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Psychopathy and instrumental aggression: Evolutionary, neurobiological, and legal perspectives

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Psychopathy and instrumental aggression: Evolutionary, neurobiological, and legal perspectives

Abstract
In the study of aggression, psychopathy represents a disorder that is of particular interest because it often involves aggression which is premeditated, emotionless, and instrumental in nature; this is especially true for more serious types of offenses. Such instrumental aggression is aimed at achieving a goal (e.g., to obtain resources such as money, or to gain status). Unlike the primarily reactive aggression observed in other disorders, psychopaths appear to engage in aggressive acts for the purpose of benefiting themselves. This is especially interesting in light of arguments that psychopathy may represent an alternative life-history strategy that is evolutionarily adaptive; behaviors such as aggression, risk-taking, manipulation, and promiscuous sexual behavior observed in psychopathy may be means by which psychopaths gain advantage over others. Recent neurobiological research supports the idea that abnormalities in brain regions key to emotion and morality may allow psychopaths to pursue such a strategy—psychopaths may not experience the social emotions such as empathy, guilt, and remorse that typically discourage instrumentally aggressive acts, and may even experience pleasure when committing these acts. Findings from brain imaging studies of psychopaths may have important implications for the law.

Keywords
Psychopathy, Neurobiological, Evolutionary, Aggression

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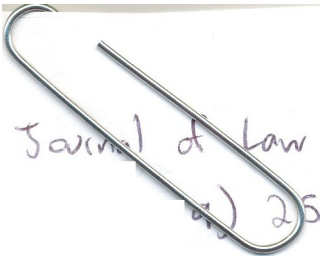

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Psychopathy and instrumental aggression: Evolutionary, neurobiological, and legal perspectives

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ABSTRACT

In the study of aggression. psychopathy represents a disorder that is of particular interest because it often involves aggression which is premeditated. emotionless. and instrumental in nature; this is especially true for more serious types of offenses. Such instrumental aggression is aimed at achieving a goal (e.g.. to obtain resources such as money. or to gain status). Unlike the primarily reactive aggression observed in other disorders, psychopaths appear to engage in aggressive acts for the purpose of benefiting themselves. This is especially interesting in light of arguments that psychopathy may represent an alternative life-history strategy that is evolutionarily adaptive; behaviors such as aggression, risk-taking, manipulation, and promiscuous sexual behavior observed in psychopathy may be means by which psychopaths gain advantage over others. Recent neurobiological research supports the idea that abnormalities in brain regions key to emotion and morality may allow psychopaths to pursue such a strategy-psychopaths may not experience the social emotiohs such as empathy, guilt, and remorse that typically discourage instrumentally aggressive acts, and may even experience pleasure when committing these acts. Findings from brain imaging studies of psychopaths may have important implications for the law.

t. Introduction

Psychopathy is a disorder involving a pronounced lack of guilt, remorse. and empathy (Hare, 2003). Psychopaths are said to be impervious to the distress of others. They also lack fear of negative consequences of risky or criminal behavior and demonstrate insensitivity to punishment (Patrick, 1994). In addition, psychopaths are often described as superficially charming, glib, manipulative, conning, and grandiose (Cleckley, 1941); they are often able to take advantage of others because they first present as likeable and well-meaning. However, these individuals often display severe aggression and high rates of criminal recidivism (Hare, 2003), making the study of psychopathy an especially important issue for the criminal justice system.

2. Psychopathy and instrumental aggression

A unique feature of psychopathy is that it is associated with an increased risk for instrumental aggression (Blair, 2007b).*Instrumental* aggression, also referred to as proactive or predatory aggression, is controlled, purposeful, and used to achieve a desired external goal (e.g., to obtain money or drugs). Injury to others is typically secondary to the acquisition of some other goal. Instrumental aggression tends to be premeditated and is not preceded by a strong emotional reaction. In other disorders such as schizophrenia or bipolar disorder, increases in aggression tend to be relatively more *reactive* in nature. Reactive aggression is impulsive and emotion-driven acts in response to threat or provocation (e.g.. in the context of a heated argument) (Meloy, 1988, 1997). The classification of individuals or acts as reactively and instrumentally aggressive is not mutually exclusive - individuals may engage in both types of aggression, and singular acts may contain elements of both types of aggression. Psychopathic individuals demonstrate reactive aggression in addition to instrumental aggression (Flight & Forth, 2007; Hare, 2003; Reidy, Zeichner, Miller, & Martinez, 2007); however, it is their proneness to instrumental aggression that may distinguish them from other antisocial individuals, and may have the most serious implications.

