenty to fifty days old) appears to have serious consequences for their adult behavior. In adulthood, these play-deprived rats show disturbances in their social behavior (Hol, Van Den Berg, Van Ree, and Spruijt 1999; Van den Berg, Hol, Van Ree, Spruijt, Everts, and Koolhaas 1999), their agonistic behavior (Lore and Flannelly 1977), and their sexual behavior (Gerall, Ward, and Gerall 1967). Rats deprived of play fighting are less tolerant of social approaches and may respond to social initiatives by behaving either more aggressively or more timidly than normal. These effects do not appear in rats provided one hour of peer play per day (Einon and Potegal 1991; Potegal and Einon 1988). We shall return to questions regarding the long-term effects of social deprivation at the end of the next section dealing with the play of monkeys.

Monkeys at Play

Because of the diversity of primate social ecologies, any discussion of the different forms and functions of social play must consider the species-specific context in which the play occurs. For example, one would expect little social play in orangutans because they live primarily in solitude. Mother orangutans spend most of their lives isolated from other adult orangutans and give birth about once every five years. The only playmate for a juvenile orangutan, therefore, is its own mother, who is not particularly playful (Biben and Suomi 1993). Thus, the development of play behavior in orangutans does not offer much insight regarding the development of play in children.

In contrast, squirrel monkeys and rhesus macaques are typically born into troops that provide a great deal of social play with age-mates. They are also the two species of monkeys that have received the greatest research attention and provide us a more comprehensive view of play behavior over the life course than other nonhuman primate species. Monkey infants begin to engage in peer social play at about five weeks (Biben and Suomi 1993) and show the typical inverted U curve seen in other species, increasing rapidly in the early months, peaking at about six months, then declining rapidly by the end of the second year as the monkeys approach sexual maturity. At about the time they begin to play, infant monkeys of both sexes also begin to prefer the company of same-sex peers; and among juveniles, sex segregation becomes the rule (Rosenblum, Coe, and

Bromley 1975). This pattern of sex differences in social play generally appears in all primates. More importantly for our purposes, gender-specific forms of play provide important clues to the evolved functions of social play. As with humans, sex differences among rhesus and squirrel monkeys are typically relative rather than absolute—some overlap occurs between the sexes. For example, compared to male peers, young females spend considerably more time in the presence of adult females, and at sexual maturity, they remain with their mothers, sisters, aunts, and daughters for the rest of their lives. Female monkeys show considerably more interest in young infants and engage in play parenting throughout their juvenile years much more often than males do (Geary 1998; Pryce 1995). The functional significance of this type of play is apparent in primates—research in five species show that the chances of survival of the monkey's firstborn is two to four times higher for mothers with previous experience in caring for infants (Pryce 1993). Finally, mothers socialize their daughters differently than they do their sons. For example, female rhesus monkeys hold their daughters closer than they hold their sons and show more concern when their daughters wander.

On the other hand, rhesus mothers direct displays of anger more often at male than at female offspring, and mothers wean males earlier. Young male squirrel monkeys and male rhesus monkeys spend more time with peers, often without their mothers close by; they engage in high-energy games of chasing and play fighting; and they leave their natal troop at sexual maturity (Biben and Suomi 1993; Drickamer and Vessey 1973). The social ecology and life history of squirrel monkeys and rhesus monkeys resemble each other in important ways. In each species, as is true of primates in general, the developmental course of males and females differs in ways that correspond with their adult reproductive roles. Sex differences in social play prepare monkeys for their respective adult roles. Monkey societies provide more structured roles for females and more variable ones for males (Biben and Suomi 1993). Females, by staying in their natal group, inherit their status from their mother, and their affiliative relationships with their mother, aunts, and sisters generally remain stable throughout their lives. In contrast, males—who leave their natal group just before adulthood—must integrate themselves successfully into the dominance hierarchy of the established males in a new troop in order to achieve any reproductive success. During this transition, the mortality rate for males reaches as high as 50 percent in some wild-monkey populations (Dittus 1979). Thus, from an evolutionary standpoint, rough-and-tumble play with peers provides critical practice for males relevant to their eventual dominance status in a new troop. Although the

