

CRIME Times

Linking **Brain** Dysfunction to
Disordered/Criminal/Psychopathic Behavior

Volume 15, Number 4, 2009

Omega-3 supplements improve cognition, memory in children

Supplementing school-children's diets with omega-3 fatty acids may improve their learning and memory skills, according to a new study.

Annalien Dalton and colleagues note that omega-3 fatty acids, which modern diets are low in, are crucial for proper brain development and function. While most studies of the effects of omega-3 supplementation focus on infants (especially those born prematurely), the researchers point out that the brain continues to develop through the teenage years. "Therefore," they say, "poor nutrition may affect the developing functions of the frontal lobes of the brain throughout childhood."

To see if supplementation with omega-3 fatty acids can improve the cognitive skills of children, Dalton and colleagues supplemented the diets of half of a group of children with an omega-3-rich fish-flour spread. The remainder of the 183 children, who ranged in age from seven to nine years, ate a spread containing no fish flour.

The researchers report that after six months, the children eating the fish-flour spread had significantly higher blood levels of the omega-3 fatty acids DHA (docosahexaenoic acid) and EPA (eicosahexaenoic acid).

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Violent behavior: consider role of environmental toxins

Explanations of violent behavior too often overlook environmental toxins, a new research review concludes.

The authors, David Carpenter and Rick Nevin, cite evidence showing that lead, arsenic, methyl mercury, and a variety of chemicals can reduce IQ. They note that in addition, lead and methyl mercury exposure can cause behavior changes including short attention span, hyperactivity, and impulsive antisocial behavior. Behavior and attention deficits, they point out, are also reported in children with heavy exposure to PCBs and dioxins as well as those exposed to pesticides.

The researchers note that studies clearly reveal an association between low IQ and violence. Theories suggesting that this link is due to genetics, they say, overlook the role of toxins such as lead—which is known to both reduce IQ and increase the risk for delinquency. They cite Nevin's earlier research (see *Crime Times* Vol. 13, No. 3, 2007, p. 1) strongly correlating changes in blood lead levels with rising and falling crime rates in a range of countries across several decades.

"Recent USA incarceration rate trends are consistent with lead exposure trends," they add, "resulting in a prison population increasingly dominated by older, life-course-persistent offenders." They note that incarceration rates dropped between 2000 and 2006 for men under 30—a pattern predicted by reductions in preschool blood lead levels since the mid-1970s—while rates continue to rise for men over 40, who were born when rates of lead poisoning were very high.

"Our conclusions that environmental exposures contribute to violent behavior are not meant to discount other factors," they say. "Clearly many children exposed to contaminants during development do not go on to become criminals. There are undoubtedly genes that contribute to susceptibility to violent behavior, just as there are genes that determine susceptibility to development of cancer consequent to chemical exposure." In addition, they say, social factors undoubtedly interact with environmental factors to influence violent behavior.

"Our point, however," they say, "is that while socioeconomic status, genes, poverty, low IQ and other factors have been widely discussed in relation to violent behavior, there has been little, and totally inadequate, attention given to the role of early life environmental exposures." For instance, they point out, researchers focus on the sociological impact of poverty—but poverty also greatly increases exposure to brain-harming environmental toxins.

The researchers conclude that if research continues to support a strong link between environmental contaminants and violent behavior, "the most effective way to fight crime may be to prevent exposure to these contaminants."

—
"Environmental causes of violence," David O. Carpenter and Rick Nevin, *Physiology & Behavior*, September 14, 2009 (epub prior to print publication). Address: David O. Carpenter, Institute for Health and the Environment, University at Albany, 5 University Place, A 217, Rensselaer, NY 12144, carpent@uamail.albany.ed.

—INTERVIEW: Bernard Gesch on Nutrition and Behavior—

In September 2009, the journal Science featured the work of British researcher Bernard Gesch of the University of Oxford, who is investigating the effects of nutrition on criminal behavior. He has generously agreed to share information about his findings and exciting new research with Crime Times.

How did you first become interested in the link between diet and behavior problems?

It was following the evidence of my own eyes. I had been involved in a nationally influential initiative that seemed to improve the management

“We found that those who consumed the active capsules committed 26% fewer offences than those taking placebos. Compared to baseline there were 37% fewer serious offences such as violence. Bear in mind that this was in a high-risk population that typically had intractable problems of violence.”

of juvenile offenders, but we never got down to why some young people offend and others don't. Later I ran a center that was used by courts as an alternative to custody. Some of our clients would turn up with bags of sweets and be almost uncontrollable. For some this was their only meal. So we started to prepare a meal together so that they would settle down, and it seemed to work great. We typically learned more about the youngster during the meal than during our formal offending program afterwards.

