

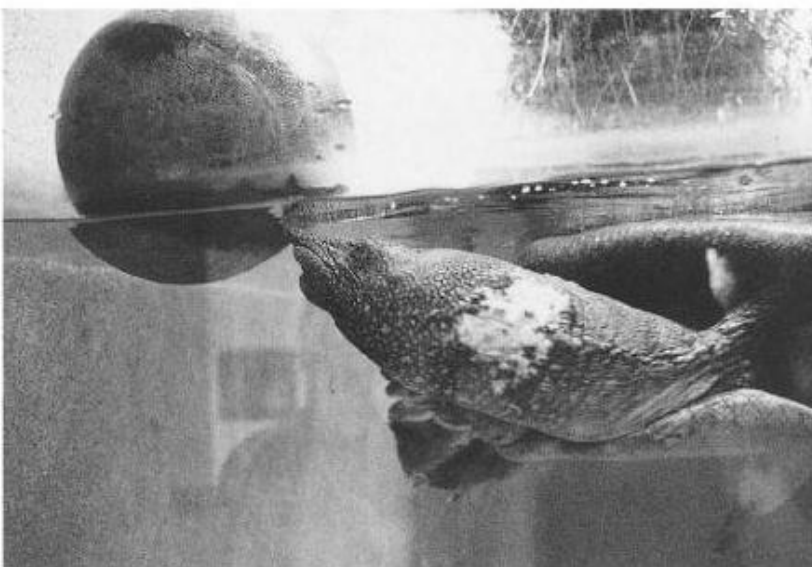
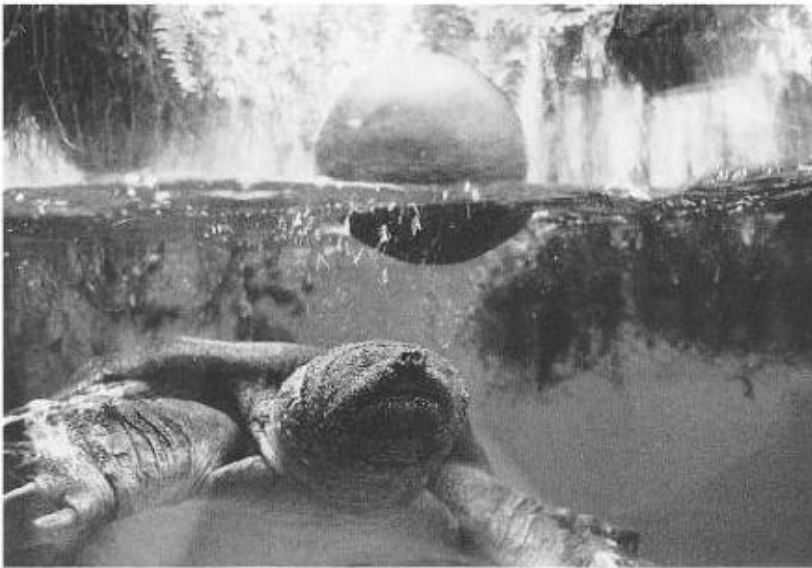
Play, Stress, and the Learning Brain

By Sam Wang, Ph.D., and Sandra Aamodt, Ph.D.

Editor's note: An extraordinary number of species—from squid to lizards to humans—engage in play. But why? In this article, adapted from Dr. Sam Wang and Dr. Sandra Aamodt's book Welcome to Your Child's Brain: How the Mind Grows from Conception to College (Bloomsbury USA, 2011; OneWorld Publications, 2011), the authors explore how play enhances brain development in children. As Wang and Aamodt describe, play activates the brain's reward circuitry but not negative stress responses, which can facilitate attention and action. Through play, children practice social interaction and build skills and interests to draw upon in the years to come.

