Problem gambling and the brain

An exciting and relatively new addition to the research on the causes and treatments of problem gambling is emerging from work being done on brain development and function. For the most part, the research is too new to come to solid conclusions, so we offer an overview of some of the findings over the past several years. Some of the studies are very small and all require much more exploration, but the findings are intriguing and may lead the way to new treatment and prevention strategies.

Article excerpts on the brain and problem gambling

Gambling has drug-like effect on brain (2001)
The brains of people anticipating a win at the roulette table appear to react much like those taking euphoria-inducing drugs. A team of investigators reports that the parts of the brain that respond to the prospects of winning and losing money while gambling are the same as those that appear to respond to cocaine and morphine.

The overlap of brain activity seen in the gambling experiment with that found in earlier studies of drug use indicates, the researchers said, that the brain uses the same circuitry for “the processing of diverse rewards.”

“The results of our gaming experiment, coupled with findings from prior studies of the anticipation and experience of positive and negative outcomes in humans and laboratory animals, suggest that a network of interrelated structures ... coordinate the processing of goal-related stimuli,” the team led by Dr. Hans C. Breiter of Massachusetts General Hospital said.

They found that in the gambling experiment, blood flow to the brain changed in ways similar to that seen in other experiments during an infusion of cocaine
subjects addicted to that drug and to low doses of morphine in drug-free individuals. The changes varied in accordance with the amount of money involved, and a broadly distributed set of brain regions were involved in anticipating a win. The more money involved, the more excited the person became. The primary response to winning, or the prospect of winning, was seen in the right hemisphere of the brain, while the left hemisphere was more active in response to losing, the researchers reported.


**The medial frontal cortex and the rapid processing of monetary gains and losses (2002)**

Choices made after losses were riskier and were associated with greater loss-related activity than choices made after gains. It follows that medial-frontal computations may contribute to mental states that participate in higher-level decisions, including economic choices. *Source:* [http://www.sciencemag.org/cgi/content/abstract/295/5563/2279](http://www.sciencemag.org/cgi/content/abstract/295/5563/2279)

**Brain activities differ in problem gamblers (2003)**

Imaging studies have identified unique brain activity changes in men with pathological gambling when they viewed videotapes about betting on cards or rolling dice at a casino, a Yale study has found.

The fMRI study showed that the men with gambling problems had a temporally dynamic pattern of brain activity when viewing gambling videotapes, with changes observed in frontal, paralimbic, and limbic brain structures. When viewing gambling cues, men with pathological gambling demonstrated relatively decreased activity in brain regions implicated in impulse regulation.

Another finding is that the pattern of brain activity changes more closely paralleled those observed in the cocaine cravings of cocaine addicts than the anticipatory urges in persons with OCD. *Source:* [http://opa.yale.edu/news/article.aspx?id=3025](http://opa.yale.edu/news/article.aspx?id=3025)

**Gambling addiction resembles brain problem: Poorer choices, more errors seen in chronic gamblers’ mental tests (2005)**

Gambling addiction may have something in common with certain brain impairments. Both conditions can hinder decision-making and the ability to determine the consequences of actions, according to Franco Manes, M.D., and colleagues. They say it’s possible that gambling addiction is associated with impairments in the brain’s prefrontal cortex, affecting the ability of gamblers to consider future consequences before taking action.
Those with a gambling addiction made “‘disadvantageous choices’” on the decision-making task. The gamblers also made more impulse control errors on another task, say Manes and colleagues.

The errors and poor choices are similar to those made by people with problems in the brain’s prefrontal cortex, the researchers say. Source: http://www.webmd.com/mental-health/news/20050413/gambling-addiction-resembles-brain-problem

**Brain’s ‘gambling circuitry’ identified (2006)**

From gamblers playing blackjack to investors picking stocks, humans make a wide range of decisions that require gauging risk versus reward. However, laboratory studies have not been able to unequivocally determine how the very basic information-processing “subcortical” regions of the brain function in processing risk and reward.

Now, Steven Quartz and colleagues at the California Institute of Technology have created a simple gambling task that, when performed by humans undergoing functional magnetic resonance imaging (fMRI) of their brains, distinguishes the “gambling” structures in the brain. Importantly, their findings tease apart the gambling function of these brain structures from their functions in learning, motivation, and assessment of the salience of a stimulus.

The researchers concentrated their analysis on the “anticipatory period” between the display of the first and second card, since it was then that the subjects were able to judge from the number on the card the risk of whether they were likely to win or lose their bet that the second card would be higher or lower.

