

**Runner-up Researcher Category – National Brain Science Writing Prize 2008**  
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**Your inner Jekyll and Hyde**

One sip of a mysterious chemical was enough to transform the genial Dr Jekyll into the murderous Hyde. We all struggle to contain our inner Hyde from time to time, and recent research hints at how this battle plays out in our brains.

When we face temptation, our primitive, emotional brain system appears to wrestle with a more recently evolved goal-driven system. At any given time, temporary changes in our brain chemistry may determine which one wins. My work aims to find out how.

Just as Robert Louis Stevenson wrote about multiple personalities within one man, our brains have multiple systems that compete to control our behaviour. The Pavlovian system governs basic responses to signals of pleasure and pain. It is very old, in evolutionary terms – even sea slugs display Pavlovian responses – and its actions evoke very predictable responses. For example, signals of danger provoke aggression, which probably evolved to protect us from danger. Free from conscience, the Pavlovian system is like the neural Hyde. It directs us to seek rewards and react aggressively to punishments, and is responsible for violent urges, like those unleashed by Jekyll's potion.

Another system, called the goal-directed system, is responsible for more detailed representations of the world and helping us visualize our goals. The goal-directed system is evolutionarily newer than the Pavlovian system, and is thought to have reached its peak sophistication in humans. Like Jekyll, the goal-directed system considers social regulations. It allows us to override Pavlovian impulses in favour of long-term goals.

To find out when each system dominates, scientists have turned to a game that allows them to watch volunteers struggle with their inner Hydes. In the Ultimatum Game, one player proposes a way to split a sum of money. The other player can either accept the offer, and both are paid accordingly, or reject the offer, and neither is paid anything. When offers are unfair, people tend to predictably reject them, despite the fact that rejection means not getting paid. That behaviour smacks of the Pavlovian brain. Accepting an unfair offer, however, means suppressing the emotional urge to reject, which researchers presume is the work of the goal-directed system.

To test this hypothesis, my colleagues at the University of California in Los Angeles used brain imaging to look inside the brains of volunteers playing the Ultimatum Game. The study, published in the journal *Psychological Science*, showed that behaviour in the Ultimatum Game may depend on the outcome of a battle between Pavlovian and goal-directed brain regions. Unfair offers activated the Pavlovian system – and the greater the activity in this system, the more likely the volunteers were to angrily reject the offers. In contrast, when volunteers were willing to stomach the unfair offers, their brain scans revealed increased activity in their goal-directed systems and decreased activity in their Pavlovian systems. Their Dr Jekylls were in charge.

Another study, conducted at the University of Iowa, showed that patients with damage to the goal-directed system were more likely to reject unfair offers than uninjured volunteers. With less competition from the goal-directed system, these patients appeared to be in a permanent Hyde-like state.

But most of us don't have brain damage, nor do we go around drinking mysterious potions – so what determines whether our inner Jekyll or Hyde reigns? Though Dr Jekyll's potion was a figment of Stevenson's imagination, it turns out that chemistry does play an important role in controlling aggressive impulses. At the University of Cambridge, I study how these chemicals act.

Recently, my colleagues and I gave 20 volunteers a 'potion' that temporarily lowered their levels of serotonin, a brain chemical that has been linked to mood. When these volunteers played the Ultimatum Game, they rejected more unfair offers than they did with normal serotonin levels. Like the brain-damaged patients, these volunteers seemed to be driven by their inner Hyde.

It's not clear from my study how exactly lowered serotonin levels affect brain activity, but we suspect that our manipulation affected the balance of power between Pavlovian and goal-directed brain systems. Now we're testing whether serotonin acts as a steroid for the Jekyll-like parts of the brain, a poison for the Hyde-like parts, or a little of both.

Looking inside the brain is helping us to figure out why we often make disastrous emotional decisions despite knowing better. Understanding these brain mechanisms may someday allow us improved control of our inner demons, maybe even by way of mood potions at your pharmacy. But before you drink anything, check the label!