

# THE VIOLENT BRAIN

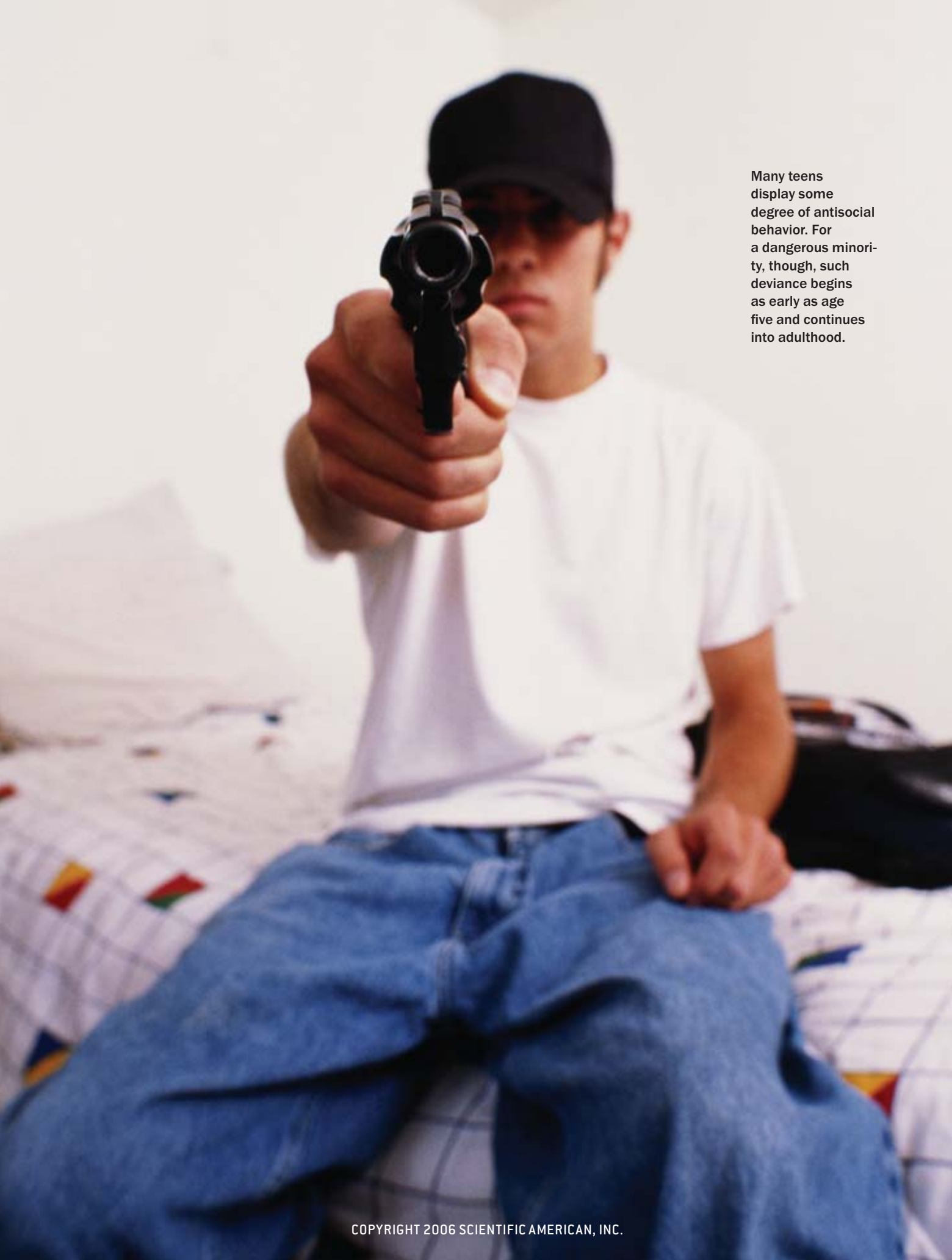
**VIOLENT BEHAVIOR NEVER ERUPTS FROM A SINGLE CAUSE. RATHER IT APPEARS TO RESULT FROM A COMPLEX WEB OF RELATED FACTORS, SOME GENETIC AND OTHERS ENVIRONMENTAL** BY DANIEL STRUEBER, MONIKA LUECK AND GERHARD ROTH

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n September 13, 2006, Kimveer Gill walked into the cafeteria at Dawson College in Montreal and, without apparent motive, shot 21 people, injuring 19 and killing two, including himself. The same day a judge in West Virginia sent a woman to jail for, among other atrocities, forcing her six children and stepchildren to gorge themselves on food and then eat their own vomit.