males' longer and more-intense play-fighting bouts are costly during the early juvenile period—involving, as they do, more energy and the risk of injury—the bouts are not as costly as failing to join a new troop successfully. Thus, natural selection builds motivational systems (i.e. at the hormonal level) in males that are substantially different from females. While females do not shun this rough-and-tumble play entirely, they participate less often, with less energy, and with far less implication for adult dominance status. In the currency of sexual selection, play-fighting skills have very different consequences for reproductive success in male and female monkeys. As a result of this asymmetry, adult male rhesus and squirrel monkeys are more aggressive than females, who generally avoid aggression and direct competition (de Waal 1996).

Experimental research also shows that many factors influence rough-and-tumble play in monkeys. For example, the amount of play in young squirrel monkeys varies from two or three hours per day to less than a half an hour depending on the availability of food (Baldwin and Baldwin 1974, 1976). Experimental studies creating food scarcities artificially reduce play rates to 1 percent of the time spent on play when food is abundant. When food supplies are renewed, play rates rebound strongly. Play rates are also subject to hormonal influences. Experimental research provides the clearest evidence for the direct influence of sex hormones on sex differences in play in rhesus macaques. Prenatal exposure to higher levels of androgen leads to increased physical competition and high-energy physical play in female monkeys, regardless of social and contextual factors (Wallen 1996; Geary 1998).

In contrast to play fighting, play chasing does not appear to be gender differentiated, and females engage in this form of play nearly as often as males engage in it. While play chasing can be mixed with bouts of play fighting, it is often distinct and can occur in the absence of play fighting. As part of a broader category of locomotor play, play chasing appears to provide different benefits than play fighting. As Karl Groos (1898) pointed out long ago, predators (e.g. wolves) prefer the chasing position, and prey animals (e.g. zebras) prefer the fleeing position in such play. Play chasing also contributes to cardiovascular strength and certainly helps monkeys learn to flee from predators and other dangers. Juvenile primates, like most young mammals, engage in a great variety of locomotor play, which occurs as solitary or social play. Other forms of locomotor play in monkeys, such as jumping, climbing trees, or swinging from branches, may also serve specific functions, such as building up bone and muscle strength and the physical coordination necessary for rapid escapes in arboreal

environments. I have more to say about locomotor play in the discussion of children's play.

Social-Deprivation Experiments with Monkeys

Not surprisingly, social deprivation in primates during infancy produces serious behavioral and emotional disorders as shown in a series of controversial experiments by Harlow, Soumi, and colleagues at the Wisconsin Regional Primate Center in the 1960s and 1970s. In general, these studies provide some of the most convincing evidence in developmental psychology for the importance of early experience. Monkeys who were isolated for their first six months of life from all other monkeys displayed a pattern of abnormal behaviors (e.g. self-clinging, stereotypical rocking) combined with developmental delays in normal behaviors such as rough-and-tumble social play with peers that resulted in excessive and socially inappropriate aggression later in life. Placing the social isolates with normally reared six-month-old monkeys was not at all effective as a means to rehabilitate them. The isolate monkeys responded with either excessive fear or excessive aggression when normally reared age-mates tried to engage them in play. The dysregulated bursts of reactive fear and aggression elicited retaliation from their normally raised peers. Later studies demonstrated that successful rehabilitation of the isolates depended on their pairing with nonthreatening, younger, female juveniles. At six months of age, isolate male monkeys were paired with normal three-month-old female monkey "therapists," who were still in the attachment phase of development. The abnormal patterns of rocking, self-clinging, and self-biting in the isolates were gradually broken down by the experience with a younger peer who would cling to them, groom them, and provide them other nonthreatening forms of social stimulation. As both monkeys developed, aspects of normal social functioning gradually built up, although the isolates remained highly reactive to stress and conflict.

