Play, ADHD, and the Construction of the Social Brain

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Because of the role of play in the epigenetic construction of social brain functions, the young of all mammalian species need sufficient play. For the same reason, the nature of that play becomes an important social policy issue for early childhood development and education. Animal research on this topic indicates that play can facilitate the maturation of behavioral inhibition in growing animals, while psychostimulants reduce playfulness. Our failure to provide adequate opportunities for natural play in modern societies, the author argues, may have contributed to the steady growth in the diagnosis of Attention Deficit Hyperactivity Disorders (ADHD) in children, which in turn has increased prescriptions of highly effective attention-promoting psychostimulants whose developmental effects on growing brains remain unclear. The author concludes that the incidence of ADHD—and hence the need for psychostimulant medications for growing children—may diminish if we create play sanctuaries for preschool children, where they could play naturally with each other, and thereby facilitate frontal lobe maturation and the healthy development of pro-social minds. Physical play should be part of the daily social diet of all children throughout grade school.

As a youth, Charles Darwin was a playful rascal, but he developed a creative life that still inspires us. Although he thought and worked long before we knew about genes, his enlightened vision provides us a framework within which we can now consider how yet-to-be discovered genes for playfulness help program full social mentality in human beings. For one of the great surprises of modern genetics is that there are far fewer genes in each of our cells than was envisioned just a decade ago, when experts suspected we had genes enough to help construct our sophisticated brains and minds. Back then, some estimated there were probably in excess of one-hundred-thousand genes, whereas now most assume there are around twenty-two thousand. Today, many ponder how our modest genetic endowment, not all that different from any mammal, could generate so much mental complexity.

Part of the answer lies in the modest genetic changes that led to a massive proliferation of higher neocortcial tissues. In addition, we should also consider how epigenetic changes guide brain-mind development. *Epigenesis* includes all those semi-permanent, non-mutational changes in how genes function—through DNA-chromatin, methylation, and acetylation, for example—that can dramatically modify body and brain, changes that can be passed down through the generations with no modification of fundamental gene structure, no change in the classic nucleotide pairings of DNA sequences. In other words, in epigenesis, lasting changes in gene expression profiles are controlled by environmental inputs rather than by the information intrinsic to the genes themselves. This helps us determine how the complexity of the human social brain emerges from such modest genetic beginnings. The key to human psychic development may lie in a combination of evolutionary tools and epigenetic programming. It appears that epigenetic programming from real experiences in society, culture, and the world in general molded *higher* brain regions much more so than the information encoded in genes.

In that context, play and the friendships it produces are likely to be key to the emergent landscape of a child's mind. They carry the fruits of human kindness epigenetically and culturally rather than genetically. To facilitate this process, we need better to understand and to use the emotional tools bequeathed by nature to each and every child. The playfulness intrinsic to childhood should especially help us promote the growth and maturation of fully social brains. The limited numbers of genes in the mammalian genome actually program a few basic evolutionary tools into mammalian brains for the construction of higher social brains. We have described the most basic among these emotional tools elsewhere, and here as there I will use capital letters to highlight their importance as feelings that emerge from complex brain networks and guide the maturation of each and every child (Panksepp 1998a, 2005a, 2005b). They are the desire to engage with the world (SEEKING); anger at being thwarted (RAGE); trepidation toward the scary things of the world (FEAR); an eventually blossoming sexuality (LUST); the desire to nurture the young (CARE); and always the awful feeling of being alone, without social support (PANIC). Perhaps the most important, though, at least for the active construction of the social brain, is that joyous enthusiasm to engage PLAYfully with others.

At some point in our primate evolution, children had many companions with whom they freely engaged in natural surroundings on their own terms.

That time has passed. We can no longer just leave play to the children, for most of them no longer have access to environments where they can play by themselves, as they once could. This is especially true for children living in urban areas (Louv 2006), all too often in one-child families where there are few play companions near at hand. Today, we can achieve our epigenetic potentials only through the quality of our child-rearing practices.

My fellow researchers and I have now spent more than three decades studying the biological nature of natural physical play, which included some work analyzing the consequences of play deprivation for behavioral and neural maturation. In fact, all our animal work has been directed toward clarifying foundational aspects of the human condition that cannot be studied in humans (Gallagher 2008). Surprisingly we "rat runners," as some have disdainfully referred to us, conducted the first formal ethological study of natural human childhood play, namely without the confounding effects of toys (Scott and Panksepp 2003). This is a much-neglected aspect of human childhood play (Pellegrini and Smith 1998). Eric Scott and I even negotiated a complex political terrain to bring natural physical play back to young children within the public school system of a Midwest university town (Scott 2001). And I have argued for the urgent need to bring the issues surrounding natural play again to the forefront of debate, so that—as I have said before—we might really "leave no child behind" (Panksepp 1998b).