Also on the 13th, a court in New York sentenced a man for killing his girlfriend by setting her on fire—in front of her 10-year-old son. There was nothing special about that Wednesday. From around the world we hear reports of murder, manslaughter, cruelty and abuse every day. Violence is ubiquitous.

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Many teens display some degree of antisocial behavior. For a dangerous minority, though, such deviance begins as early as age five and continues into adulthood.

# Perpetrators who carefully plan their crimes typically express **no empathy or regret.**

But what drives one person to kill, maim or abuse another, sometimes for little or no obvious reason—and why do so many violent offenders return to crime after serving time in prison? Are these individuals incapable of any other behavior? We have evaluated the results of studies conducted around the world, focusing on acts ranging from fistfights to murder, in search of the psychobiological roots of violence. Our key conclusion is simple: violent behavior never erupts from a single cause. Rather it results from a combination of risk factors—among them inherited tendencies, a traumatic childhood and other negative experiences—that interact and aggravate one another. This realization has a silver lining: positive influences may be able to offset some of those factors that promote violence, possibly offering hope for prevention.

## Impulse Control

In 1972 an international team of psychologists launched one of the largest longitudinal studies ever conducted. The Dunedin Multidisciplinary Health and Development Study has now followed approximately 1,000 people born in the

New Zealand city of Dunedin for nearly 34 years. Terrie E. Moffitt and Avshalom Caspi, both at King's College London and the University of Wisconsin–Madison, have participated in the study, examining, among other things, antisocial behavior associated with physical violence. They have observed that those who exhibit antisocial behavior fall into two distinct groups. Most are between the ages of 13 and 15, and their delinquency stops just as quickly as it starts. A small minority, however, display antisocial behavior in childhood—in some cases as early as age five—and this conduct continues into adulthood. Among this latter group, almost all are boys.

Indeed, male gender is the most important risk factor for violent behavior. As criminal statistics show, boys and young men commit the majority of physical assaults. According to the Federal Bureau of Investigation's statistics on crime in the U.S., 90.1 percent of murderers apprehended in 2004 were male and men accounted for 82.1 percent of the total number arrested for violent crimes. Girls and women are not necessarily less aggressive, as was assumed until the 1990s. But women engage in more indirect, covert aggression, whereas men tend toward immediate, outward physical aggression [*see box on page 24*].

The causes of these gender differences are manifold. Learned sex roles certainly enter into it: “girls don't hit,” for example, but “boys need to be able to defend themselves.” Also, indirect aggressive strategies require a relatively high level of social intelligence, which girls develop earlier and faster. Moreover, neurophysiological discrepancies almost certainly play a role. The small group of males who exhibit chronic violent behavior from an early age typically share other telltale traits, among them a low tolerance for frustration, deficiencies in learning social rules, attention problems, a decreased capacity for empathy, low intelligence and, most characteristic, extreme impulsiveness.

Similarly, repeat offenders—particularly those who have long prison records—seem unable to keep their aggressive urges in check. The late neuroscientist Ernest S. Barratt and his colleagues at the University of Texas Medical Branch interviewed imprisoned criminals in Texas in 1999 and found that many inmates consistently picked fights, even though they knew that their lives