In reviewing this extensive literature, it is important to note that the social isolation in the early studies from the Harlow lab involved much more than mere "play deprivation." However, their subsequent research of comparing peer-reared monkeys with mother-reared monkeys does approximate play deprivation in the latter group. In these studies, mother-reared monkeys were deprived of all contact with age-mates in the first six months of life, a critical period in the development of social play with peers. Conversely, peer-reared monkeys were

permanently separated from their biological mothers at birth, hand-reared in a neonatal nursery for their first month, then placed with similarly reared agemates for the rest of their first six months. During this first six months, the peer-reared monkeys developed compensatory attachment relationships with each other. Suomi (2005) describes these peer attachments as almost always anxious in nature because peers are not nearly as effective as mothers in providing a secure base for exploration. Consequently, the exploratory behavior of peer-reared monkeys was compromised, and their reluctance to approach novel objects extended to unfamiliar peers as well. Even during interaction with familiar peers, their social play showed developmental delays in both frequency and complexity. Peer-reared male monkeys were more impulsive and aggressive than mother-reared male monkeys in peer play, a difference that became more pronounced as they approached puberty. This elevated rate of aggression in males continued throughout adolescence.

From the standpoint of the complex social ecology of primates and their gender-differentiated life-history challenges, we can confidently argue that maternal and peer deprivation each produce specific handicaps for male and female monkeys. This is true because each of these social partners provide specific and complementary functional relationships that are normally interwoven in the early development of monkeys living in the wild. When deprived of normal maternal care giving, monkeys exposed only to peers do not develop normally even in those domains specific to peer socialization. Thus peer play gets compromised in peer-reared monkeys because they never learn the earlier lessons in emotional regulation normally acquired during the attachment phase from a competent mother.

Suomi interprets his isolation experiments as a demonstration of the critical function of peer play in regulating aggression. I suggest that what is being regulated is emotional arousal. When confronted with other monkeys, the isolates could not deal with the emotional arousal engendered by such stimulation, and they responded by mixing expressions of fear and threat, alternating between withdrawal and hyperaggressiveness. Mason (1965) hypothesized that these inabilities to engage in appropriate social interaction may be exacerbated by deficiencies in their nonverbal communication of emotion.

In order to test this hypothesis Miller, Caul, and Mirsky (1967) compared isolated and normal monkeys in a cooperative-conditioning paradigm that assessed their ability to encode and decode facial expressions. This experiment demonstrated that the isolates could not communicate effective emotional cues.

Not only did they fail to send clear emotional signals, they also proved unable to decode clear signals. This lack of competence in nonverbal communication of emotion in isolate monkeys directly contributed to their maladaptive social relations with peers. The role of facial expressions in regulating harmonious social interaction in rhesus monkeys finds further support in experiments conducted by Izard (1990). He discovered that monkeys whose facial nerves had been bisected became the victims of aggression by other monkeys because of their inability to send facial expressions. Both sending and decoding skills contribute to the smooth flow of social interaction, and these important abilities to communicate and interpret emotional signals appear to be dependent on social interaction with parents and peers for their full development. Collectively, these diverse experiments with rhesus monkeys in the 1960s and 1970s have had an enormous impact on the field of child development and have served to inspire naturalistic research in children a decade later, including my own observational studies of peer interaction in early childhood.

Children at Play

The research literature on various types of children's play has a long history in both developmental psychology and ethology, which fortunately has been reviewed recently in two separate books by noteworthy contributors to these research traditions (Pellegrini 2009; Smith 2010). In my brief comments here, I intend to address both the similarities of research findings on children's play with the findings I have just reviewed on mammalian and primate play and the differences between children's play and animal play.

As with the analysis of monkeys at play, an analysis of the types and functions of children's play should be grounded in the unique features of human life history and social ecology. Many of the characteristic trends in primate social ecology and life history are evident in exaggerated form in humans. Although we share almost 99 percent of our genes with chimpanzees, our brains are more than triple the size of theirs. Among other differences, our brain size necessitates a relatively short gestation period because of the constraints of pelvic size on the birth of such a large-brained infant. This "premature" birth for humans necessitates a much longer period of dependency in infancy and an even longer juvenile period than those of other primates. In comparison with chimpanzees and gorillas, for whom physical growth is complete at about age eleven, physical

growth in humans continues to about age twenty (Smith 2010). Moreover, life-history patterns are gender-differentiated in humans; humans are distinguished by the two-year gap between females and males in puberty onset, growth spurts, and adult sexual maturity (LaFreniere 2010).