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For Pigface, life at the zoo had recently improved. Previously prone to clawing and biting himself, he had developed various tricks with sticks and other items that the zookeepers had given him. One trick was to push a basketball with his snout and sometimes snap at it. Hoops of hose were favorite objects, which he would nose and chew and sometimes swim through. On days when zookeepers cleaned his tank, he would get in front of the stream of incoming water and remain there unmoving, just feeling the water run over his face. Once the cleaning was done, he was off again. These activities make Pigface sound like an otter or a seal. But the behaviors look like mammalian play only when played back at three times normal speed, because Pigface is a turtle (see photos).



Courtesy of Gordon Burghardt.

Play is widespread among animals, beyond the familiar cases of mammals and birds, to vertebrates and even invertebrates. How can we be sure that an animal is playing? Researchers use three criteria.¹ First, play resembles a serious behavior, such as hunting or escaping, but is done by a young animal or is exaggerated, awkward, or otherwise altered. Second, play has no immediate survival purpose. It appears to be done for its own sake and is voluntary and pleasurable. Third, play occurs when an animal is not under stress and does not have something more pressing to do.

These criteria for play are met by leaping needlefish, water-frolicking alligators, and prankish lizards. At the National Zoo in Washington, D.C., monitor lizards play games of keep-away. The largest monitor species, the Komodo “dragon” lizard, plays tug-of-war with its keepers over a plastic ring. It can pick notebooks and other objects out of a familiar keeper’s pockets and then walk around carrying them in its mouth. A movie of a Komodo dragon playing looks quite a bit like one of a dog, only slowed down to about half speed.

The lizard’s behavior is not just displaced foraging or hunting. If the plastic ring is coated in tasty linseed oil or animal blood, playfulness vanishes and turns into a pronounced possessiveness. YouTube videos of Komodo dragons swallowing whole pigs—or even other Komodo dragons—suggest that these food-oriented behaviors are not easily confused with play.

The fact that play is so widespread suggests that it arose long ago in the history of animals.² It appears in many animals with far less social complexity than people have. This universality suggests that even though play is literally fun and games, it must serve some vital function. In other words, when your child is playing, he is doing something crucial for his development. Furthermore, the features of his play are distinctive not only to him but also to humans in general.

Types of Play

Play takes different forms in different animals, including humans, and its content provides some hint as to what purpose it might serve. Play researchers (there’s a fun-sounding job) recognize three major types of play. Most common is object play; that’s what Pigface does with basketballs and hoops. Object play is typically found in species that hunt, scavenge, or eat a wide variety of foods. About as common is locomotor play, such as leaping about for no apparent reason. (The term *locomotor* has to do with coordinated movement, such as crawling,

walking, or running.) Locomotor play is common among animals that move around a lot—for instance, those that swim, fly, or live in trees—and, notably, often must get away from predators. The third and most sophisticated form of play is social play. Social play can take many forms, including mock fighting, chasing, and wrestling. Pretending is a major component of social play.

Social play is especially prominent in animals that show a lot of behavioral flexibility or plasticity. In mammals and birds, this boils down to a simple rule: If your species has a big brain for its body size, you probably engage in social play.³ Among these species, most of the variation in brain size occurs in the forebrain; different mammals or birds of a given body size will have about the same amount of brain stem but very different amounts of neocortex (in mammals) or forebrain (in birds). Animals with more neocortex or forebrain typically live in larger groups and have more complex social relations. Ducks engage in so-called coordinated loafing, which means they basically just hang around together. Great apes and their relatives (such as humans) form societies in which alliances constantly shift, and in which the young play recognizable games, such as chasing, wrestling, and tickling. In playing these games, your child is indulging her inner ape.

This phenomenon is not limited to vertebrates. Among invertebrates, cephalopods, which include squid and octopuses, have perhaps the most complex brains. Octopuses use their water jets to push floating objects like pill bottles back and forth in a tank or in a circular path.⁴ Despite this behavioral complexity, however, octopus brains are still small by vertebrate standards—half the diameter of a dime, smaller than those of even the smallest mammals. Another invertebrate that appears to play is the honeybee, which has one of the largest and most complex nervous systems among invertebrates. As a counterexample, playlike behavior is not reported in houseflies.

Play: What Is It Good For?