One very important consideration for focusing on natural play comes from our belief that the proper use of play can reduce the current epidemic of ADHD (Attention Deficit Hyperactivity Disorder) and the heavily medically condoned psychostimulant use (and all too often, abuse) by the youth of our society.

I know the issue is controversial, so let me reiterate what I have also said elsewhere: I do not doubt there is a genetically based temperamental variability that contributes to the diagnosis of ADHD. Nor do I question that psychostimulants effectively reduce impulsive behavior. These are well-established facts. I simply assert that we have within our grasp more tools to address the problem than we currently recognize widely or use in our educational systems. The claims I make for these social-emotional, maturation-promoting tools grow from a lifetime of research, much of it included in the references at the end of this article. But here, in this inaugural issue of a journal devoted to play, I want, as an advocate for natural play as well as a researcher of the primeval urge to PLAY, to present my case first within the general framework my science over the years has provided me, then to discuss more specifically the problems with ADHD and a few of my findings related to it, and finally to suggest briefly how that leads to re-imagining recess as a chance to recapture something of the rough and tumble of natural play, as a modern homage to Plato's play sanctuaries.

Let me start with a poem from my wife, who has supported my research efforts into the basic social emotions over the years. It invokes an incomparable image of old style rough and tumble physical play, a kind of play that is—perhaps fortunately, perhaps regrettably—no longer a prominent part of our cultural landscape. Thus, it reflects the depth of the debate and the bitterness of the divide in opinion about this topic:

Why the Boys Must Take Ritalin
by Anesa Miller

The boys must take Ritalin because they are boys
who don't like school. One or two things
about school they do like
but ten or twelve they don't.
They must take Ritalin
because they punch other boys in the shoulder,
on the arm, the chest and
stomach. They smash hands
with books, notebooks, paint boxes,
whatever they find beside them.

They punch the boy with black hair,
the one with blond hair, the one with no upper teeth.
They hit the white boy, the black or brown boy,
the boy who wears torn jeans, or white shirts.
They must take Ritalin, they must take Adderall,
because they hit the boy beside them,
they smash and hit because he is beside them.
He is handy. He is close by.

The tomboys must also take Ritalin.
Because they act enough like boys
to need control like boys.
They punch boys everywhere
that boys punch, and they hit girls,

though probably not in the chest.
They pull hair and scratch and bite,
they aim to hurt. They don't seem to care
who they hurt, although they do skip hurting
some they'd like to call their friends.

The tomboys' eyes are too intense.
Their bodies tend to be thin and marked by sun.
They tend to be raw-boned.
The boys who must take Ritalin
also tend to be brown and thin.
They don't like to sit
for 15 minutes and eat.

They punch and push kids down
because there are ten things
they don't like about school:
They are not swinging on ropes. Their palms
are not growing calloused from ropes
swinging out over ponds. They are not
dropping five or ten feet through bare air
into the splash. They are not sinking
cannonballs into the mud
or bursting the surface, sucking
a fair share of breath.
They are not wrestling
with dogs, brothers, sisters,
or boys who sit beside them.
They are not chasing birds, dogs,
horses. They are never riding horses.
They are never falling.

Some say, "Thank God—
at least they are never falling.
Let the transparent ones fall—
their friends, Barney and Burt,
their friends in Grand Theft Auto—

let them take the fall."
Some of us cannot help saying,
"Thank God—they are finally on Ritalin.
They are finally on Adderall, calming down
on these cousins of cocaine."
Thank God—they are not grabbing manes
not swinging into saddles. Thank God
they are not sighting the first
geese, duck, swan, salmon.
They are not spying the fleet
herds of horses, buffalo, pronghorn
that can be chased down
only by those ever ready to spring.
Thank God—they are not grabbing guns.

Thank God they take their drugs.
It is the only way we have left to help them.
Thank God there are drugs for this.
There is Ritalin. It helps. Without drugs
there would be no place
for the boys and the tomboys to fit.
With prescriptions they are better off.
Don't fret—at least they are not shunned.
Because Ritalin works. It makes them
hold still, teaches them who to become.
It works like all drugs.
Like all drugs it helps us
to forget.

There we have the dark side to play. Rough and tumble play, across all mammalian species, arises from ancient brain systems that coax youngsters to engage physically and energetically, and at times too robustly, with each other on the field of life. Unregulated play can lead to bullying. However, if we use play urges well to guide the maturation of our children, we can construct pro-social brains of great social subtlety and sensitivity.

Of course, a powerful emotional force such as play rapidly takes children to the edge of their social-emotional knowledge, where they must re-negotiate behavioral options in order to get the maximum joy out of life. These are the moments when bullies may rule and especially bad things may happen during unregulated play, as my wife's poem starkly suggests. But with occasional sage advice from elders, these difficult moments can be converted from emotional lead into gold—creating lasting brain-mind skills that become deeply ingrained. From them may develop pro-social affiliations and caring tendencies that lead to empathy and a life fully lived. In contrast, as physician Stuart Brown has noted, pathological aggression often characterizes a childhood blighted by little or no playfulness (Brown 1998).