Many of the more basic and pervasive research findings on animal play also prove true for the play of human children, revealing structural and functional similarities with mammals in general and primates in particular. As with most mammals, play appears to be a primary affective-motivational system. It shows the characteristic inverted U-shaped curve—gradual development in infancy, a peak in childhood, and decline in adolescence as children approach sexual maturity. Naturalistic studies of play deprivation in children also demonstrate a rebound effect, and the frequency of play appears highly sensitive to contextual factors. In addition, gender segregation also appears in young play groups, and the two types of play in which sex differences are widely observed in primates, play parenting and rough-and-tumble play, are also evident in children's play (Fagen 1981, 1995; Smith 2010).

Sex Differences

Many developmental psychologists believe that, in addition to our shared biology with primates, socialization is another source for some differences in play behavior between girls and boys. The details of the behavioral ecologies of boys and girls are important to understand because of the role that peers play with respect to gender identity and sex roles.

Universally, children begin to sort themselves into sex-segregated enclaves beginning at about three years of age, which also marks the emergence of gender identity (a child's knowledge of his or her own gender and identification with others of the gender). Prior to their establishing gender-segregated play groups and before they establish a stable gender identity, toddlers begin to develop sex differences in toy preferences. In fact, children manifest such preferences even before they can accurately label toys as "boy things" or "girl things" (Fagot, Leinbach, and Hagan 1986). As early as fourteen months of age, girls begin selecting dolls and soft toys while boys choose trucks and cars (Smith and Daglish 1977). Toddlers' early tendencies to associate more with same-sex peers than with opposite-sex peers may derive from the sex differences in toy and activity preferences.

One study that addressed the origin of same-sex preferences found that by two years of age, girls already prefer same-sex peers while boys do not show a similar preference until age three (LaFreniere, Strayer, and Gauthier 1984). These data, derived from extensive observations of peer play in fifteen different children's groups, may actually reflect girls' avoidance of boys, rather than preference for girl playmates. This reasoning receives further support in experimental findings and in sociometric studies showing negative evaluations of boys by girls. As same-sex play becomes increasingly prominent, a number of behavioral differences between the sexes become more evident as well.

According to such developmental psychologists as Hartup (1989) and Maccoby (1998), sex differences in social behavior and peer relationships in childhood reveal that male and female "cultures" differ in many important ways. Researchers have generally found that boys are more physically active, engage in more rough-and-tumble play and risk taking, and exhibit more anger and aggression towards their peers than girls do. From the point of view of most young girls, these sex-typed behaviors are all good reasons to avoid groups of boys. In addition, boys tend to play in larger groups, occupy more space, monopolize more resources (e.g. attractive toys), and are more likely to demonstrate these behaviors away from adult supervision than are girls. In contrast, girls engage in more dyadic play than boys and more often prefer the company of their (mostly) female preschool teachers than do boys. The picture from a combination of naturalistic and experimental studies emerges as one of limited, but systematic, sexual dimorphism in play behavior and emotional expression that is well established by early childhood and increases thereafter. These sex differences in children's social and expressive behavior appear in the behavior of girls and boys in mixed-sex groups and in the behavior of groups of girls with groups of boys. See LaFreniere (2010) for an extensive review.

If early sex-segregated play reflects girls' avoidance of boys, by the end of the preschool years, preference for same-sex peers transforms into clear avoidance of crossing the gender divide for both boys and girls. Segregation between the sexes increases throughout early childhood. By age four, the ratio of same-sex to opposite-sex peer play is 3:1, and by age six, it has climbed to more than 10:1 in the typical American classroom (Maccoby 1988). As play groups become more gender segregated in middle childhood, boys' rough play begins to lose the innocent quality it had in early childhood.