With the help of Professor Derek Bryce Smith, Dr Damien Downing, and Dr David Horrobin, this gradually turned into a full-blown dietary analysis intervention package that was offered to the courts. The courts responded very favorably and it became national news. Most importantly I saw such positive changes in many of our clients that it motivated me to pursue this.

Can you summarize your findings to date?

We founded the charity Natural Justice to continue this work with an empirical study to test if nutrition was a cause of offending behavior. I began work in 1992 with colleagues to design a double-blind RCT [placebo-controlled randomized trial].

A prison is a good place to do this as behavior is closely monitored and all food sources are known. Aylesbury housed particularly violent long-term prisoners, so this was chosen as the site for our study.

We had the advantage of being able to look at criticisms of previous work so we could address them. Researchers like Stephen Schoenthaler were generous with their advice. Organizations such as the Wacker Foundation kindly helped fund the study.

We established that the prisoners made poor food choices, so we wanted to test what would happen to their behavior when nutrients were reinstated to government recommended levels. We used placebos or food supplements that contained broadly the daily requirements of vitamins, minerals, and essential fatty acids.

We found that those who consumed the active capsules committed 26% fewer offences than those taking placebos. Compared to baseline there were 37% fewer serious offences such as violence. Bear in mind that this was in a high-risk population that typically had intractable problems of violence. As a consequence we took these findings to numerous statistical experts to review them before publishing them in 2002.

Our other finding was that our well-validated self-reported measures of anger, aggression, malaise, depression and anxiety were unresponsive to the changes observed in actual offences between groups over time. It seemed to be an anomaly, but other teams have now replicated this observation. Traits such as aggression are often reported as violence. That is fine if they can be shown to relate to the incidence of violence, which is a series of events. We found otherwise. We are now firmly of the view that event-based analysis is the way forward.

More recently we have done work to assess the dietary intakes of children in the care system, and as we would predict, their diets are worse than the prisoners. This is being written up.

Can you describe your new study? Do you have any preliminary findings you can report?

The new study is around five times larger than Aylesbury, is based in three prisons, and is funded by the Wellcome Trust and run from Oxford University. It is designed to be conclusive and to explore how such

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effects on behavior are mediated and which nutrients are involved.

We will monitor offences again as well as incidents of self-harm. We are conducting pre-post tests of frontal lobe mediated tasks such as impulse control, stop-go, and risk taking. These are done on computerized test batteries developed at Cambridge University and the Institute of Psychiatry. We will also collect pre-post blood samples to allow us to relate changes in blood nutrient levels with changes in behavior and other cognitive outcomes. The challenge is to do all of this without disrupting the prison regime! So far, so good.

Unpicking effect is not as simple as it seems. A pharmacological approach would be to provide one isolated nutrient, but in a dietary intervention, the participant also consumes nutrients in the diet. Unless you monitor the dietary baselines, you do not know if other nutrients are changing or if the effect you observe is in part due to lack of other nutrients in the baseline diet.

Our approach to this is to ensure that the active group consume physiological dosages of all the essential nutrients and then build up a picture of effect as follows: *That there is evidence of nutritional deficiencies at baseline* (from blood). *That nutritional deficiency is linked to poor dietary intakes* (from seven-day food diaries). *That nutritional indices are improved by supplementation* (compare pre-post blood). *That the rate of improvement in nutritional indices will predict a reduction in the rate of disciplinary incidents* (difference in pre-post blood nutrient status related to behaviors). Hopefully this will give us data with which to advise dietary standards of the effect of nutrients on behavior.

We have a number of other studies designed for schools and crime in the community, but as ever the limiting factor is finding the funds.

What specific dietary changes do you implement in your interventions?

We use broad-spectrum food supplements as they facilitate a placebo control and provide the daily requirements of vitamins, minerals, and essential fatty acids.

The Aylesbury study was designed before the omega-3 story began to emerge. We provided 80% omega-6 and 20% omega-3. The current study provides around one gram of EPA and DHA, which is 80% omega-3, plus a small amount of omega-6 for the GLA. The vitamin package is based around 100% of the daily requirements. The mineral composition is similarly based around the daily requirements with the exception of magnesium, calcium, and phosphorus. For the current study we increased the magnesium to provide 300mg, which is the daily requirement.