## FAST FACTS

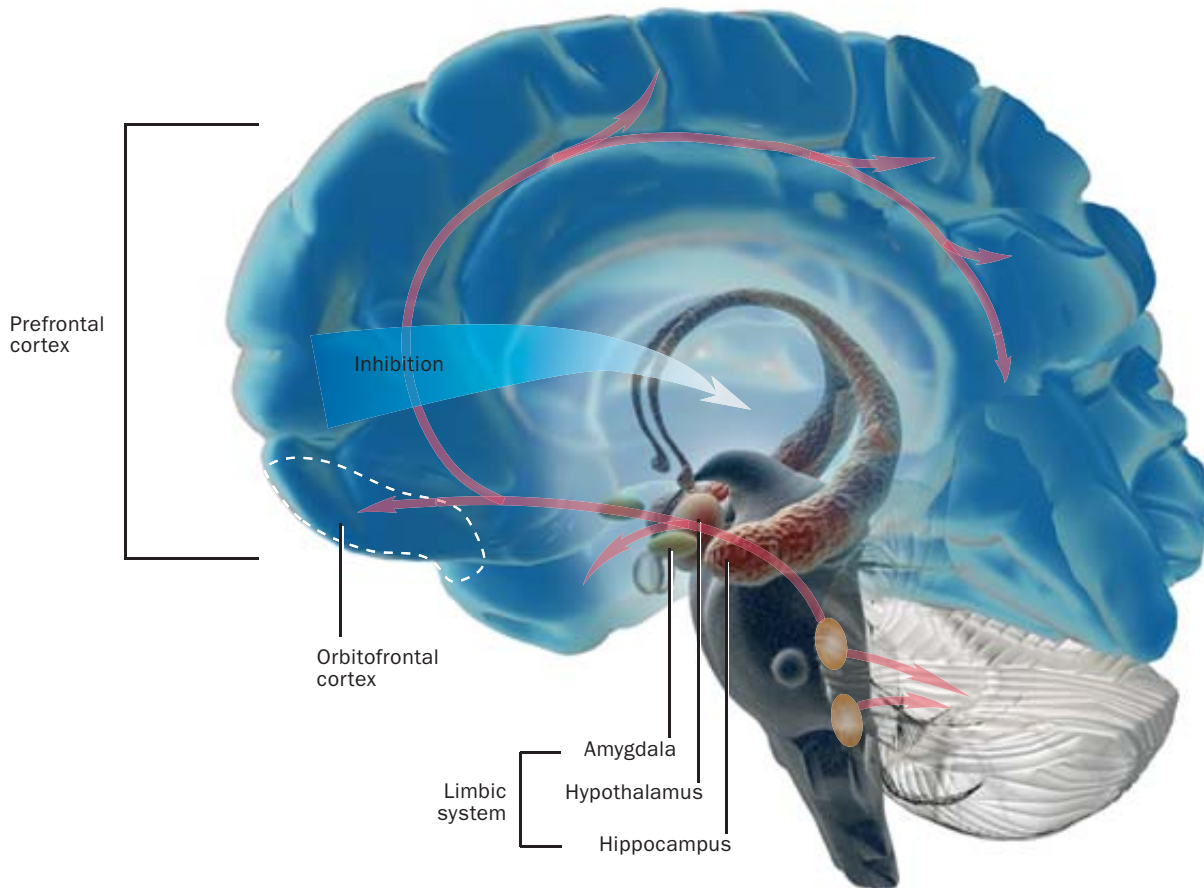
### Roots of Violence

**1>>** Violent behavior never erupts from a single cause. Rather it results from a complex web of interrelated factors—among them an individual's inherited tendencies, brain anatomy and childhood experiences. Male gender is the most prominent risk.

**2>>** Abnormalities in the frontal cortex may cause deficiencies in emotional control that fail to stop impulsive criminals from acting. Anomalies in the limbic system may hinder communication between the hippocampus and amygdala so that emotional information is not processed correctly. Irregular neurochemistry, too, may cause increased aggression in some violent offenders.

**3>>** If biology and circumstance conspire to prime certain individuals toward violence, how much responsibility do people really bear for their actions? Some legal experts now question whether a violent offender can truly exercise free will despite his or her psychobiological and social predispositions.

# Anatomy of Aggression



Anomalies in the prefrontal cortex may handicap some individuals, making it difficult for them to show restraint. Some scientists hypothesize that the orbitofrontal cortex, an area involved in decision making, normally inhibits regions in the limbic system—specifically the hypothalamus and the amygdala, where fear and aggression arise. If a defect blocks this communication, a person might not be

able to moderate his or her emotional reactions. Damage to the hippocampus may also impair the brain's processing of emotional information. In some instances, a malfunction of the amygdala may underlie violent behavior. This theory could explain the lack of fear, empathy and regret that is characteristic of criminals who plan their acts and commit them in cold blood.  
—D.S., M.L. and G.R.

would be made more difficult as a result. When asked why they continued to behave in ways that hurt them, many responded that they had no idea. Even though they understood the consequences and resolved to act with greater self-control the next time, they did not trust their own ability to keep their impulses at bay.