In an ethological study of same-sex groups of twelve- to sixteen-year-old girls and boys at a summer camp, Ritch Savin-Williams (1987) found gender-

distinct play and gender-distinct social interaction styles. Whereas boys ordered, teased, argued, and dominated through physical play, girls gossiped, ostracized, and provided unsolicited advice. Typically, boys established highly stable status hierarchies on the day of their arrival at the cabin using very direct and overt strategies of physical dominance and verbal ridicule. In contrast, girls used physical assertion much less often and were more indirectly manipulative in their verbal directives and ridicule. One of the girls who gradually took control of a cabin did so by ostracizing a high-status peer and undermining her through gossip, directing middle-status peers with "suggestions," and subtly ridiculing a low-status peer with "assistance." In some cabins, girls resolved conflicts by giving someone the "silent treatment," which lasted for days.

Dominance in boys' cabins was anything but subtle, and boys engaged in exuberant rough play that occasionally escalated into real fighting. When this happened, strained relations were quickly patched up with assertions that it was all "in fun."Almost 90 percent of the sixteen hundred recorded instances of dominance behavior in one cabin of boys were overt rather than indirect. Quantitative analyses of all eight cabins revealed that the most overt female cabin (57 percent) was less overt than the least overt male cabin (67 percent). Dominance behavior was not only more overt among boys, it also occurred more frequently, sixteen times per hour, compared to six times per hour in the female cabins (Savin-Williams 1987).

Naturalistic observation reveals that the types of play and the experiences associated with them appear to differ substantially between girls and boys and that peers themselves actively develop and maintain these differences. Of course, sex differences in play are not due to peer socialization alone. The organizing effects of hormones secreted during prenatal development shape sex differences in both brain structures and social behavior, particularly in play. These steroids help direct the organization and wiring of the brain during development, and they influence the structure and neuronal density of various regions. Several researchers have reported sex differences in a variety of brain structures, including the amygdala and hypothalamus, both of which are involved in play behavior (Lewis and Barton 2006). These two parts of the brain appear to be implicated in gender-differentiated patterns of rough-and-tumble play. In the comparative study of nonhuman primates, their relative sizes were found to correlate positively with the frequency of social play.

Such anatomical dimorphism would be expected to produce sex differences in behavior at an early age, well before the activating effects of sex hormones

during puberty. Indeed, experimental research confirms a direct causal influence of sex hormones on early-childhood differences between boys and girls in both play parenting and play fighting. Prenatal exposure to higher levels of androgen in girls relates to decreased interest in infants and doll play and increased preferences for the toys usually chosen by boys (such as vehicles and weapons), increased preferences for boys as playmates, and increased interest in rough-and-tumble play, in cross-national samples of girls with CAH—a type of disturbed hormone production (Hines 2004).

Cross-Cultural Research

It follows directly from such biological evidence that gender differences in play would be universal rather than culturally specific. The results in both preindustrial and industrial societies generally demonstrate consistent sex differences in rough-and-tumble play favoring boys and play parenting favoring girls. For example, DiPietro (1981) found that boys engaged in rough-and-tumble play involving playful pushing, shoving, hitting, tripping, and wrestling, four to five times as often as girls. It is noteworthy that these dramatic sex differences involve play fighting and wrestling, as opposed to chasing, which several researchers find is equally common among boys and girls (Smith 2010). For this reason, researchers need to distinguish chasing from play fighting, instead of lumping them together, as they sometimes do. Cross-cultural research indicates that although the magnitude of the sex differences in these two forms of play varies across cultures, the direction of the differences is constant (Eibl-Eibesfeldt 1989; Maccoby 1988). Whiting and Edwards (1988) studied social development in Guatemala, India, Japan, Kenya, Liberia, Mexico, Peru, the Phillipines, and the United States. They concluded that these diverse cultures share two sex differences: girls exhibited more nurturing than boys, and boys engage in more dominance behavior than girls. More recently, a multinational study involving ten countries (Austria, Brazil, Canada, China, France, Italy, Japan, Russia, Spain, and the United States) using teacher ratings confirmed these findings, documenting sex differences in empathy and social competence favoring girls and physical aggression and dominance favoring boys in all ten countries (LaFreniere et al. 2002).