Several studies have demonstrated that psychopathic criminals are more likely to engage in predatory violence, while non-psychopathic violent criminals are more likely to engage in reactive violence (Meloy, 1988, 1995; Serin, 1991; Williamson, Hare, & Wong, 1987). This is especially true for what are typically considered more serious types of offenses, such as serious sexual assault or homicide. Less serious offenses, such as theft or burglary, are likely to be committed at similar rates by non-psychopathic individuals. Williamson et al. (1987) examined characteristics of violent offenses and found that psychopathic offenders were much.more motivated by material gain or revenge (45.2% of violent acts) than non-psychopathic offenders

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(14.6% of violent acts). Furthermore, psychopaths were less likely to have experienced emotional arousal during their crimes than non-psychopaths (2.4% compared to 31.7% of violent acts). Woodworth & Porter (2002) found that psychopathic individuals were about twice as likely to have committed primarily instrumental homicides as non-psychopathic offenders. In fact, 93.3% of homicides committed by psychopathic offenders were instrumental in nature, compared with 48% of those by non-psychopathic offenders; again, psychopaths were found to rarely commit violent crimes under intense emotional arousal. Cornell et al. (1996) found that offenders who had committed at least one act of instrumental violence were more psychopathic, specifically with respect to pathological lying, manipulativeness, superficiality, lack of empathy, exhibiting a parasitic lifestyle, irresponsibility, and criminal versatility. In addition, instrumental offenders demonstrated more violent criminal behavior. A higher proportion of spousal abusers who were classified as instrumentally aggressive were found to be psychopathic compared to spousal abusers classified as being reactively aggressive (Chase. O'Leary,& Keyman, 2001). Based on these studies. it appears that violent aggression committed by psychopathic individuals is more likely to be instrumental in nature.

There is some evidence that psychopathic traits in non-incarcerated populations may also be associated with increased instances of unprovoked aggression. In a study by Nouvion, Cherek. Lane,Tcheremissine, and Lieving (2007), subjects recruited from a large, urban community participated in a laboratory-based computer task that involved opportunities to subtract points from a partner in provoked and unprovoked conditions. Participants were classified as instrumental, reactive only, or nonaggressive. The study found that individuals who demonstrated instrumental aggression scored higher in psychopathy than individuals in the other two groups (nonaggressive and reactive only). However, it should be noted that the instrumental group may have also exhibited reactive aggression; this was not measured. In a different study, Rilling et at. (2007) examined the behavior of undergraduates playing an iterated Prisoner's Dilemma game, in which a player has the option to cooperate with a partner to earn money, or to defect. and attempt to benefit at the partners expense. Undergraduates scoring higher on a psychopathy measure were more likely to disrupt patters of mutual cooperation by defecting; such unprovoked defection allowed these individuals to earn money at the expense of their partner and could be viewed as a form of instrumental aggression. These studies provide some evidence that variation in psychopathic traits within community samples may also be associated quantifiable increases in instrumentally aggressive acts.

Several studies of youth with psychopathic traits have also found increased rates of instrumental aggression. Adolescent offenders who had committed instrumentally motivated violence were found to score higher in psychopathic traits (Loper, Hoffschmidt, & Ash, 2001). Similarly, instrumentality of prior violence was significantly correlated with psychopathy scores in another group of adolescent offenders (Murrie, Cornell, Kaplan, McConville, & Levy-Elkon, 2004). Kruh, Frick, and Clements (2005) found that young adults with any history of unprovoked violence had higher psychopathy scores than participants who had a history of reactive violence only. Finally, delinquent adolescents who had engaged in prior instrumental violence scored significantly higher in psychopathy than those classified as never instrumental. Furthermore, psychopathy scores were found to be significantly associated with the amount of instrumental violence of an individual (Flight & Forth, 2007). However, it should be emphasized that psychopathy scores were also associated with increased reactive aggression. These studies suggest that instrumental aggression is evident in youth with psychopathic traits, and therefore may result from factors early in life.