Furthermore, the researchers divided that anticipatory period into two subperiods. During a one second [sic] period immediately after the first card was displayed, subjects were concentrating on expected reward, theorized the researchers; and in the following six seconds before the second card, they were assessing the risk.
revealed by the first card. The researchers based this approach on studies by other researchers of such processes in primates.

Quartz and colleagues found they could distinguish brain regions that specifically responded to either reward expectation or risk. Importantly, these areas showed activity that increased with the level of expected reward and perceived risk. The researchers found that the activation related to expected reward was immediate, while the activation related to risk was delayed.

Of the practical implications of their findings, the researchers wrote that “pathological behaviors ranging from addiction to gambling, as well as a variety of mental illnesses such as bipolar disorder and schizophrenia, are partially characterized by risk taking. To date, it is unknown whether such pathological decision making [sic] under risk is due to misperception of risk or disruptions in cognitive processes, such as learning, planning, and choice.

Source: http://www.sciencedaily.com/releases/2006/08/060803091759.htm

**Brain atrophy in elderly leads to unintended racism, depression and problem gambling (2007)**

University of Queensland psychologist, Bill von Hippel, reports that decreased inhibitory ability in late adulthood can lead to unintended prejudice, social inappropriateness, depression, and gambling problems. Von Hippel also found that a penchant for gambling can be toxic for older adults, as those with poor executive functioning are particularly likely to have gambling problems. Interestingly, these problems are exacerbated in the afternoon, when older adults are less mentally alert. Older adults were more likely to get into an unnecessary argument and were also more likely to gamble all their money away later rather than earlier in the day. These findings suggest a possible avenue for intervention, by scheduling their important social activities or gambling excursions earlier in the day.

While social changes commonly occur with age, they are widely assumed a function of changes in preferences and values as people get older. Von Hippel argues that there may be more to the story and that some of the changes may be unintended and brought about by losses in executive control.


**Science shows how slot machines take over your mind (2007)**

From the perspective of the brain, gambling has much in common with addictive drugs, like cocaine. Both work by hijacking the brain’s pleasure centers -- a lure that some people are literally incapable of resisting. “Gambling games grew up
around the frailty of our nervous system,” says Read Montague, a professor of neuroscience at Baylor University. “They evolved to exploit specific hiccups in our brain.”

The neural circuits manipulated by gambling originally evolved to help animals assess rewards, such as food, that are crucial for survival. Dopamine is the neurotransmitter involved with the processing of these rewards. Whenever we experience something pleasurable, such as winning a hand of blackjack or eating a piece of chocolate cake, our dopamine neurons get excited. These neurons help the brain learn about the pleasure, and attempt to predict when it will happen again.

Wolfram Schultz, a neuroscientist at Cambridge University, has exposed how this system operates on a molecular level. He has spent the past two decades measuring the activity of dopamine neurons in the brains of monkeys as they receive rewards of fruit juice. His experiments observe a simple protocol: Schultz flashes a light, waits a few seconds, and then squirts a few drops of apple juice into the monkey’s mouth. While the monkeys are waiting for the sweet liquid, Schultz painstakingly monitors the response of individual cells.

At first, the neurons don’t get excited until the juice is delivered. The cells are reacting to the actual reward. However, once the animal learns that the light always precedes the arrival of juice, the same neurons begin firing at the sight of the light instead of the reward. Schultz calls these cells “prediction neurons,” since they are more interested in predicting rewards than in the rewards themselves.

These predictions are a crucial source of learning, since the monkey constantly compares its expectations of juice with what actually happens. For example, if the light is flashed but the juice never arrives, then the monkey’s dopamine neurons stop firing. This is known as the “error signal.” The monkey is disappointed, and begins to change its future predictions. However, if the monkey receives an unexpected reward -- the juice arrives without warning -- then the dopamine neurons get extremely excited. A surprising treat registers much larger than an expected one.

“A reward that’s unpredictable typically counts three or four times as much,” Schultz says. Games of chance prey on this neural system. Consider, for example, the slot machine. You put in a coin and pull the lever. The reels start to whirr. Eventually, the machine settles on its verdict. Chances are you lost money. But think about the slot machine from the perspective of your dopamine neurons. Whenever you win some money, the reward activates those brain cells intent on
anticipating future rewards. These neurons want to predict the patterns inside the machine, to decode the logic of luck. Yet here’s the catch: slot machines can’t be solved. They use random number generators to determine their payout. There are no patterns to decipher. There is only a little microchip, churning out arbitrary digits.