In her cross-cultural analysis of children's social behavior in ninety-three societies, Bobbi Low (1989) found that sex-differentiated patterns of child rearing were systematically related to various dimensions of the social ecology in

ways predictable from evolutionary theory. In polygynous, nonstratified societies in which men elevate their social status and achieve higher reproductive success by taking multiple wives, boys were socialized to be industrious, competitive, and aggressive. In these societies, the larger the maximum number of wives, the more boys were socialized to be competitive. These results were not found in monogamous, stratified societies in which men's social status and reproductive success could not be advanced by competitive and aggressive behaviors, although socialization for industriousness was still evident.

Similarly, socialization for girls tended to emphasize more aggressive behavior and achievement in societies where women inherited wealth and held political office than in societies where men had near total control of economic and political power (Low 1989). In summary, cross-cultural research demonstrates that parenting styles can influence childhood behavior in ways that align such behavior with the demands of a particular social ecology. At the same time, cross-cultural research consistently demonstrates universals in sex roles. In general, biological and cultural factors collaborate to produce adaptive behavior within any particular ecology.

Adaptive Functions

Questions regarding the adaptive functions of social play in children are central to both human ethology and developmental psychology, and the answers have clear social-policy implications with respect to early childhood. Unfortunately, definitive answers to functional hypotheses are scarce, though opinions abound. All functional hypotheses need to be specific to the type of play and formulated with immediate or deferred benefits in mind. With respect to the two types of social play previously discussed for nonhuman primates—play parenting and rough-and-tumble play—functional hypotheses should also be gender specific.

A review of the literature on rough-and-tumble play reveals a number of competing functional hypotheses. Sex differences in the amygdala and hypothalamus, both of which are implicated in gender-differentiated patterns of play (Hines and Shipley 1984; Lewis and Barton 2006) strongly suggest different benefits for boys and girls who engage in rough-and-tumble play. In modern Western cultures, some of these benefits may be largely vestigial, such as deferred benefits leading to enhanced hunting or fighting skills. Other benefits, related to

achieving dominance status and acquiring valuable resources, may remain significant in modern cultures. Additional benefits may also still operate, including benefits derived from play chasing. In games involving chasing, children seem to prefer the fleeing position (e.g. in the game of tag and in all games modeled after tag, the preferred position is to be chased), which suggests that such play has more to do with our legacy as prey than our legacy as hunters. Consistent with this, girls do not engage much in play fighting, but they frequently engage in play chasing, perhaps almost as much as boys. Chasing very clearly serves to build cardiovascular strength and may also play a role in learning to flee from predators, enemies, and other dangers. Such abilities may still be adaptive because running away and hiding can still save lives.

Typical playground forms of locomotor- and physical-exercise play, including tag, hopscotch, jump rope, and climbing on monkey bars, benefit children in a variety of ways. These physically challenging and vigorous forms of play certainly provide short-term benefits with respect to cardiovascular health and muscular development. Combined with proper dietary habits, long-term habits of healthy exercise may help prevent obesity, which had reached epidemic proportions in the United States by the twenty-first century. Currently, two out of three American adults are overweight or obese, and the number climbs annually. Minority and low-socioeconomic groups are disproportionately affected at all ages (Wang and Beydoun 2007). According to Cynthia Ogden and her colleagues in the *Journal of the American Medical Association* (2010), childhood obesity has more than tripled in the past thirty years. The prevalence of obesity in children aged six to eleven years increased from 6.5 percent in 1980 to 19.6 percent in 2008. Among adolescents aged twelve to nineteen years, it increased from 5.0 percent to 18.1 percent (Ogden et al. 2010). Because exercise and eating habits, once established, tend to remain stable over time, overweight adolescents have a 70 percent chance of becoming overweight or obese adults (USDHHS 2008). Besides burning calories and helping to prevent obesity, different forms of playground play may also provide other long-term benefits. For example, sustained jumping—as in jump rope—increases bone density in childhood (Pellegrini 2009).

Children may also benefit cognitively in terms of sustained and focused attention from regular exercise. Younger children, especially boys, seem to need opportunities for vigorous play more than older children. Studies have shown that young children become increasingly restless in the classroom after long periods of sedentary activity and they play more vigorously when released from

their desks (Smith and Hagan 1980). This behavior appears to be quite similar to the "rebound effect" in the play deprivation studies of animals. When children are deprived of exercise indoors then given an opportunity for outdoor play, the intensity and duration of exercise increases (Pellegrini, Huberty, and Jones 1995). These effects for American five- to nine-year olds appear greater for boys than for girls.