Preliminary research indicates that biology may handicap some of these individuals, making it more difficult for them to show restraint. Among violent offenders, neuroscientists have found anatomical and physiological differences in both the limbic system and the prefrontal cortex, brain regions that are involved in the development and control of emotions. Some scientists propose that the orbitofrontal cortex, a region of the prefrontal

cortex where decision making takes place, inhibits areas of the limbic system—specifically the hypothalamus and the amygdala, primitive brain regions that are a source of fear and aggressive impulses. Thus, if some defect or injury impairs communication between the limbic system and the frontal cortex, a person might not be entirely able to moderate his or her emotional reactions.

## Frontal Brain Hypothesis

This assumption underlies the so-called frontal brain hypothesis, which several studies support. Cognitive neuroscientist Jordan Grafman and his colleagues at the National Institutes of Health have discovered that Vietnam War veterans who suffered damage to the prefrontal cortex



# The Testosterone Connection

**W**hy are men more likely to resort to physical aggression? The sex hormone testosterone, which readily passes through the blood-brain barrier, offers some clues. In many animal species, male aggressiveness is closely linked to testosterone levels. In humans, the association seems slight—but researchers have found significantly higher levels of testosterone in violent offenders as compared with nonviolent criminals.

The concentration of testosterone is subject to considerable fluctuation: it increases in men, for example, just before competitive sports. The level remains high for some time in the winners but decreases rapidly in the losers. Constant competition and conflict may thus permanently alter an individual's testosterone level. In general, male testosterone levels peak in the late teens and remain high until the mid-20s—exactly the age group in which male aggression and violence are most common.

The data on testosterone in women are contradictory, which is not surprising given that women synthesize only a small fraction of the quantity that men do. Of interest, though, James Dabbs and his colleagues at Georgia State University measured testosterone in 87 women at a maximum-security prison and found that



the hormone levels varied with the violence of the women's crimes and their behavior behind bars. The most violent women who also showed the greatest aggression toward other inmates had the most testosterone. When asked to describe the women who had the lowest hormone levels, prison staff used words like "sneaky" and "treacherous"—which may show that, in place of outward aggression, these women used less direct strategies to get their way. —D.S., M.L. and G.R.

tend to be more aggressive. Similarly, adult patients who have frontal brain lesions are generally more uninhibited, inappropriate and impulsive—much like people with antisocial behavior disorders. In these adult groups, however, there is no direct indication that their brain damage predisposes them to actual violence.

For children who suffer frontal brain injury, the behavioral consequences are often more dramatic, as documented by neuroscientist Antonio R. Damasio and fellow researchers at the University of Iowa College of Medicine. In one case, surgeons removed a tumor from the right frontal cortex of a three-month-old infant. By age nine the boy had become almost impossible to motivate in school, remained socially isolated and spent almost all of his free time in front of the television or listening to music. Occasionally he would "go wild" and threaten others, sometimes

physically. Of significance, the boy grew up in a caring environment with loving parents and his siblings developed normally.

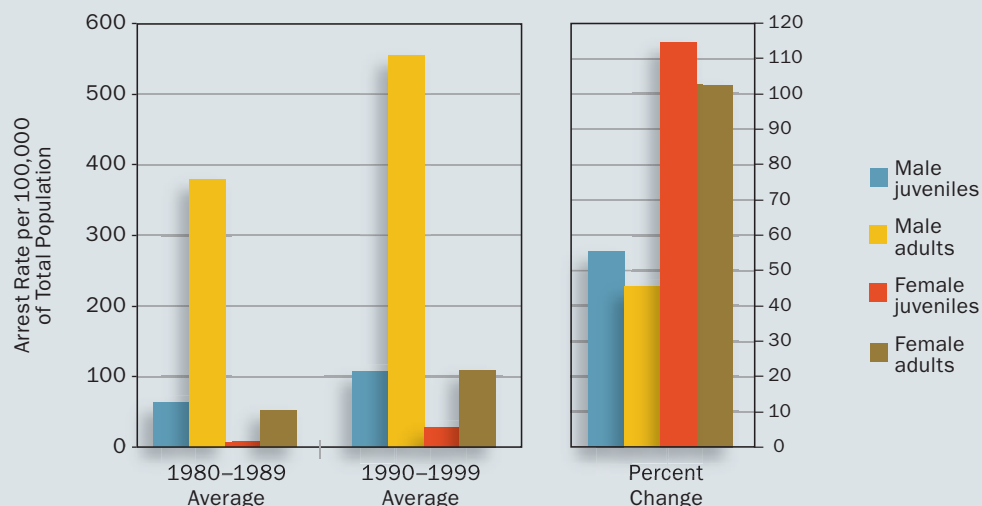
In another case described by Damasio, a 15-month-old girl suffered head injuries in a serious automobile accident. She progressed typically at first but, at age three, started to exhibit behavioral disorders. At the time, her parents noted that she failed to react at all to punishment. Later she refused to comply with rules, frequently fought with teachers and classmates, lied shamelessly, stole and broke into homes. Most notably, she constantly attacked other people both verbally and physically. She, too, had normal brothers and sisters.