We now know much about play across different species (Burghardt 2005; Fagen 1981) and quite a bit about the brain sources of play (Panksepp, Siviy, and Normansell 1984; Vanderschuren, Niesink, and Van Ree 1997). Playfulness is an irresistible pleasure-seeking urge that arises from deep regions far below children's relatively simpleminded neocortical thinking-caps (Burgdorf and Panksepp 2006; Burgdorf et al. 2007). When consummated well, it is filled with laughter in both human children (Scott and Panksepp 2003) and adolescent rats (Panksepp and Burgdorf 2003; Panksepp 2007a). If one surgically eliminates all the higher brain tissues—pretty much all the neocortex—which gradually become the repository of our knowledge and higher social values, physical play, at least in rats, proceeds quite normally (Normansell and Panksepp 1984; Panksepp et al. 1994; Pellis and Pellis 1998).

We think this data is also relevant for the human condition. Childhood eagerness for play arises from deep and ancient brain regions, ones we share with other animals. This urge to play sets in motion brain events that are very important for social-brain maturation in both children and animal offspring. It allows them to learn about the world, the ways of their own kind, and what they can or cannot do to others and with others. It helps construct the fully social brain by engendering robust epigenetic changes in higher neocortical regions of the brain that are initially not needed for the vigorous urge to play, but which rapidly become filled with new ideas for games and dramatic re-enactments.

We believe that play promotes brain-mind maturation, and we have initiated studies on this topic. We hypothesize that inadequate opportunities for "real play" throughout early development may lead later to depression and other failures in life, including a higher incidence of ADHD. We believe lots of the "good stuff" early on may prove prophylactic, lessening the probability of being diagnosed with ADHD early in life and protecting against depression for a lifetime. Let us explore briefly some of the science behind such ideas.

Play and the Construction of the Social Brain

First, we return to how the subtlety of the human mind can emerge from our relatively modest hereditary storehouse of some twenty-two-thousand genes. We have an enormous neocortex that is more akin to the classic *tabula rasa*—the blank-slate of philosophers—than to a massively "modularized" evolutionary toolbox envisioned by too many evolutionary psychologists who misunderstand the true nature of our brains. At birth, then, the neocortex is largely a clean "blackboard" upon which experience writes the unique script of an individual's life. Or to use metaphors perhaps more appropriate to the times, the neocortex—with its endlessly repetitive, computer-chip like "columns" of about three thousand neurons—resembles the random access memory (RAM) space of our digital computers much more than it does their read only memories (ROMs)—the stable ("instinctual") operating systems that allow so much magic to be programmed into RAM space. We have a series of genetically ordained attentional, emotional, and motivational tools for learning about the world. All the details of this learning get stored away in the neocortex. These powerful emotional and motivational tools for living and learning, these genetically provided instinctual networks, are all contained in the more ancient subcortical reaches of our brains—regions that are remarkably similar in all mammals.

The PLAY urge is likely to be one of the main tools that can help construct our social attitudes in the initially empty executive and memorial spaces of the neocortex. So many unique and dynamic social interactions occur during brain activity, there is bound to be use-dependent programming of social skills in the brain's higher regions. If so, we better learn to use such evolutionary tools well, for much of the programming that occurs up there will last a lifetime, partly through very powerful epigenetic processes that have only recently been revealed in exquisite detail.

Epigenetic effects arise from the chemical changes, usually methylation, in the chromatin support surrounding genes. These changes affect the three-dimensional environment around genes, controlling the degree to which transcription factors have access to genes and hence dictating their degree of expression. This is one of the ways bodily organs differentiate, allowing different cells to do different things, and for our purposes, it is a major factor in determining how brain cells develop and specialize to handle specific life skills. The consequences for brain and body functions are as far-reaching as mutations, but unlike mutations, they remain more dynamically responsive to environmental influences. Such epigenetic effects control the extent to which transcription factors can modify the expression of specific genes. Indeed, as researchers have demonstrated, they are a major means for long-term brain and behavioral changes to emerge as a function of social environments as well as physical environments (Szyf, McGowan, and Meaney 2008).

Thus, much of higher brain development—neocortical maturation and programming—is controlled more by the quality of environmental factors than by information already contained in the genome. All this affirms that many human capacities—perhaps even aspects of personality and temperament—are as much a result of the impact of environmental conditions as they are of inherited genetic dictates.