Vigorous social play also clearly benefits social behavior and emotions. Panksepp (1993) has stated that rough-and-tumble play may be beneficial primarily because it serves to generate positive emotional states that mediate social bonding. Other benefits, such as enhanced emotion regulation, especially under conditions of high arousal, may remain as important today as ever. Animal research suggests that emotionally arousing play provides a unique context in which the young child can safely practice the expression, control, and regulation of highly arousing affective states, both positive and negative.

Managing Emotions

Research that examines the free flow of behavior in young children's play suggests that unsupervised social play provides an opportunity for learning about emotional communication, not only by sending and decoding signals but also by affective perspective taking and emotion management. Like any language, the language of play requires developmentally appropriate experiences for children to speak it fluently. In his clinical research, Stuart Brown (2009) has followed this learning trajectory by taking general play histories of some six thousand individuals. As a result of these extensive interviews, he believes that the absence of unsupervised preschool play results in a deficit in reading play signals that leads to major integrative difficulties as group play becomes more complex on elementary-school playgrounds. Deficits in reading play signals can lead to the inappropriate management of aggression, manifested by hyperaggression or withdrawal. In his retrospective clinical analysis of many cases, Brown repeatedly finds that the roots of this dysfunction precede elementary school.

Daily observations of children's struggles with emotion management in the sometimes chaotic preschool classroom and playground confirm that socially active children learn a great deal, whereas children who are passive and socially withdrawn or hostile and rejected by their peers do not learn. The more deeply we study social interaction during children's free play, the more important affec-

tive expression and emotional regulation appear. The central role of emotional control and expression becomes most apparent in the free flow of behavior—that is, in chains of initiations, responses, adjustments, shared delight, protests, apologies, modifications, new directions, and further shared feeling. The place of affect in promoting, guiding, and perpetuating exchanges (or disrupting, disorganizing, and terminating them) is obvious to trained observers, but very difficult to quantify (Sroufe et al. 1984).

In early childhood, quantitative measures of positive affect recorded during free play strongly correlate with both teacher ratings of social competence and peer popularity because a child's affect plays the central role in initiating and regulating harmonious social interchanges among preschool peers (LaFreniere and Charleworth 1983; LaFreniere and Sroufe 1985). In contrast, teachers and peers viewed much less favorably preschoolers who expressed chronically high or unusually intense negative emotions. Some researchers have attempted to go beyond general indices of positive and negative emotions in order to provide a more differentiated view regarding the role of affective expression in children's social interaction. It is particularly important that we discriminate between different types of negative affect. Observers recording affective expressions during preschoolers' free play can reliably distinguish (as can the children themselves) distress, sadness, and anger from each other based on vocal, facial, and postural cues.

In one observational study of the expressions of anger during free play of preschoolers, Fabes and Eisenberg (1992) recorded the causes and consequences of children's anger and related these observations to measures of social competence and peer popularity. Most of these angry reactions occurred during disputes among the children over objects. Consistent with previous research, children who were judged by peers as popular or by teachers as socially competent were less often involved in angry disputes. They were also more likely than less popular or competent children to deal directly and nonaggressively with the provocation, often using their greater social status in the peer group to retaliate by isolating the angry child. In addition, children's responses to these provocations differed depending on the age and sex of the child, the cause of the conflict, and the status of the person with whom they were in conflict. These results suggest that children of preschool age begin to control their emotional expressions to fit the context.

In our experimental work with young children, we decided to examine male preschoolers' abilities to regulate disappointment, frustration, and anger in order to achieve positively toned cooperation with a peer (LaFreniere 1996). Our

prior observations had revealed that the primary proximate cause of aggression in early childhood was the frustration of losing a competition over a desirable resource. Particularly among boys, instrumental aggression about objects in the preschool setting accounted for the vast majority of recorded acts of aggression in the classroom (LaFreniere and Charleworth 1983). Based on these observations, we designed an experiment to induce mild frustration by controlling the outcome of a competition. Preschool boys were instructed that the first one who completed his jigsaw puzzle would receive a prize. The boys typically competed enthusiastically. When they won the competition, they broadcasted smiling and triumphant looks at their partners and occasionally boasted of their success. When they lost, they looked down or away, frowned, slumped, and occasional whined or complained.