Are prisoners initially enthusiastic about participating?

Overall, we consistently manage to recruit around 75% of the population. That is a healthy figure as some also decide not to join, which is their right.

The prisoners are often surprised at the outcome. In the first study, the prisoners did not guess better than random which group they were in.

How do prison staff members feel about the changes they see in the prisoners?

There is often a mixture of enthusiasm and cynicism among the pris-

on staff. You get a lot of anecdotes about changes in prisoner behavior during the clinical work, but we will only know where we stand once the blind is broken.

A few weeks into the Aylesbury study, the officers were surprised at how quiet the prison was. The number of alarms had dropped dramatically—so much so that the principal officer who coordinated responses to alarms complained that he was bursting out of his trousers as he had been getting so little exercise!

Is this intervention cost-effective?

Very much so. The *Economist* reported that it would cost about 0.2% of the cost of using prison. This low-cost, low-risk approach contrasts with typical rollouts of criminal justice programs that can cost £100Ms and are often found to be ineffective, such as cognitive training in our prison system.

Are you seeing increased interest in your work on the part of government officials or law enforcement officials?

Attitudes are definitely changing now. I cannot pretend it has been easy or the future will be without frustration. Nevertheless, none of us work in this field to boost our egos; we do it because we believe this work is important.

As our understanding of the neuroscience of behavior advances, some of the assumptions that underpin criminal justice are becoming increasingly untenable. We often describe crime as brainless, but we should not take that literally!

For additional information, see Crime Times Vol. 8, No. 3, 2002, p. 1.

High-candy diet in childhood: a link to violent crime?

Children who eat large amounts of candy are more likely than other children to be convicted of violent offences in adulthood, according to a new study.

Simon Moore and colleagues analyzed data from the British Cohort Study, a long-term study of 17,000 subjects born in April 1970. The study included data on the children's diet (including candy consumption) at age 10. At the age of 34, participants were asked if they had ever been convicted of a crime.

"Children who ate confectionery daily at age 10 years were significantly more likely to have been convicted for violence at age 34 years," the researchers say, "a relationship that was robust when controlling for ecological and individual factors." Overall, 69% of people convicted of violent crimes by the age of 34 reported eating candy nearly every day in childhood, while only 42% of nonviolent study participants ate candy frequently.

Editor's note: Moore and colleagues say their findings suggest

that parents who frequently use sweets to control children's behavior may fail to teach them delayed gratification, making them more impulsive in adulthood. However, an alternate explanation is that a diet high in candy and low in nutrients leads to poor brain function, resulting in impulsive behavior. Studies showing reductions in criminal behavior following the implementation of healthful diets add weight to the latter theory. (See our interview with Bernard Gesch on pages 2 and 3 of this issue for more on this topic.)

—
"Confectionery consumption in childhood and adult violence," Simon C. Moore, Lisa M. Carter, and Stephanie H. M. van Goozen, *British Journal of Psychiatry*, Vol. 195, No. 4, October 2009, 366-7. Address: Simon C. Moore, Violence and Society Research Group, Applied Clinical Research and Public Health, School of Dentistry, University of Cardiff, Cardiff CF14 4XY, UK, mooresc2@cardiff.ac.uk.

—see also—

"Eating candy in childhood linked to adult crime," Alice Park, *Time*, October 3, 2009.

Quotable....

Children have a right to an environment in which they can reach and maintain their full potential—an environment free from preventable chemical exposures beginning with preconception and continuing throughout development. We have an obligation to provide an optimal environment for all children. The scientific evidence on the neurodevelopmental effects of many chemicals is well established, and action to reduce exposure is essential to prevent adverse health effects.

The consequences of LDDs (learning and developmental disorders) are most significant for the affected individual but also have profound implications for the family, school system, local community and greater society. Despite some uncertainty, there is sufficient knowledge to mandate preventive action to reduce fetal and childhood exposures to environmental contaminants. Given the serious consequences of LDDs, a precautionary approach is warranted to protect the most vulnerable members of our society.