Psychopathy is comprised of a constellation of features which have been grouped into two inter-related factors, one describing interpersonal and affective features, and a second describing the impulsive and antisocial features (Hare, 2003). These factors can be further divided into four subfacets: Interpersonal (Facet 1). including superficial charm, manipulativeness, and pathological lying; Affective (Facet 2), including a lack of guilt and empathy, blunted emotions, and callousness; Impulsive Lifestyle (Facet 3), including stimulation-seeking and impulsivity; and Antisocial (Facet 4), including criminal behavior (Hare, 2003). Some studies have found instrumental aggression to be more strongly associated with the lnterpersonal/ Affective factor of psychopathy, whereas reactive aggression demonstrates stronger relationships with the lmpulsive/ Antisocial features. Woodworth and Porter (2002) found significant relations for both psychopathy factors with instrumental aggression; however, partial correlations revealed a unique relationship only with the Interpersonal/ Affective factor. Porter, Birt, and Boer (2001) found that psychopathic murders scored higher on the Interpersonal/Affective factor, whereas non-psychopathic murders showed higher scores on the lmpulsive/ Antisocial factor. In adolescent offenders, the Interpersonal/ Affective factor, but not the Lifestyle/Antisocial factor, was found to be associated with increased likelihood of instrumental violence (Flight & Forth, 2007). Similarly, in incarcerated youth with psychopathic traits, the interpersonal facet was found to relate most strongly to instrumental violence *(Vitacco,* Newmann, Caldwell, Leistico, & *Van* Rybroek, 2006). In male undergraduates, Reidy et al. (2007) found that instrumental aggression on a laboratory aggression task was uniquely related to the Interpersonal/Affective factor of psychopathy. In contrast, reactive aggression was associated with both the lnterpersonal/ Affective factor and the Impulsive Lifestyle/Antisocial factor. Together these studies suggest that instrumental aggression is not exclusively related to the Interpersonal/Affective factor of psychopathy, but is more strongly associated with that factor.

A notable feature of the instrumental aggression of psychopaths is that the ultimate goal is for personal gain. Woodworth and Porter (2002) provide an example of one psychopathic inmate who carefully planned and murdered his wife in order to benefit financially from her insurance policy. Psychopaths have been described as individuals who prey on others across the lifespan (Hare, 1998). The use of aggression to serve a selfish function could be thought of as evidence for the idea that psychopathy is an evolutionarily adaptive strategy.

3. Psychopathy as an evolutionary strategy

Several researchers have explored the idea that psychopathy represents an alternative evolutionary strategy consisting primarily of "cheating" behaviors (Barr & Quinsey, 2004; Crawford & Salmon, 2002; Mealey, 1995; Raine, 1993). In this view, the emotional, cognitive, and behavioral features of psychopaths are seen as specified, organized mechanisms which facilitated a viable reproductive social strategy during human evolutionary history (Crawford & Salmon, 2002). Instrumentally aggressive behaviors such serious theft, rape, and homicide are all means by which psychopaths may cheat, taking advantage of others in order to gain status, resources, and to pass on genes with minimal effort (Raine, 1993). Psychopathic traits such as glibness and superficial charm may allow them to take advantage of others through manipulation and conning. Some evidence suggests that psychopaths may maximize reproductive fitness by pursuing a strategy involving early and high mating effort involving short-term, uncommitted relationships with multiple partners. Psychopathy has been associated with an increased number of sexual partners (Halpern, Campbell, Agnew, Thompson, & Udry, 2002; Lalumiere & Quinsey, 1996), engaging in sexual behavior at an earlier age (Harris, Rice, Hilton, Lalumiere, & Quinsey. 2007), an uncommitted approach to mating. increased mating effort and sexual coercion (Lalumiere & Quinsey, 1996), many short marital relationships, sexual promiscuity (Hare, 2003), and poor performance as parents (Cleckley, 1976).

At low frequencies in the population, psychopaths may be able to successfully maintain cheating as an evolutionarily adaptive strategy. Harpending and Sobus (1987) used game theory research to show

that cheaters can achieve reproductive success when they are difficult to detect, are highly mobile, are verbally facile, and are skilled at persuading females to mate. Many of the features of the personality of psychopaths seem to describe characteristics that would be important in pursuing an evolutionary strategy of cheating. Being manipulative, conning, and glib, not experiencing empathy, guilt, or remorse, being risk-taking and sensation seeking, and engaging in instrumental, goal-directed aggression are all ways that psychopaths may gain advantage.