Now, maybe play isn't "for" anything. Perhaps play behavior is simply early maturation—precocious behavior that develops before it is absolutely required. Another possibility is that play is what our brains do when there are no more pressing matters—a screensaver for the mind, as it were.

But one key piece of evidence contradicts these ideas: Play is fun. At first, this may seem like an odd argument. Aren't fun activities the ones we engage in for their own sakes?

Superficially, yes, but dig a little deeper. The ability to enjoy an activity is a survival trait. We are wired to like activities that help ensure our survival. For example, we may think we seek sex because it's fun, but in reality, sex is essential. Sex is fun because seeking it is adaptive. People who don't like sex have a harder time finding mates and having kids. In general, enjoying an activity is a hardwired response that causes the brain to seek out that activity. If these essential behaviors weren't enjoyable, we might forget to do them. On these grounds, it seems that play must have an adaptive purpose, providing some survival advantage.

The brain generates chemical signals that encode a key component of fun: reward, the quality that makes us come back for more. Reward is conveyed within the brain by dopamine, a neurotransmitter that has many functions depending on where and when it is secreted. Dopamine is made by cells in the brain's core, in the substantia nigra and the ventral tegmental area (see figure). In rats, dopamine and play are linked. Among chemicals that activate receptors for various neurotransmitters, including drugs that activate dopamine receptors, only a few increase play behavior.⁵

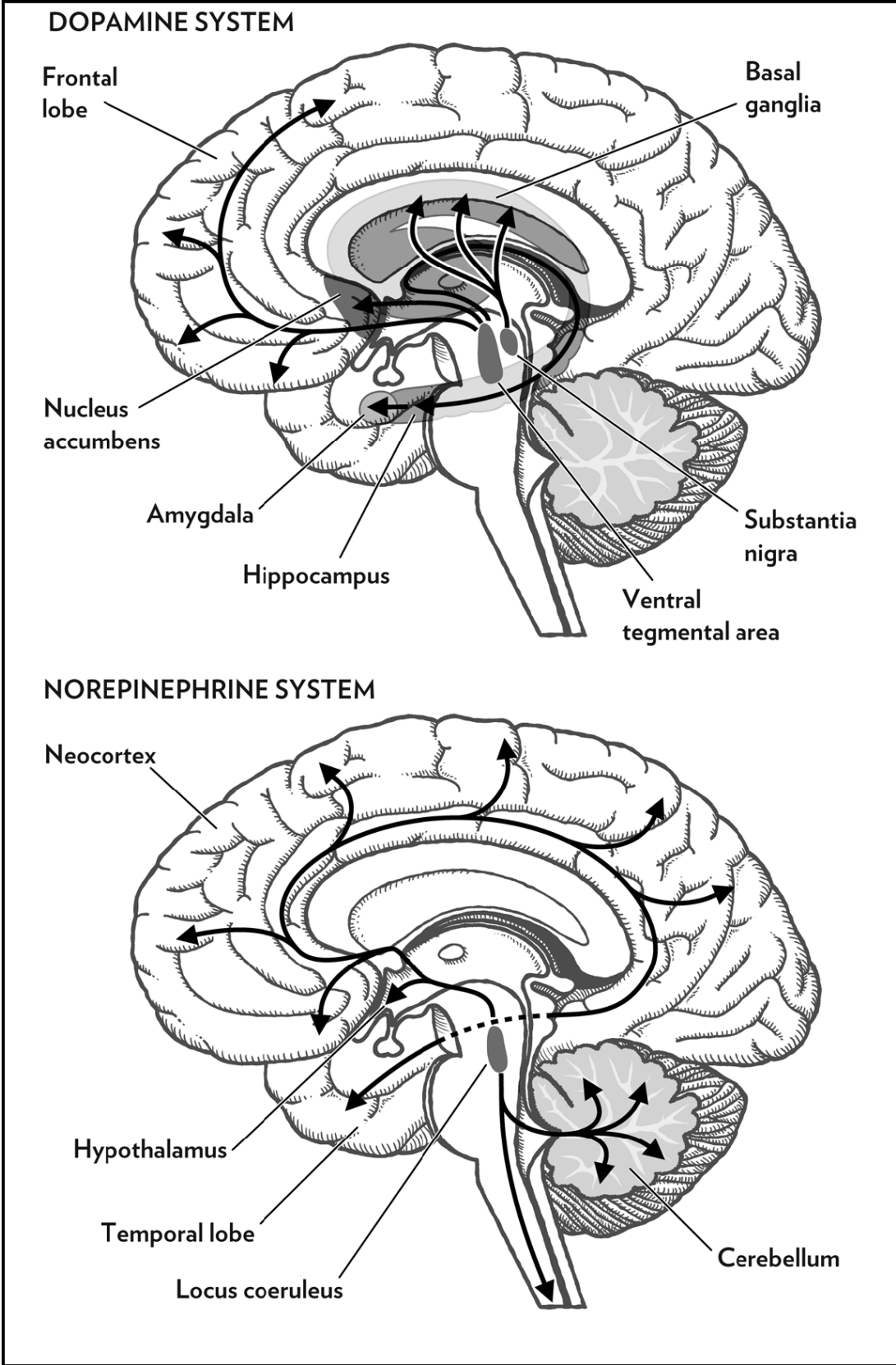
One way to find out what play is good for is to take it away from animals and see how they fare. The problem is that this experiment is nearly impossible to do. Animals (including children) are irrepressible; they play under the most adverse of conditions. The only way to get an animal to stop playing is to restrain its mobility. This severe restriction leads to decreases in physical activity and increases in stress, as measured by the amount of the stress hormone cortisol in saliva. Play, exercise, and stress are closely linked.