To put my point bluntly, the human genome does not contain enough information to construct a fully social brain. PLAY and the many other basic emotional systems of ancient regions of the brain (Panksepp 1998a, 2005b) are the tools that allow the social brain to develop. Realizing that this is so compels us to consider, with renewed devotion, how much of the human brain is created by social learning as opposed to ancestral genetic molding. And if, in other words, most of the social brain matures under the tutelage of environmental factors, those factors can in turn help support life-long mental health or they can help create a lifetime of emotional problems. Which path a child follows in life very much depends on how we recruit, use, and invest in the social-emotional tools that nature has provided for jump-starting optimal development (Sunderland 2006).

Although the neuroscientific database remains regrettably slim (largely because federal funding agencies have yet to fully recognize the importance of this area for the mental health of children), one of the prime tools for assuring optimal maturation must surely be the genetically dictated capacity and desire to engage in rambunctious physical play during the early years of life. Thus, we begin finally to understand the nature of fundamental PLAY systems of the brain, from which the urge for joyous social engagements emerges (Burgdorf et al. 2007; Panksepp, Siviy, and Normansell 1984; Pellis and Pellis 1998; Panksepp 1993, 2007a). If we use and guide such energetic emotional states of mind well, we can help all children flourish. On the other hand, if we increasingly rely on psychostimulants to promote quiet-attentive behaviors without knowing their long-term cerebral and psychological results just because our knowledge of these brain systems is deficient, we may well fail to create optimal environments for childhood thriving.

Let me reiterate by approaching the question from a slightly different angle. So far as we know, the underlying genetic controls of the higher neocortical reaches of the human brain—those parts of the brain upon which all our uniquely human social abilities depend—were not programmed to support some evolutionary psychology pipe dream through as yet unfathomed evolutionary-functional weavings into the fine interconnectivities and dynamics of the neocortex. Instead, given our current knowledge of newborn cortical organization, human socialization occurs when a child's brain is allowed to learn in culturally rich, mind-supporting environments that allow many self-generated activities, with the most important one being natural play.

In short, the only things that genes contribute to growing brains are rough and ready attentional, emotional, motivational, and learning-associative "instinctual" tools that allow family, peers, and societal influences to create fully functional minds. To be confident that we are using the gifts of nature well, we need to promote family and classroom environments that resonate with the joyful play urges of our children. These are urges they naturally experience in more abundance than most can ever freely express within the constraints of modern social institutions. Here is how it works from a sensitive adult's perspective (this vignette shared by German psychiatrist Elisabeth Troje):

> Our big house in the Black Forest is surrounded by meadows and trees. In vacation time the family meets there. In my apartment are two grandchildren who live in Antigua, West Indies, and speak only English, Jasper, 10, and Imogen, 5 years old. There arrive two boys, grandchildren of my sister, 8 and 6 years, who live near London, speaking English and German. The four children stare at each other without a word. Then Jasper and Imogen begin to tease each other, using their feet, to knock each other, it looks dangerous, they hit the other's stomach and genital regions, but they do it softly, perhaps practised in Karate-like sports. They begin to laugh at each other without taking notice of their cousins, who stare at them, begin to move, to jump on the spot, begin to laugh, too. As soon as they move all in the same rhythm, Jasper turns to the door, running downstairs, behind him Imogen, behind them the two cousins follow immediately, they are running outside, and they disappear in the meadows and between the trees, playing for hours.

Are we, as a culture, using such brain energies optimally, or is play just deemed superfluous fun? I suspect we have a long way to go before we develop social structures that use playful energies coherently and optimally to promote early child development. Rather than spending their early years in the schoolrooms of natural play, increasing numbers of children are dispensed attention-promoting psychostimulants (all of which reduce playfulness in animals) that help their restless, self-generative minds sit still for all-too-often boring lessons. Although such mind medicines do help many kids sit quietly "attentive," there is no clear scientific evidence yet, after many years of research, that they actually improve learning.

My premise here, then, is that most, albeit not all, of ADHD reflects a cultural ailment rather than a biological disease (Panksepp 1998b). Other than generally heightened sensitivity to learning disabilities among children, there is no other way to understand why the diagnostic rates of ADHD have been steadily increasing across the last twenty years, with another doubling of diagnoses in the past decade (Winterstein et al. 2008). The prevalence of this "disorder" seems to be driven as much by social issues as by biological ones. Although the rapid percent increase of ADHD diagnosis has abated somewhat in the past decade, the overall percentage of kids diagnosed still ranges from about 8 percent to 16 percent depending on perceived degree of severity (Barbaresi et al. 2002; Visser, Lesesne, and Perou 2007; Zuvekas, Vitiello, and Norquist 2006). More than ten million American children are presently being chronically medicated with psychostimulants, certainly at the highest rates of any country in the world. We know that these drugs influence brain plasticity in various ways (Moll et al. 2001; Robinson and Kolb 2004). Yet, the long-term psycho- and neuro-biological effects of these drugs remain inadequately clarified in animal models, not to mention young human beings and their subsequent adult development. Moll et al. found that modest doses of methylphenidate reduced dopamine transporter proteins, which makes me worry about their long-term effect, though I admit I have not a scintilla of real clinical evidence as yet to support such a worry. As I will emphasize here, though, the increasing trickle of evidence from animal models should alert us to potential dangers, including perhaps facilitation of depressive disorders later in life.