At this point, our dopamine neurons should just turn themselves off: the slot machine is a waste of mental energy. But this isn’t what happens. Instead of getting bored by the haphazard payouts, our dopamine neurons become obsessed. The random rewards of gambling are much more seductive than a more predictable reward cycle. When we pull the lever and win some money, we experience a potent rush of pleasurable dopamine precisely because the reward was so unexpected. The clanging coins and flashing lights are like a surprising squirt of juice. The end result is that we are transfixed by the slot machine, riveted by the fickle nature of its payouts. “The trick of a one-armed bandit,” Montague says, “is that it provides us with the illusion of a pattern. We get enough rewards so that we keep on playing. Our cells think they’ll figure out the pattern soon. But of course they won’t.”

The irony of gambling is that it’s entertaining because it’s so frustrating, at least for our dopamine neurons. One of the big remaining questions for scientists is why only some gamblers get addicted. While most people can walk away from the slot machines, some gamblers ... can’t resist the temptation. For these compulsive gamblers, the misplaced predictions of their dopamine neurons become self-destructive. Source: 

Gambling and risk taking (2007)
Once considered a character defect, gambling is now known to be a highly addictive disorder with neurological causes. Thanks to new advances in brain imaging, scientists are beginning to identify the neural mechanisms that go awry in the brains of pathological and problem gamblers. What they’re learning from such research is also shedding light on how these same mechanisms determine individual risk tolerance – and influence the financial choices we all make throughout our lives.

You hold your breath as the wheel spins on the roulette table. You briefly close your eyes as the croupier deals you another card at the blackjack table. You stand frozen in place as the horse you bet on lunges toward the finish line.

At such moments – when you’re anticipating the possibility of a financial reward – certain areas of your brain jump into action. The particular pattern of that activity, neuroscientists are now discovering, helps identify how risk-averse you are – not only when you’re at the gambling table or the racetrack – but when you ponder any decision that involves some financial risk. Should you take a new job? Should you invest in a new business? Should you put your savings in potentially volatile stocks or in the “sure thing” of a bank certificate of deposit?

Those same neural patterns may also reveal whether you’re at risk of becoming a pathological gambler, someone so addicted to gambling that you continue the activity even while mounting losses ruin your personal finances and relationships.
Recent studies have found that when we anticipate financial gains – whether at the gaming tables or on the stock market – an area of our brain known as the ventral striatum becomes activated and flooded with dopamine, a brain chemical linked to pleasurable sensations. The release of this chemical also occurs during physically rewarding activities such as eating, sex and taking drugs, and is a key factor behind our desire to repeat these activities.

When we start to consider the possibility of losing money, however, the same brain areas become less active. In fact, most people’s brains show more negative sensitivity to losses than positive sensitivity to gains – neural evidence of our tendency toward risk aversion. In one study, researchers could predict how tolerant individuals were to risk by analyzing how their brains responded to potential gains versus potential losses. Those whose brains were less turned off by the possibility of increasing their losses tended to be more eager gamblers.

In pathological gamblers, neural activity in the ventral striatum remains remarkably unreactive – even during winning streaks. Their brains also show decreased activation in the ventrolateral prefrontal cortex – the brain’s “superego” – which, when functioning normally, keeps people from acting impulsively. This finding may explain why pathological gamblers keep betting despite the havoc it inflicts on their lives. To maintain even a normal level of dopamine in their brains, they must gamble with increasing frequency – and often for greater and greater stakes. And the impulse control in their brain is not functioning properly. Drug addicts show a similar brain pattern – and a similar need to keep feeding their addiction.

Recently, pathological gambling has been found to be a rare side effect of specific types of dopamine agonists, drugs used to treat the tremors and balance problems associated with Parkinson’s disease. The dopamine boost from these drugs appears to overload receptors in the ventral striatum, causing an irresistible urge to gamble. The effect does not occur in everybody who takes dopamine agonists and it dissipates once the medication is discontinued. Source: http://www.sfn.org/index.cfm?pagename=brainbriefings_gambling#full (pdf of full article is available)

**Brain challenges for compulsive gamblers** *(2008)*
A new research study finds that gambling addicts do not learn from their mistakes. The finding suggests [that] differences in the prefrontal cortex of the brain may
explain the development of impulsive or compulsive behavior that can lead to pathological gambling.