Though the deprivation experiment is hard to do, that very fact means that seeing an animal play already tells us something good about its state. In young squirrel monkeys, low levels of cortisol are associated with high amounts of play, suggesting either that play reduces stress or, possibly, that unstressed monkeys are more likely to play. In bear cubs during their first year of life, survival over the winter is highly correlated to the amount that cubs played during the preceding summer. Play might be an indicator of health or resistance to stress. No matter how you slice it, seeing your child play is a good sign.

Stress Systems

Play activates other brain signaling systems as well, including the neurotransmitter norepinephrine (see figure). Its close relative epinephrine (also known as adrenaline) is released

to the body as an initial component of stress-related signaling. As the main activator of the sympathetic nervous system, epinephrine mobilizes our energies for “fight, flight, fright, or fornication,” as the medical-school mnemonic goes. Norepinephrine is also involved in rousing us to attention and action, but by acting as a neurotransmitter. Norepinephrine facilitates learning mechanisms at synapses as well. In some neurons, norepinephrine improves brain plasticity, such that change becomes possible when this chemical is present in elevated amounts. The same is true for dopamine, which accounts for how reward leads to long-term changes to make us want more—neural plasticity mechanisms are strongly facilitated when reward occurs.



Courtesy of Sam Wang and Sandra Aamodt.

Though real-life stressors trigger the release of both epinephrine and cortisol, play does not increase cortisol. Cortisol is a stress hormone that helps us in genuinely dangerous situations by redirecting resources to the most urgent needs, such as repairing a wound or fighting an infection. In the case of the brain,⁶ enhancing memories of danger and learning about the stressful context at hand are urgent; other brain mechanisms, such as working memory and recall of social memories and of other facts and events, are not urgent. It is safe to say that if you find play to be a source of stress, you're not doing it right. Even violent video games, which raise physiological arousal as measured by epinephrine-based response, do not increase cortisol.⁷ In some cases, cortisol levels actually decrease—people work off stress by shooting 'em up. On the whole, play is associated with responses that facilitate learning.

Play as Practice

The conditions of play—the generation of signals that enhance learning without an accompanying stress response—allow the brain to explore possibilities and to learn from them. Thus, a major function of play may well be to provide practice for real life. The use of a skill or other mental capacity builds up that ability. Evidence from animals suggests that this is the case for play, which usually reflects an animal's more serious needs. Kittens play at pouncing on objects, a behavior that resembles the hunting they do later. Fawns don't pounce much, but they do gambol around, a behavior that resembles escape.