If any of this comes to pass, we will regret our cultural shortsightedness including, perhaps, our failure to use fully the tools nature provided for developmental maturation. To head in that direction now, we must employ the natural power of play. In the long term, abundant physical play probably builds and strengthens the reflective, inhibitory resources that enable socially sensitive, deeply empathetic brains. We must create joyful learning environments where diverse, self-generated, playful activities have optimal opportunities to do their appointed mind-creating work.

That conclusion will of course come as no surprise, given our previous work on the subject. Of the at least four genetically provided, social-emotional tools I mentioned earlier in our mammalian genetic heritage that provide for children to become productive members of society, we have studied the nature of two of them most closely: the ancient subcortical PANIC and PLAY emotional systems (Panksepp 1993, 1998b, 2001; Panksepp et al. 1980; Panksepp, Siviy, and Normansell 1984). Among the most emotionally painful, genetically provided "tools for living" are the circuits that mediate separation distress (PANIC states), facilitating crying, sadness, and social bonding. Such pro-social feelings assure that young children come to value the company of those who have invested in their welfare. Without adequate social attachments, no child can seize the opportunities that healthy educational environments provide.

The most wonderful tool provided to achieve full socialization of the brain is the psycho-physical PLAY system of the mammalian brain. Social PLAY allows youngsters to learn about social dynamics in affectively positive ways. An enormous number of behavioral and mental functions may be refined during youthful play, during the fulfillment of cyclic ludic urges that percolate persistently in every normal child, each and every day. If these neurobiological urges remain unfulfilled, there will be consequences, and among them we contend will be an increasing incidence of ADHD (Panksepp 1998a).

Thus, one goal I fervently favor is the establishment of "play sanctuaries" across our land, where preschoolers can congregate, under the watchful eye of young and sensitive student caretakers (who surely need part-time jobs), and thereby, on a regular basis, experience the joy of socializing in ways that they themselves desire. For grades K–3, at the very least, the first class of each day should be recess, where joyful physical activity and positive socialization are encouraged.

The Neuroscience of Play and Critical Importance of Animal Models

Because obvious ethical concerns forbid critically important neurobiological research on humans, animal brain research must be used to reveal how the specific circuits and molecules of the brain generate the miracle of affective consciousness. I will briefly summarize recent work on animal playfulness that may be relevant for understanding ADHD. There is every reason to believe—based on the subcortical localization of core PLAY circuitry—that the neurobiological forces that energize play in our children are homologous to those that coax the young of all other mammals onto the field of play. If so, the *general principles* by which our children's brains become ludic and how that feeds back on brain maturation, should be so similar that knowledge derived from detailed animal research will generalize, in principle if not detail, to the human condition. I trust this knowledge will eventually allow us to envision how various developmental difficulties—from ADHD to autism and oppositional-defiance problems—may be related to basic brain issues (Barkley 1997; Panksepp 2001) and will help guide useful and meaningful social policies.

Evidence from other animals demonstrates that our basic emotional feelings may arise substantially from evolutionary processes that evolved to generate "instinctual" emotional behaviors (Panksepp 2005b, 2008). In other words, affective feelings appear to be closely linked to the "action neurodynamics" that generate instinctual emotional displays within the animal brain. The most dramatic and intriguing positive social urge is that for rough and tumble play in young animals. The joyous feelings accompanying such action patterns do not have to be learned, even though they probably guide behavioral choices as well as a great deal of subsequent learning.

To derive especially useful knowledge from such animal studies, we will have to understand the molecular underpinnings and psychoneurological consequences of these systems better than we presently do. Fortunately, the neuroscience and molecular biology revolutions have now provided the essential tools for penetrating such mysteries. The work has already yielded potential neurochemical codes for various emotions, drives, and appetites (Panksepp and Harro 2004)—the many state-control systems of the brain that may be the primal sources of our biological values and possibly a major source process for consciousness itself (Panksepp 2003, 2007b), and psychiatrically significant disorders thereof (Panksepp 2006).

ADHD and the Neural Consequences of Play and Joy

Play has enormous effects on activating the brain from its lowest to highest reaches (Gordon et al. 2002). My own recent goal has been to fathom how many brain gene expression patterns are modified by play, and which might be the most important for brain maturation. We are far from an answer, but new genetic methods are capable of probing how the DNA "orchestra" plays its tunes under different environmental circumstances. "Gene chip" technologies, which monitor the changing activities of thousands of genes simultaneously, are among the most promising ways to clarify such issues. Indeed, with the help of molecular biological colleagues at the Falk Center for Molecular Therapeutics at Northwestern University, we have evaluated how the genetic orchestra in the cortex changes its "tunes" as a function of play.