The research team evaluated a group of 15 male and five female pathological gamblers. They carried out various neuropsychological tests in order to explore which areas of the brain are related to the disorder. The tests included the Wisconsin Card Sorting Test (WCST), the Wechsler Memory Scale revised (WMS-R) and the Verbal Associative Fluency Test (FAS). Each of which can assess particular problem-solving abilities. [sic] They compared the results with those of healthy individuals.

They found that the pathological gamblers scored well in all tests except the card sorting. In this test, the patients had great difficulty in finding different ways to solve each problem in the test as they worked through them, whereas the healthy individuals got better with practice.

“Our findings show that in spite of normal intellectual, linguistic and visual-spatial abilities, the pathological gamblers could not learn from their mistakes to look for alternative solutions in the WCST,” say the researchers.

This suggests that there are differences in the part of the brain involved in this kind of problem solving, the prefrontal region. “These differences might provoke a sort of cognitive ‘rigidity’ that predisposes a person to the development of impulsive or compulsive behaviour, leading to pathological gambling.”

The Changing Adolescent Brain
excerpted from an article by Sarah K. Ramowski and Robert J. Nystrom

The idea that the teenage years are full of change and growth is not new to public health professionals, teachers, parents, or teens themselves, for that matter. Adolescence is often a time of encountering new freedoms and new situations.

Over the past few years, strong research has emerged that documents the enormous changes to the brain in the developing years between childhood and adulthood. T

Previously, it was thought that most brain development was complete by adolescence and that teenagers’ brains were as fully matured as adult brains. As the result of increasingly sophisticated research and imaging abilities, we now know this is not the case. Just as teens’ bodies are maturing and their social skills are expanding, their cognitive centers are also in flux.

During adolescence, the brain adopts a “use-it-or-lose-it” pruning system, resulting in a decreasing number of connections among brain cells even as the speed of these connections increases. Major changes are also underway in the prefrontal cortex (PFC), known as the executive planner of the brain. The PFC is responsible for weighing risks and benefits, strategic thinking, and impulse control. Throughout adolescence, the PFC is refining its wiring to become more sophisticated. Studies demonstrate that the PFC is among the last parts of the brain to fully develop, in many cases not maturing until well into the third decade of life. Unused branches are sloughed off, and other pathways are refined. As this
construction phase progresses, synapses that normally go through the PFC in an adult brain are instead re-directed to the amygdala, known as the emotional center of the brain. When this happens, the response is rooted in emotion—fight, flight, freeze, freak out—rather than rationality. The amygdala can also misinterpret others’ facial emotions, perceiving fear or nervousness as anger or hostility.

All these processes can alter the ability of adolescents to harness their decision-making abilities, making them more vulnerable to risk-taking and impulsive behaviors. As a parent, when you sometimes feel your son or daughter is over-reacting or misinterpreting, you have likely met their developing brain in action.

The adolescent brain is especially sensitive to the effects of dopamine, a chemical neurotransmitter that is activated by substance use, exposure to high-intensity media, and gambling, as well as food and sex. It is still not known how much of brain development is influenced by environment vs. genetics, but some evidence suggests that constructive learning experiences can positively shape teen cognitive development.

As research results have emerged, some public health professionals have voiced concern that the results will be used to squelch teen independence or rights in areas such as reproductive health and health care decisions. Public health policy and science provide us with a few key responses to that concern. First, brain development, as an isolated issue, should be just one of several factors considered when designing good programs and policies. Second, it is important to recognize that successful brain development relies on exercising this organ. From a use-it-or-lose-it perspective of refining maturing brain connections, it would be most productive for caring adults to provide meaningful opportunities for adolescents to exercise brain functions that require analytical, decision-making, and valuing skills, to help teens demonstrate their real and valuable role in making good decisions and advocating for their health.

Other resources on gambling and the brain

“Youth, Brain Development and Gambling Risk: Intersections on the Developmental Highway” PowerPoint presentation by Dr. Ken Winters
www.dmh.missouri.gov/ada/provider/Wintersyouthbrainandgamblingtalk.ppt

“Gambling Addiction: What’s the Brain Got to do With It?” PowerPoint presentation by Dr. Mark Potenza
http://braininstitute.vanderbilt.edu/Vanderbilt_March07_PotenzaLecture.ppt

The Brain From Top to Bottom: brain function tutorial/overview Web site
http://thebrain.mcgill.ca/