Successfully pursuing a strategy that primarily involves cheating behavior may require one or both ofthe following elements: (1) a lack of emotions that normally guide moral behavior (Raine & Yang, 2006b) and (2) reward or pleasure from causing harm to others (Porter & Woodworth, 2006). Regarding the first element, without the experience of emotions such as guilt or remorse, psychopaths may easily engage in aggressive or manipulative behaviors with little fear or concern for potential consequences. They may be less hindered by concern for the pain and distress that their actions cause others, and thus able to employ strategies that maximize the benefits for themselves. Woodworth and Porter (2002) suggested that the high rates of instrumental homicides committed by psychopaths may be due to a lack of empathy, which serves as a deterrent for instrumental violence. In support of this, Flight and Forth (2007) found that scores on a measure of empathy were lower in delinquent adolescents who had engaged in instrumental violence; these scores accounted for 12% of the variance in instrumental violence.

Regarding the second element, psychopaths may also be driven to engage in instrumental behavior because of the pleasure that they take in causing others to suffer. It has been suggested that psychopaths may derive gratification or enjoyment from their violent behavior, and may be driven by thrill seeking or sadistic interests (Porter & Woodworth, 2006). In a study of psychopathy and the types of aggression used by homicidal offenders during the crime, Porter, Woodworth, Earle, Drugge, and Boer (2003) examined both gratuitous violence, defined as excessive violence beyond the level necessary to complete the homicide, and sadistic violence, defined as evidence of enjoyment or pleasure from the violence. Homicides committed by psychopaths showed higher levels of both gratuitous and sadistic violence. Further evidence of a link between sadism and psychopathy comes from a study by Holt, Meloy, and Strack (1999) showing that psychopathy is associated with increased sadistic personality traits. There is also evidence of increased rates of sexual aggression in psychopaths; psychopathy has been found to be associated with an increased risk for sexual violence (Kosson, Kelly, & White, 1997). Both adolescent and adult sexual homicide offenders have been found to have moderate to high rates of psychopathy (Meloy, 2000; Myers & Blashfield, 1997). Some evidence suggests that the violence of psychopaths may reflect thrill seeking motives; psychopathy has been associated with more severe violence in the commission of sexual offenses (Gretton, McBride, Hare, O'Shaugnessy, & Kumka, 2001) and the targeting of a wider range of victims, suggesting that they do not specialize in the way that paraphilic offenders do (Porter et aI., 2000), but rather may take advantage of opportunities as they arise. Finally, there is also evidence that psychopathic demonstrate sexual arousal to deviant visual and auditory stimuli (Serin, Malcolm, Khanna, & Barbaree, 1994), suggesting they may be more likely to derive pleasure from the suffering of others.

Recent neurobiological research is beginning to support the idea that psychopaths may not experience emotions that typically serve to guide morally appropriate behavior - structural and functional differences have been observed in brain regions key to emotion and morality (Raine and Yang, 2006a). Although less neurobiological research has been done to examine pleasure as a motivation for the criminal behavior of psychopaths, a few studies are beginning to support this hypothesis. This research will be discussed in the following section.

4. The neurobiology of psychopathy

The evolution of moral behavior has shaped the functioning of several neural structures (Moll, de Oliveira-Souza, & Eslinger, 2003). Recent brain imaging studies have begun to explore the neural correlates of moral decision-making (e.g., Greene, Nystrom, Engell, Darley, & Cohen, 2004; Harenski & Hamann, 2006; Moll et aI., 2003; Robertson et a!., 2007). Many of the structures identified appear to also be associated with psychopathy (Raine & Yang, 2006a). One such area is the prefrontal cortex, specifically the orbitofrontal region. In moral decision-making, the orbitofrontal cortex may be important in integrating moral knowledge with emotional cues (Moll, Oliveira-Sousa, Bramati, & Grafman, 2002). understanding the emotional states of others *(Vollm* et al., 2006), and inhibiting antisocial impulses (Brower & Price, 2001). Yang et at. (2005) found a 22.3% reduction in prefrontal gray matter in a group of psychopaths with prior convictions. Functional brain imaging studies have observed reduced activity associated with psychopathy in the orbitofrontal region of the prefrontal cortex during fear conditioning (Birbaumer et aI., 2005; *Viet* et aI., 2002) and during a socially interactive game (Rilling et aI., 2007). Lesion studies have demonstrated that early damage to the orbitofrontal cortex often leads to several psychopathic characteristics, including pathological lying, irresponsibility, promiscuous sexual behavior, shallow affect. and a lack of guilt or remorse (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999). Regarding aggression, it appears that abnormalities in the orbitofrontal cortex may primarily contribute to the increases in reactive aggression that have been observed in psychopathy, as it has not been associated with increased instrumental aggression (Blair, 2007b).