—*Policy statement, Learning and Developmental Disabilities Initiative, September 16, 2008*

Omega-3 aids learning

(continued from page 1)

In addition, children in this group showed significant improvement compared to the unsupplemented group on tests of word recognition and word discrimination and did better than controls in spelling. They also showed improvements in other areas, although these did not reach significance. The results, the researchers say, indicate that DHA supplementation can result in improvements in learning and short-term memory.

—
"A randomised control trial in schoolchildren showed improvement in cognitive function after consuming a bread spread containing fish flour from a marine source," A. Dalton, P. Wolmarane, R. C. Witthuhn, M. E. van Stuijvenberg, S. A. Swanevelder, and C. M. Smuts, *Prostaglandins, Leukotrienes and Essential Fatty Acids*, Vol. 80, No. 2-3, 2009, 143-9. Address: Annalien Dalton, Nutritional Intervention Research Unit, Medical Research Council, P.O. Box 19070, Tygerberg 7505, South Africa.

Mediterranean diet may reduce depression risk

People eating a Mediterranean diet high in fruits, vegetables, fish, whole grains, and nuts may reduce their risk for depression, according to a recent study.

Almudena Sánchez-Villegas and colleagues collected data on more than 10,000 healthy adults surveyed about their diets between 1999 and 2005. None of the participants reported having depression at the time the data were collected.

Following up approximately four years later, the researchers found that the incidence of depression was 30% lower for participants who followed the Mediterranean diet than for those who did not.

—
"Mediterranean diet may help prevent depression," *HealthDay*, October 5, 2009.

RESEARCH IN BRIEF

Are dangerous teens' brains too mature?

Why do many teens do dangerous things—speeding, having unprotected sex, drinking and driving? One theory is that areas of the brain involving behavioral control are slower to develop in these adolescents than in teens who behave more cautiously. However, a new study indicates that teens who engage in dangerous behaviors exhibit *increased*—not decreased—white matter maturity.

Gregory Berns and colleagues used an imaging method called diffusion tensor imaging (DTI) to explore the development of white matter tracts in the brains of 91 teens between the ages of 12 and 18. They also asked the teens to complete the Adolescent Risk Questionnaire, which measures levels of dangerous activity.

After adjusting for age, the researchers detected significant evidence of increased myelination and/or density of fibers—both evidence of greater brain maturity—in the teens who took more risks. “The direction of correlation,” they say, “suggests that rather than having immature cortices, adolescents who engage in dangerous activities have frontal white matter tracts that are more adult in form than their more conservative peers.” The researchers conclude that “precocious development of these tracts may predispose some adolescents to engage in behaviors that society considers too adult in nature for their chronological age.”

“Adolescent engagement in dangerous behaviors is associated with increased white matter maturity of frontal cortex,” Gregory S. Berns, Sara Moore, and C. Monica Capra, *PLoS One* (open access), Vol. 4, No. 8, August 26, 2009, e-6773.

BPA and girls' aggression

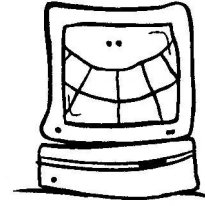
Researchers report an association between bisphenol A (BPA), a chemical widely used in plastics, and aggressive behavior in girls.

Joe Braun and colleagues analyzed data from 249 mothers and their children in Cincinnati, Ohio. The researchers measured levels of BPA in maternal urine samples at 16 and 26 weeks of gestation and at the children's birth. When the children were two years old, the researchers evaluated their behavior using a standardized test. They adjusted for factors including maternal age, race, education level, marital status, and household income, the child's sex, the caregiving environment, and the presence or absence of maternal depression.

Overall, the researchers saw no relationship between BPA exposure and externalizing behaviors such as aggression and hyperactivity. However, when they analyzed the data by gender, they found that girls exposed to higher levels of BPA (particularly at 16 weeks of gestation) were more aggressive than less-exposed girls.

“Consistent with our findings,” they say, “some animal studies have shown that prenatal BPA exposure is associated with increased aggression, changes in the dopaminergic system in the limbic forebrain, and other neurobehavioral changes.”

“Prenatal bisphenol A exposure and early childhood behavior,” Joe M. Braun, Kimberly Yolton, Kim N. Dietrich, Richard Hornung, Xiaoyun Ye, Antonia M. Calafat, and Bruce P. Lanphear, *Environmental Health Perspectives*, October 2009 (epub prior to print publication). Address: Bruce Lanphear, 3415 Ash Street, Vancouver, BC V5Z 3E5.