Additional evidence bolstering the frontal brain hypothesis comes from Adrian Raine and his colleagues at the University of Southern California, who have studied convicted murderers.

SIGGI BUCHER Reuters Corbis

Women engage in more indirect, **covert aggression**, whereas men tend toward physical force.

## Violent Crime Rates



Although men account for the majority of arrests for violent crime, the number of women taken into custody for similar offenses is rising—and rising fast. The total arrests among juvenile and adult females shot up by more than 100 percent

from the 1980s to the subsequent decade, whereas the figure rose by approximately half that amount among male teenagers and even less than that among adult men.

—D.S., M.L. and G.R.

Using positron-emission tomography (PET), they found lower levels of metabolic activity in the murderers' frontal brain regions as compared with members of the general public. Further analysis, however, revealed that this difference existed only among criminals who had killed on impulse. The frontal brain appeared normal in those murderers who had planned their crimes meticulously and committed them in cold blood, seemingly without conscience.

### “Successful Psychopaths”

This finding backs the notion that deficiencies in emotional control may fail to prevent impulsive violent offenders from acting. They do not stop to think through to the consequences. In contrast, the cold, calculating criminal requires a largely intact frontal brain because long-term planning involves complex decision processes. Even though perpetrators who plan carefully are relatively few in number, they elicit the most horror, in large part because they often express little to no empathy or regret.

Raine and his colleagues further investigated criminals who premeditate—both before and after capture. This new area of research is thorny, not least because of the methodological difficulties in identifying at-large psychopaths. To get reliable information, researchers must guarantee their subjects absolute confidentiality and promise not to alert the authorities, which is exactly what Raine and his co-workers recently did. They compared two groups of violent criminals who had antisocial personality disorders, only some of whom had faced conviction, with 23 control subjects. Raine characterized the 16 apprehended offenders as “unsuccessful psychopaths” and the 13 who evaded the law as “successful psychopaths.”

### (The Authors)

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Some repeat offenders report that they distrust their ability to control aggressive urges, despite having a desire to do so.



An anatomical comparison using structural magnetic resonance imaging (MRI) revealed significant differences: the volume of gray matter in the prefrontal cortex was 22.3 percent lower among the unsuccessful offenders as compared with the control subjects. Moreover, the volume was within normal limits among those violent criminals who avoided capture. Supplemental testing showed that the frontal brains of successful psychopaths performed even better than average on a variety of neuropsychological tasks.

Additional investigations of the same violent criminals identified irregularities in the hippocampus, a limbic structure that straddles both hemispheres of the brain: in the unsuccessful group, the hippocampi in either hemisphere differed in size, an imbalance the researchers presume arose early in brain development. This asymmetry may impair the ability of the hippocampus and amygdala to work together, so that emotional information is not processed correctly. If the prefrontal cortex then fails as the control of last resort, inappropriate verbal and physical reactions might result.

Raine's findings, if substantiated, suggest that successful psychopaths exhibit an entirely different causal pattern of violent behavior. Al-

though these calculating criminals have intact impulse control, they may suffer from other brain abnormalities. To find out, scientists must study the role of the amygdala, as well as the reward centers in the limbic system. Researchers such as James Blair of the National Institute of Mental Health now believe that these structures are responsible for psychopathic behavior. Blair has suggested that dysfunction of the amygdala detrimentally affects an individual's socialization, leading to a reduced capacity to feel empathy or guilt, among other emotional impairments.

Clearly, antisocial behavior is a complicated phenomenon—one that the frontal brain hypothesis may explain only in small part. In light of Raine's results, frontal brain defects seem more closely associated with the risk of apprehension than with serious, chronic violence. So, too, it is unclear whether the frontal brain hypothesis applies to women.