The effects have been spectacular: of twelve hundred genes monitored, almost a third exhibited significant changes in the degree to which they were transcribed (Burgdorf et al. 2007). The gene from our micro-arrays that showed the largest effect was the Insulin Like Growth Factor system, one of the many neural "fertilizers" that facilitate neuronal growth and maturation. Preliminary human data indicate this growth factor can facilitate positive feelings (Arwert, Deijen, Müller, and Drent 2005; Unden et al. 2002) and may, along with play, eventually be a way to reduce depression (Malberg et al. 2007). Earlier, we had already seen some increased gene activity of BDNF (Brain Derived Neurotrophic Factor), one of the first neuronal growth factors discovered in the brain (Gordon et al. 2003). We are most interested to see how psychostimulants used to treat impulsive kids influence the same brain parameters, and would be surprised if they simulate the effects of play.

Psychostimulants like Ritalin (methylphenidate) are among the most powerful play-reducing drugs ever discovered through the use of animal models. Adequate research should be conducted to determine how play and psychostimulants influence long-term brain organization. Troublesome facts have already arisen from animal research. These drugs easily "sensitize" animal brains, making them hyper-responsive to similar drugs throughout the life span (Berridge and Robinson 1998; Robinson and Berridge 1993). Typically, young animals do not sensitize as readily as older animals (Solanto 2000), but we have observed sensitization in young rats (Laviola et al. 1999; Panksepp et al. 2003), and we have also found such sensitization to elevate the craving not only for drugs but for a variety of conventional rewards such as food and sex as well (Nocjar and Panksepp 2002). To put it bluntly again, psychostimulant sensitization makes animals more urgently “materialistic”—more eager for all kinds of external rewards. If there is anything we should wish to sensitize in the brains of ADHD children, it is the urge for pro-social activities, not the desire for drugs or other external rewards.

There may be some serious personality consequences for children who have little chance to play normally, whether for lack of opportunities or sustained medication with play-reducing drugs. Thus, there is a compelling issue to be considered: what if it turned out that a substantial percentage of ADHD kids receiving psychostimulants are simply normal kids who have strong, unsatisfied desires to play?

Our past work with animal models has also demonstrated that play “therapy” reduces impulsive behaviors resembling ADHD. This compels us to ask, persistently, whether abundant physical play might also be therapeutic for children diagnosed with ADHD? Since the urge to play is a neurological “drive” or urge, we suspect that if it is left unfulfilled then symptoms of ADHD will more easily emerge in social situations, such as classrooms, where rough and tumble activities may not be appropriate. As a result of such thinking, we performed a feasibility study to see whether we could introduce a play-intervention program for pre-kindergarten classes of our local public school system (Scott 2001). We certainly learned that the kids liked it very much, even as some of the teachers did not. The natural playing field was also an ideal environment for coaxing children to participate in more pro-social interactions, especially at moments bad things happened, which they invariably did.

What are the alternatives? Medication is the easiest one. But what if these medications sensitize their brains? It is disturbing to contemplate these issues, especially since animal research already suggests that early experiences with such drugs can promote addiction later in life. Might such medications have permanent effects on children’s personalities? Relevant data is scarce, but our animal work suggests such changes do occur. Some experts claim, on the basis of scant data and without ever having properly evaluated changes in the underlying psychological urges, not to mention potential brain changes, that such medications may reduce future drug use. However, it seems to me that many older children begin to use these drugs in recreational ways. Animal research clearly indicates that past experiences with these drugs typically increase future drug-seeking behaviors. These troublesome concerns are not being addressed adequately at either scientific or cultural levels, even though the neurochemical actions on human and animal brains are identical to cocaine, except for lower potency and speed of action.

Because of the widespread acceptance of psychostimulant medication of ADHD, such work must now be pursued in a cultural context of contentiousness, since these medications are so widely prescribed and so highly effective for what some segments of society seek. Of course, the secondary benefits for children, especially if they are no longer marginalized by teachers and other children, can be enormous, even if the primary drug effects do not benefit the psychoneurological status of the child in demonstrable ways. In short, the number of people who want to believe in these highly effective treatments is huge. This can easily lead to polarization of attitudes and beliefs that can retard support for such work and an honest confrontation with the scientific issues.

Although no study has yet attempted to evaluate *the intensification of desire* for drugs among medicated children vs. non-medicated ones, it is long past time to evaluate whether psychostimulant-induced "sensitization" has transpired in kids medicated for ADHD, as it has in human adults (Strakowski and Sax 1998; Strakowski et al. 2001; Wachtel and deWit 1999). This could be done by contrasting the acute physiological effects of psychostimulants in children about to be medicated as compared to those that have been chronically medicated in the past.