Abnormal structure and functioning in the prefrontal cortex has not been observed in all studies of psychopathic or instrumentally aggressive individuals. In a study of predatory (instrumental) and affective murderers, Raine et al. (1998) found that prefrontal glucose metabolism of predatory murders was similar to controls, whereas prefrontal metabolism in affective murderers was significantly reduced. They suggest that predatory murderers may have good prefrontal functioning to be able to regulate their impulses and carefully plan their crimes. Yang et al. (2005) found that individuals who were psychopathic but had not received prior convictions had similar volumes of the prefrontal cortex to controls, whereas those with prior conviction, as noted above, demonstrated reduced prefrontal gray matter. Although both studies measured the prefrontal cortex as a whole, and did not distinguish subregions, it appears that some psychopathic individuals may exhibit good prefrontal functioning that allows them to carefully plan crimes and avoid being caught.

Further evidence comes from several functional imaging studies that have observed *increased* activation specifically in the dorsolateral region of the prefrontal cortex in psychopaths during tasks that involve emotional processing (Gordon, 2004; lntrator et aI., 1997; Kiehl et aI., 2001; Rilling et aI., 2007). As the dorsolateral cortex is an area involved in higher cognition, it has been suggested that psychopaths may use more cognitive resources to process affective information than non-psychopaths (Kiehl et aI., 2001).

In subcortical regions, brain imaging studies of psychopathy have revealed structural and functional abnormalities in the amygdala. Reduced volume of the amygdala has been reported in a study of psychopathic individuals (Yang, Raine, Narr, Lencz, & Toga, 2006). In several fMRI studies, reduced activity in the amygdala has been associated with psychopathy during the processing of emotional stimuli (Kiehl et aI., 2001), during fear conditioning (Birbaumer et aI., *2005; Viet* et aI., 2002), during an affect recognition task (Gordon, 2004). and during a socially interactive game (Rilling et aI., 2007). Psychopathy was also found to be associated with reduced amygdala functioning during moral decision-making about emotional moral dilemmas (Glenn, Raine, & Schug, 2009). It has been suggested that reduced functioning of the amygdala may be most likely to contribute

to the increased risk for instrumental aggression in psychopathy (Blair, 2007b). The amygdala is crucial in the formation of stimulus-reinforcement associations, which are important in fear conditioning and may be particularly relevant to socializing children so that they learn to avoid actions that might harm others (Blair, 2007a). Without having learned these associations, psychopathic individuals may be undeterred from engaging in acts that benefit themselves at the expense of others.

In addition to the amygdala, abnormalities have also been observed in other subcortical regions such as the hippocampus. Laakso et at. (2001) found psychopathy to be negatively correlated with the volume of the posterior hippocampus. Raine et al. (2004) found abnormal structural hippocampal asymmetries in psychopaths with prior convictions. Hippocampal dysfunction may result in affect dysregulation, poor contextual fear conditioning, and insensitivity to cues predicting capture (Raine et aI., 2004). The hippocampus has dense interconnections to both the amygdala and prefrontal cortex, which are also implicated in psychopathy, so it may have an effect on and be affected by the functioning in these structures.

Other areas that have been implicated in psychopathy include the anterior and posterior cingulate and the angular gyrus. Reduced functioning in the anterior cingulate has been observed in psychopaths during fear conditioning (Birbaumer et aI., 2005; *Viet* et aI., 2002), during an affective memory task (Kiehl et aI., 2001), and during the processing of emotional information (Muller et aI.,2003). The anterior cingulate is closely connected with the amygdala and is involved in emotional processing. Reduced functioning of the posterior cingulate has also been observed in psychopaths during an affective memory task (Kiehl et aI., 2001). The posterior cingulate may be important in the recall of emotional memories (Maratos, Dolan, Morris, Henson, & Rugg, 2001), the experience of emotion (Mayberg et aI., 1999), and self-referencing (Johnson et aI., 2006). Deficits in the angular gyrus (Le., posterior superior temporal gyrus) have been found in psychopathic and antisocial individuals during a semantic processing task (Kiehl et at., 2004); it has been suggested that the angular gyrus is important in complex social cognition and linking emotional experiences to moral appraisals (Moll, Oliveira-Souza, Eslinger, 2002). Because the left angular gyrus it is also involved in reading and arithmetic, impairments in this region may help account for the poorer school and occupational failure of antisocial and psychopathic individuals (Raine et aI., 1997).