Female violent offenders are rare and therefore less well studied. Even so, no connection appears to exist in females between a decreased frontal brain volume and psychopathological tendencies, as has been shown in the male population. By nature, women appear to have more

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# Does it really make sense to assume that a criminal can consciously choose to not act violently?

effective impulse control, which tends to fail only when the functioning of the prefrontal cortex is massively impaired in childhood.

## A Combustible Mix

Other lines of evidence suggest that neurochemistry may help prime the violent brain. Numerous studies have linked low levels of serotonin—an often inhibitory and fear-reducing substance in the brain—to antisocial, impulsive acts. Of interest, researchers have found this association not only among criminals but among men in general. Studies have not confirmed the same connection in women, suggesting that the male sex hormone, testosterone, also plays a role. Psychologist James Dabbs of Georgia State University has conducted several studies demonstrating that violent criminals have higher testosterone levels than nonaggressive criminals do. Such biochemical differences may be genetic or linked to environmental factors. For example, neglect and abuse in childhood may permanently reduce serotonin levels.

Biochemical differences, as well as genetic and structural brain variations, do seem to increase the risk of violent behavior in some men. Except in the most severe and early cases of damage, though, these factors are not enough to precipitate actual violence. It is in combination with psychosocial risk factors that a predisposing biological mix can become explosive, as numerous studies have confirmed. Such psychosocial risk factors include serious deficiencies in the early mother-child relationship, abuse in childhood, parental neglect and inconsistent parenting, as well as persistent parental conflicts, a breakup or loss in the family, parental criminality, poverty and long-term unemployment.

Researching these factors is problematic because several cannot be viewed independently from the anatomical and physiological changes mentioned previously. If, for example, behavioral and emotional disorders are present very early on, the parents' child-rearing abilities will be severely tested. As Mechthild Papoušek, a pediatric psychiatrist at the Max Planck Institute of Psychiatry in Munich, has shown, intimate communication between the infant and the primary caregiver begins shortly after birth. The two reinforce each other's behavior, both in the positive and in the negative sense. The infant's qualities

determine the interaction just as much as the caregiver's personality and psychological state do. And a problematic early relationship can in time lead to severe developmental disorders, among them lowered impulse control, a lack of empathy and a reduced capacity for resolving conflicts. The result is a vicious cycle.

A robust cognitive and emotional makeup can help some children to overcome the negative influences in their environment. At present, it is still unclear why many people are able to compensate for terrible childhood experiences or early brain damage and violent offenders are often not. This knowledge gap is worrisome. Can we hold people responsible for their genetic makeup, brain development or traumatic experiences? How much responsibility do people bear for their actions? Does it make sense to believe that a criminal could decide to not act violently—if only he or she wanted to?

Some legal experts now question the assumption that a violent offender can exercise free will despite psychobiological and social predispositions [see "Brain Scans Go Legal," by Scott T. Grafton, Walter P. Sinnott-Armstrong, Suzanne I. Gazzaniga and Michael S. Gazzaniga, on page 30]. It is an assumption that, when reconsidered, may force us to revise our notions of culpability. But we need not be helpless in the face of violent crime. Though a subject of contentious debate, it may be enough to pursue a policy of prevention, consisting of deterrence, treatment and incarceration. Future research, too, may provide the tools to help authorities identify potential offenders sooner and intervene before it is too late. **M**

## (Further Reading)

- ◆ **Sex Differences in Antisocial Behaviour: Conduct Disorder, Delinquency and Violence in the Dunedin Longitudinal Study.** Terrie E. Moffitt, Avshalom Caspi, Michael Rutter and Phil A. Silva. Cambridge University Press, 2001.
- ◆ **Males on the Life-Course-Persistent and Adolescence-Limited Antisocial Pathways: Follow-up at Age 26 Years.** Terrie E. Moffitt, Avshalom Caspi, Honalee Harrington and Barry J. Milne in *Development and Psychopathology*, Vol. 14, Issue 1, pages 179–207; March 2002.
- ◆ **Hippocampal Structural Asymmetry in Unsuccessful Psychopaths.** Adrian Raine, Sharon S. Ishikawa, Estibaliz Arce, Todd Lencz, Kevin H. Knuth, Susan Bihle, Lori LaCasse and Patrick Colletti in *Biological Psychiatry*, Vol. 55, Issue 2, pages 185–191; January 15, 2004.
- ◆ **Dunedin Multidisciplinary Health and Development Study:** <http://dunedinstudy.otago.ac.nz/>