At present, the jury remains out on the question of whether juvenile animals exhibit stronger or weaker addiction liability after being exposed to psychostimulants. There is evidence both pro and con (Andersen et al. 2002; Brandon, Marinelli, Baker, and White 2001), and rather consistent evidence that early exposure to such drugs may promote a depressive brain neurochemical profile (Carlezon, Mague, and Andersen 2003; Mague, Andersen, and Carlezon 2005). Regardless of how the above issues are resolved by future research, I must reemphasize that psychostimulants used to treat ADHD are among the most powerful social play-reducing drugs ever discovered through the use of animal models (Beatty et al. 1982).

At the same time, it is clear that as a population, *unmedicated* ADHD children are at higher risk for developing substance abuse disorders later in life (Biederman et al. 1998; Wilens 2004). Regrettably, despite some debatable claims to the contrary (Mannuzza, Klein, and Moulton 2003; Wilens and Biederman 2006), there is presently no credible data that early experiences with psychostimulants reduce *the underlying urge* to consume such drugs later in life. There is some data that psychostimulant treatment of ADHD children does not promote drug abuse in adolescents. However, the initial study in that series (Biederman et al. 1999) not only failed to include the total quantities of psychostimulants prescribed by physicians in overall levels of drug intake, but the ADHD children placed on methylphenidate initially had substantially lower drug intake patterns than the unmedicated controls (0 percent and about 38 percent, respectively, with about 27 percent and 77 percent at four year follow-up). In fairness, should we not be computing the amounts of psychostimulants being medically administered in overall drug consumption, especially when many older adolescents begin to sell and/or abuse their medications?

These are troublesome issues to contemplate. Clearly, a great deal of fundamental brain research is needed before we can make well-informed cultural choices on the costs and benefits of such interventions.

Some may believe that it is presumptuous to suggest that such animal data will have important implications for human clinical practice. This is bound to remain a controversial issue until robust predictions are generated for humans. For starters, ours are that, (1) when properly evaluated, we will find that psychostimulants reduce the urge of human children to play; (2) a regular diet of physical play, each and every day during early childhood, will be able to alleviate ADHD-type symptoms in many children that would otherwise be on that "clinical" track; (3) play will have long-term benefits for children's brains and minds that are not obtained with psychostimulants; (4) psychostimulants may sensitize young brains and intensify internally experienced urges that may, if socio-environmental opportunities are available, be manifested as elevated desires to seek drugs and other material rewards; and (5) if and when we finally get to human brain gene expression studies (methodologically almost impossible, since one needs brain tissue samples), we would anticipate that the profiles of gene-activation resulting from lots of play and lots of psychostimulants will be quite different in their brains. In short, we suspect the data will show that different genetic tunes can be strummed in various regions of the brain by the relevant pharmacological and socio-environmental factors.

If data from animal models continue to sustain our concerns, there may be implications of this type of research for social policy issues, coaxing us to reconsider the importance of abundant early physical play for brain-mind development. It is worth noting that even Plato encouraged free play—"those natural modes of amusement which children find out for themselves when they meet." In *The Republic* [section IV] he insisted that "our children from their earliest years must take part in all the more lawful forms of play, for if they are not surrounded with such an atmosphere they can never grow up to be well conducted and virtuous citizens." Whether future affective, behavioral, and cognitive neuroscience studies support such assertions remains to be seen. Until then, I suggest a wise society would invest in building "play sanctuaries" for our preschoolers, so there are optimal chances for the children to become cooperative students and happy citizens. Once they enter the lower grades, perhaps the first class each day should still be the chance to play.

Conclusions: Play Sanctuaries for Our Times?

Our postmodern societies have stolen natural play away from our children, to be replaced, all too often, with regimented activities and medications that reduce the urge to play. Preclinical evidence suggests that if we learn to restore the power of PLAY to our preschoolers' educational diet, in new and creative ways, we may dramatically reverse the rate at which ADHD is proliferating. Real play opens up the possibility of using all of our natural emotional tools for the epigenetic construction of social brains (Panksepp 2001). A fine practical guide for such neuroscientifically based child rearing is Margot Sunderland's new book *The Science of Parenting* (2006).

Impulse control problems can be hugely difficult in childhood, but our emerging understanding of primary-process PLAY functions encourages us to conceptualize new ways to facilitate pro-social brain-mind maturation, and thereby reduce impulse control problems in our children. Despite years of psychiatric research, *most* of what gets diagnosed as ADHD may be little more than natural variability of brain maturation that results partly from genetic factors and partly from the social environments we have created. Although we now know that ADHD children are anatomically (and hence functionally) a bit "short" (around 5 percent) in their frontal lobe executive functions (Castellanos and Tannock 2002), this typically only becomes a social problem when kids on the low end of that brain size distribution enter school. They are not as compliant as children who have better brain-mind regulatory functions. Although there are more serious problems with a small minority of children, most diagnosed with ADHD have no clinically relevant brain disorder. Many merely have problems with social-compliance behaviors when their urges to play are thwarted.