So it's possible that play is practice that prepares animals for the real activity later—when it matters. Researchers of early childhood development have applied the concept of play skill building in *Tools of the Mind*, a preschool program that uses complex play to get children to make elaborate plans and to exercise self-restraint—practice for the prefrontal cortex, which is involved in self-control. Even before that, the 19th-century kindergarten movement, which popularized the concept of preschool education, was based on the idea that songs, games, and other activities are a means for children to gain perceptual, cognitive, social, and emotional knowledge that prepares them for entering the world.

In mammals, play is necessary for forming normal social connections. Rats and cats raised in social isolation become incompetent in dealing with others of their kind and typically react with aggression. In our species, abnormal play as children often presages dysfunction in adults. A notable feature of psychopaths is that their childhoods lacked in play. Serial killers are

often reported to have had abnormal play habits, keeping to themselves or engaging in particularly cruel forms of play. Sometimes such problems are associated with early-life head injury.

Play also transmits culture.⁸ Middle-class mothers in the United States encourage their infants to pay attention to objects and are likely to prompt them to play with toys such as blocks. Japanese mothers encourage their babies to engage in social interactions while playing—for example, suggesting that they feed or bow to their dolls. Communities that emphasize the development of independence place more importance on object play, while interdependent communities encourage social play.

There are some downsides to play, too. For one thing, though play by definition occurs in the absence of stressors or external threats, children aren't always good at detecting threats, such as the hazards of fast-moving traffic; thus, play can be dangerous. This problem is not unique to people. In a study of baby seal mortality, 22 of 26 deaths happened when the pups played outside the sight or hearing of their parents. Play can distract people and other animals from recognizing danger. But even here, play may be practice for real life. Risk taking in children's play may be an important developmental process. It tests boundaries and establishes what is safe and what is dangerous. In the United States, playground equipment has been made very safe, leading to the unanticipated problem that children lack experience with such distinctions, which may lead to trouble later in life.

When Play Becomes Passion

In addition to providing experience, play also helps children learn what they like and don't like. Nobel chemistry laureate Roger Tsien tells of reading about chemical reactions before he was eight years old and then trying out the reactions for himself. He was able to bring about beautiful color changes in his house and backyard. Because he didn't have enough laboratory glassware, he had to make equipment from used milk jugs and empty Hawaiian Punch cans (see photo). Tsien later won the Nobel Prize for developing colored dyes and proteins that become brighter or change hue when they encounter chemical signals in living cells, including neurons. (This can make certain biological processes, such as brain signaling, much easier to see and to understand.) Tsien's great contribution to science—the invention of tools that help us visualize what is happening in active biological systems—had its roots in his childhood interest in home

chemistry experiments. Not all childhood endeavors lead to such heights, of course, but regardless of your children's eventual interests, discovering them may be one of the most important outcomes of play.



A homemade chemistry apparatus built by Nobel laureate Roger Tsien when he was about 14 years old. He was trying to synthesize aspirin. Courtesy of Le Prix Nobel and Roger Tsien.

For many people, play continues in adulthood and is a major contributor to successful problem solving. Physical scientists often report having built and taken apart machines when they were kids. Conversely, work in adult life is often most effective when it resembles play. Indeed, total immersion in an activity often indicates that the activity is intensely enjoyable; this is the concept of flow, or what athletes call being in the zone. Flow occurs during active experiences that require concentration but are also highly practiced, where the goals and boundaries are clear but leave room for creativity. This describes many adult hobbies, from skiing to music, as well as careers like surgery and computer programming. Such immersion can make solving a great challenge as easy as child's play. Encouraging your child to pursue tasks that produce flow is a great way to contribute to his lifelong happiness.

Think of it this way: Play is the work of children. It is perhaps the most effective way for them to learn life skills and to find out what they like. For these reasons, it is important to prevent play from becoming a compulsory, dreary activity, as its enjoyable nature is part of what

makes most children grow like dandelions. So, rather than trying to change your child's personality through enforced activities, let her play, and help her become who she's going to be.

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