In a subsequent cooperative play situation involving the sharing of an attractive toy, typically some form of taking turns prevailed, where each child played with the toy for a brief period. However, we observed a great variation in the degree of cooperation, conflict, and competition. Affective regulation following the puzzle competition strongly predicted the subsequent degree of cooperation and conflict in the second task. Boys who were previously assessed by their preschool teachers as socially competent successfully regulated the mild negative emotion produced by the unequal outcome to the puzzle competition and subsequently played enthusiastically with a peer with more cooperation and less competition and conflict than children who were less competent. In contrast to socially competent preschoolers, preschoolers with a history of problem behavior showed considerably more tension and less emotion regulation in their interactions. Boys who were previously assessed by their preschool teachers as angry and aggressive tended to respond to losing the puzzle competition with frustration and difficulty in regulating this emotion. In contrast, anxious and withdrawn children in the same circumstances often responded with passivity, dejection, and resignation. In neither case were the boys able to sustain positive cooperation with their partner during the cooperative play session.

Collectively, these studies suggest that emotion-regulation skills underlie children's abilities to balance cooperative and egoistical concerns in the daily challenges of social life among peers, where children sort themselves into leaders and followers, bullies and victims, and adopt popular, isolated, or rejected social roles. For boys especially, vigorous social play in early childhood provides a scaffold for learning skills needed in adolescence related to social dominance in the peer group. Dominance status, in turn, may eventually relate to acquiring

important social and material resources and be a key factor in achieving fitness, as it is in other species of primates. Boys who withdraw and fail to compete successfully, or who become hypercompetitive and aggressive, were not likely to achieve reproductive success in our evolutionary past, and may be similarly handicapped in our own society.

Conclusions

Many of the basic research findings regarding play in a wide range of mammalian species also hold true for children, revealing important structural and functional continuities that have endured over several hundred million years. I have reviewed research on locomotor and rough-and-tumble play in juvenile laboratory rats, monkeys, and humans to show how the adaptive functions of play for each species are related to their specific social ecology and life history. These comparisons reveal the inventive hand of natural selection as a tinkerer, taking components out of complex systems that have worked in the past and embedding them into new designs and new contexts. Despite the fact that American children spend most of their waking hours surrounded by recent products of an ever-inventive technological society, when left to their own devices, they often return to these enduring patterns of play because of the joy and pleasure they bring. Nature provides its own reinforcement for honing skills that are vital to the organism.

As with most mammals, play in children appears to be a primary affective and motivational system. It shows the characteristic inverted U-shaped curve with gradual development in infancy, a peak in childhood, and decline in adolescence as children approach the age of sexual maturity. Play deprivation is followed by a rebound, and the frequency of play is highly sensitive to contextual factors. In addition, the early gender segregation and sex differences in play parenting and rough-and-tumble play that occur in primates also appear in children's play of different cultures.

Evolved patterns of vigorous social play benefit children in a variety of ways. First, and certainly important in today's sedentary society, are the physical benefits. Vigorous play helps children develop strong bones, muscles, and cardiovascular fitness and encourages exercise habits that, if maintained, can help prevent obesity and lead to a lifetime of physical fitness. Second, social play enables children to establish friendships and maintain them even when

conflicts arise. This type of unsupervised peer interaction provides children an opportunity to hone emotion-communication and emotion-regulation skills, especially during emotion-arousing situations, as conflicts are sure to arise due to early childhood egocentrism. In this sense, programming out such conflicts by relentless adult supervision and interference in children's play may actually be a disservice. This was one of Jean Piaget's key insights. He advocated peer interaction, not parent or teacher tutoring, as the principle means by which young children shed their egocentrism and learn the importance of perspective taking (Piaget 1932). Finally, for boys especially, rough-and-tumble play in early childhood provides a scaffold for learning emotion-regulation skills related to managing anger and aggression in the peer group in the absence of adult control.

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