Indeed, probably every child could be diagnosed with ADHD at some point in his or her life. The same applies for oppositional-defiant behaviors. This syndrome is diagnosed when a child "(1) often loses temper; (2) often argues with adults; (3) often actively defies or refuses to comply with adults' requests or rules; (4) often deliberately annoys people; (5) often blames others for his or her mistakes or misbehavior; (6) is often touchy or easily annoyed by others; (7) is often angry and resentful; (8) is often spiteful or vindictive" (Sadler 2002, 162). True, this set of symptoms could be observed in most children during the course of their lives, but "often" is the operative term here. I expect that children would also exhibit fewer such symptoms had they adequate daily physical play, especially with wise supervision.

Obviously, it would be more desirable for families (and society) to intervene with such children at the earliest and most plastic phases of development to maximize the maturation of frontal brain regions (Barkley 1997) by providing maximum opportunities for socializing their brains. When children are falling behind, the sooner we implement positive life-promoting social interventions, the better. If we do that, we may have much less need to prescribe attention-promoting, behavior-improving medications, whose long-term biological cost-benefit functions remain inadequately characterized. Wisdom dictates that all natural interventions should be given a proper chance before resorting to powerful psychostimulants that have long-term effects on brain plasticity.

There must be much greater investments in research to determine how both social play and psychostimulants influence long-term brain organization. Our work on the neurobiology of playfulness suggests that this important gift of nature is a primary-process tool for helping construct social brains (Panksepp 2001). Chronic psychostimulant use may abort the ability of PLAY to encourage kids to join the social structures in which they find themselves. If these medications block the dramatic play-stimulated gene expression patterns in the cortex, we may be playing dice with our children.

Have we restricted the playful birthrights of our children? Can a fully social brain emerge without play or will it remain socially stunted for life? In *The Laws* [VII, 794] Plato extolled the benefits of and encouraged free play in children. He asserted that "At the stage reached by the age of three, and after ages of four, five, six, play will be necessary. These are games which nature herself suggests at that age; children readily invent these for themselves when left in one another's company. All children of the specified ages, that of three to six, should first be collected at the local *sanctuary*—all the children of each village being thus assembled at the same place. Further, the *nurses* are to have an eye to the decorum or indecorum of their behavior" (my italics). Although he went on to suggest greater social engineering than is wise in a free society, his basic message was that without play our children couldn't become fully human.

So where might Plato's play *sanctuaries* fit in our world, where nature has been removed from the lives of most of our children and most kids are over-protected, regimented, and TV-vegetated; where most young children have too few rough and tumble play partners (organized sports and video games being a pale imitation of real PLAY); where most parents and educators don't even recognize the profound value of real play for their children; where many believe that treating children like little adults helps rear social brains? If, as we hold, there is no evidence young minds can mature in healthy ways without daily use of the rough and ready emotional PLAY tools that nature provides, and if young children do not have playmates each day, then probably roughhousing with a parent can serve some neural needs, certainly when the alternative is no physical play at all.

It is reasonable to postulate that full maturation of higher brain social networks (perhaps even "mirror neurons") requires full immersion in real PLAY. If families can no longer provide such childhood luxuries, then perhaps it should become a societal responsibility to create "play sanctuaries"—places where we combine the best of play and the best emotionally fulfilling education.

By using the power of each child's SEEKING system, all children could become lifelong learners, yielding joyful engagements with living and learning that become internalized habits, perhaps inoculating the young against future depression. Perhaps deep pro-social brain maturation, under the control of epigenetic developmental programs, can never happen without abundant daily PLAY throughout the preschool years. Indeed, one can envision *epigenesis* operating at a cultural rather than just an individual level. Thus, social policies can influence how the brains of our young people mature.

If preliminary animal data is a valid guide, abundant play will facilitate maturation of the frontal cortical inhibitory skills that come to regulate children's impulsive primary-process emotional urges. The more children indulge in pro-social play, the sooner and more intensely will they develop invaluable mind functions—the precious mind skills of maturing brains. Frontal lobe executive functions allow children, indeed all of us, to inhibit impulsive urges—allowing us to stop, look, listen, and feel. Such inhibitory skills promote enhanced capacities for self reflection, imagination, empathy, and creativity/play: the resulting frontal lobe working-memory abilities permit the kind of behavioral flexibility and foresight that constitute well focused, goal directed behavior. Such long-term benefits on frontal lobe development should last a lifetime. If so, to really leave no child behind, the first class of every school day should be filled with play, and each subsequent class should be filled with playful learning energies.

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