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Elevated lead levels in young U.S. children: calculating the long-term cost to society

Reducing blood lead levels in U.S. children between the ages of birth and six years to less than one microgram per deciliter (mcg/dL) could save society an average of \$50,000 per child annually, a new study suggests.

The paper, by Peter Muennig, used data from multiple studies to analyze the effects of lead levels on criminality and high school graduation rates and calculate downstream effects on earnings, crime-related costs, health, and welfare dependency. Data on children's lead levels came from the 1999-2006 National Health and Nutrition Examination Surveys (NHANES).

Muennig notes that 17 million of the 24 million children six years of

age or younger in the United States have blood lead levels of one mcg/dL or higher. He says, "If current trends continue, we would expect

Overall, Muennig says, reducing children's lead levels to less than one mcg/dL would add more than a trillion additional dollars to the economy during these children's lifetimes.

68% of these children to ultimately graduate from high school on time. This rate would increase to 91% if none of these children had a blood lead level higher than one mcg/dL. Each of these additional high school graduates could reasonably be expected to realize earnings at

least \$11,500 higher per year than if they had not graduated from high school and would use \$691 less per year in administrative overhead for welfare programs." Moreover, he points out, these additional high school graduates would have a better health-related quality of life and a lower mortality rate. "Finally," he says, "lower exposures to lead in childhood would reduce the mean per person social cost of crime in the United States by \$399 per year."

As a result, he says, reducing children's blood lead levels to less than one mcg/dL would add more than a trillion additional dollars to the economy during these children's lifetimes.

Government standards currently place the threshold for lead toxicity
continued on page 7

Quotable....

"Fetal Alcohol Syndrome has had an odd place in criminal law. Once involved in the legal system, many people with FAS/FAE [Fetal Alcohol Effects] lack the ability to follow through on tasks in either a timely or reasonable fashion. Their ability to retain information is often compromised and they will commonly give whatever answer is 'on the top of their head' or what they think is wanted. It is difficult for many professionals in the legal system to understand these problems and limitations as people with FAS/FAE often 'sound' or 'look' competent, capable, and rational The courts are not likely to recognize and understand FAE and thus, are likely to impose detention/institution time rather than appropriate services."

Robin LaDue and Tom Dunne, in The Challenge of Fetal Alcohol Syndrome: Overcoming Secondary Disabilities, edited by Ann Streissguth and Jonathan Kanter, University of Washington Press, 1997

Diet boost early in life helps pretermers' IQ in teen years

Offering preterm infants even a few weeks of dietary intervention can boost their IQ scores well into the teen years, a new study reports.

Elizabeth Isaacs and colleagues analyzed data on 49 preterm infants (born at 30 weeks of gestation or less) who received a special high-nutrient diet for about four to six weeks after birth, comparing them to 46 preterm children who received a standard-nutrient diet. The children were a subgroup from a larger study conducted by a coauthor of the current paper. The high-nutrient diet used in the initial study included approximately 40% more protein and 20% more energy than the standard diet.

The current follow-up included only children considered neurologically normal. Isaacs and colleagues report that at the age of eight years, "the high-nutrient

group had higher mean verbal, performance, and full-scale IQ scores compared with the standard-nutrient group." The verbal IQ difference persisted at the age of 16, with the high-nutrient group showing a seven-point advantage.

The researchers say that the verbal IQ difference is particularly important "because verbal IQ is strongly related to academic achievement." In particular, the high-nutrient group did better in tests measuring semantic processing and memory.

—
"Early diet and general cognitive outcome at adolescence in children born at or below 30 weeks gestation," Elizabeth B. Isaacs, Ruth Morley, and Alan Lucas, *Journal of Pediatrics*, Vol. 155, No. 2, August 2009, 229-34. Address: Elizabeth B. Isaacs, Childhood Nutrition Research Centre, UCL Institute of Child Health, 30 Guilford Street, London WC1N 1EH, UK, e.isaacs@ich.ucl.ac.uk.

Studies show that kids with conduct disorder, delinquency have trouble reading expressions

Two new studies build on previous research indicating that problems in recognizing emotions may play a role in the antisocial behavior of many children and teens.

In the first study, Graeme Fairchild and colleagues evaluated 42 teens between 14 and 18 years of age with early-onset conduct disorder (CD), 39 with adolescence-onset CD, and 40 teens with no history of serious antisocial behavior or psychiatric problems. The researchers tested participants' ability to recognize facial expressions of anger, disgust, fear, happiness, sadness, and surprise. In addition, they evaluated the teens' ability to recognize unfamiliar faces. The study excluded participants with IQs lower than 75.

The researchers report, "Relative to controls, recognition of anger, disgust, and happiness in facial expressions was disproportionately impaired in participants with early-onset CD, whereas recognition of fear was impaired in participants with adolescent-onset CD." Participants with high scores on psychopathy were more impaired in recognizing fear, sadness, and surprise than those with few or no psychopathic traits. No differences were seen in the test measuring recognition of unfamiliar faces, showing that this skill did not affect participants' ability to recognize expressions.

Fairchild and colleagues say their findings are consistent with suggestions that antisocial behavior may involve deficits in the function of the orbitofrontal cortex. The behavioral similarities between individuals with CD and those who develop sociopathic behaviors after injury to this brain region, they say, "suggest that subtle orbitofron-

tal damage or dysfunction may be present in the former group, which would potentially be reflected in deficits in anger and disgust recognition."

In a related study, Wataru Sato and colleagues used a similar test to compare the facial recognition abilities of 24 incarcerated male delinquents to those of non-delinquent males. The researchers found that the delinquents were significantly more likely than the controls to misinterpret expressions of disgust as anger.

The researchers say their data and similar findings from other studies "suggest that delinquents might be projecting their own heightened angry emotions onto others when they misperceive others' negative, but not hostile, emotional states as anger." They note that while both angry and disgusted expressions cause negative reactions in observers, "angry expressions induce higher arousal than do disgusted expressions" and may imply that an attack is going occur. Thus, they say, the delinquents' misinterpretation of expressions "might result in anticipation of relatively more dangerous behavior on the part of the sender than

would accurate recognition."

Editor's note: See related article in Crime Times Vol. 13, No. 1, 2007, page 5.

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"Deficits in facial expression recognition in male adolescents with early-onset or adolescence-onset conduct disorder," Graeme Fairchild, Stephanie H. M. Van Goozen, Andrew J. Calder, Sarah J. Stollery, and Ian M. Goodyer, *Journal of Child Psychology and Psychiatry*, Vol. 50, No. 5, May 2009, 627-36. Address: Graeme Fairchild, Developmental Psychiatry Section, Cambridge University, Douglas House, 18b Trumpington Road, Cambridge, CB2 8AH, gff22@cam.ac.uk.

—and—
"Misrecognition of facial expressions in delinquents," Wataru Sato, Shota Uono, Naomi Matsuura, and Motomi Toichi, *Child and Adolescent Psychiatry and Mental Health*, September 18, 2009 (epub prior to print publication; open access online). Address: Wataru Sato, Department of Comparative Study of Cognitive Development, Primate Research Institute, Kyoto University, Kanrin, Inuyama, Aichi 484-8506, Japan, L50158@sakura.kudpc.kyoto-u.ac.jp.

—and—
"Face off: Misunderstood expressions facilitate adolescent aggression," news release, BioMed Central, September 17, 2009.

High lead levels in children: calculating the cost to society (continued from page 6)

at 10 mcg/dL. However, research by Bruce Lanphear and colleagues has revealed a consistent inverse relationship between blood lead levels and IQ even at levels under five mcg/dL.

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"The social costs of childhood lead exposure in the post-lead regulation era," Peter Muennig, *Archives of Pediatric and Adolescent Medicine*, Vol. 163, No. 9,

September 2009, 844-49. Address: Peter Muennig, Department of Health Policy and Management, Mailman School of Public Health, Columbia University, 600 W. 168th St., 6th Floor, New York, NY 10032, pm124@columbia.edu.

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QUOTABLE "In 1997, Adrian Raine and Lori LaCasse, then at the University of Southern California (USC) in Los Angeles, and their colleague Monte Buchsbaum from Mount Sinai School of Medicine in New York published one of the first explanations of the neurobiology of homicide. Among the brains of 41 murderers pleading not guilty by reason of insanity, they found lower activity (as measured by glucose metabolism) in the prefrontal cortex, and greater activity in structures in the limbic system, thought to drive aggression, than they found in non-murderous brains. 'Put crudely, murderers don't have the prefrontal resources to regulate that unbridled emotional output,' says Raine."

—Dan Jones, "Human behaviour: killer instincts," Nature News, 2008

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