Finally, a structural imaging study by Raine et at. (2003) found increased volume of the corpus callosum in psychopathic individuals. The corpus callosum is the major connection between the two hemispheres. Recently, Hiatt and Newman (2007) found that the time required to transfer information from one hemisphere to the other is significantly prolonged in criminal psychopaths compared to criminal non-psychopaths. This effect was more pronounced in right-handed response conditions, which are controlled by the left hemisphere. They suggest that impaired connectivity between hemispheres may cause functions primarily mediated by the left hemisphere (e.g. approach behavior and language processing) to be relatively unmodulated by functions mediated predominantly by the right hemisphere (e.g., behavioral inhibition and emotion processing) and vice versa (Hiatt & Newman, 2007).

Regarding the association between psychopathy and reward-motivated crime, there is some initial neurobiological research that may suggest that antisocial individuals may demonstrate increased activity in the striatum, a brain region associated with reward processing. Despite its association with reward-seeking and impulsivity, the striatum has received very little attention in the study of antisocial behavior, and has not been the focus of any psychopathy study to date. Perhaps the most notable piece of evidence is a recent study by Decety, Michalska, Akitsuki, and Lahey (2009), in which adolescents with aggressive conduct disorder demonstrated increased activity in the striatum when viewing images of other individuals in painful situations. The authors suggest that the activity observed in this reward-related region may indicate that these individuals enjoy seeing victims in pain. This, in concert with reduced amygdala and ventromedial prefrontal cortex functioning, may contribute to their aggressive behavior. Structurally, increased volume of the striatum or its subregions has been observed in men with antisocial personality disorder (Barkataki, Kumari, Das, Taylor, & Sharma, 2006) and adolescents and adults with aggressive behavior (Amen, Stubblefield, Carmichael, & Thisted, 1996). Future research on the structure and function of the striatum in psychopathy specifically is needed to determine whether this may be a region that may contribute to the pleasure-driven motivations of psychopaths.

5. Implications

Taken together, neurobiological evidence suggests that there are differences in the brains of psychopaths compared to normal individuals, particularly in regions that are important in guiding moral behavior. Reduced functioning in regions important in generating emotions such as fear, guilt, and empathy may mean that psychopaths are undeterred from harming others to gain advantage. At the same time, increased functioning in regions associated with reward may lead psychopaths to take pleasure in causing harm to others. In addition, learning based on both reward and punishment information may be disrupted, which may impair socialization.

Although psychopathic individuals have typically been found to be insensitive to treatment attempts, research on the neurobiological abnormalities observed in psychopathy may provide new possibilities for future treatment. One possibility may be to try to alter the functioning of some of the brain regions implicated in psychopathy, such as the amygdala or striatum. This may be accomplished either pharmacologically, by focusing on hormone or neurotransmitter systems, or behaviorally through therapy. Another method that has been shown to directly alter brain functioning is repetitive transcranial magnetic stimulation (rTMS), a noninvasive technique that is used to stimulate the brain using strong, pulsed magnetic fields. Initial evidence has shown this method to be effective in altering the brain functioning and subsequent behavior of depressed patients (Schutter & van Honk, 2006). A similar technique may prove to be effective in altering the brain functioning of psychopathic individuals.

Neurobiological evidence, in combination with other risk factors, may eventually be able to aid in the identification of individuals who are at significant risk for future criminal behavior, which could have important implications for prevention and treatment. For example, children with neurobiological abnormalities could be entered into treatment programs designed to prevent antisocial behavior. However. the identification of individuals based on brain abnormalities carries with it many ethical issues; there are dangers of harm caused by labeling, miscategorization, and the potential misuse of such information to limit the freedoms of some individuals. Although neurobiological research has great potential to help with the prevention of crime. careful considerations should be taken regarding the use of such information.

The source of most of the neurobiological abnormalities discussed above is unknown, and may result from genetic, developmental, or environmental factors. Research into the causes of such abnormalities has tremendous potential for possible intervention methods. Changes to the early environment may be able to prevent abnormalities from developing. In addition, early knowledge of genetic risk factors for criminal behavior may allow caretakers to take special measures to reduce the instances of other risk factors to aggression, as it is often the combination of both biological and social risk factors that produce the most risk for aggression (Raine, 2002).

Findings that psychopathic individuals may demonstrate neurobiological abnormalities in regions that are important in guiding appropriate moral behavior present a new set of challenges to the

criminal justice system. If psychopaths lack a core moral sense, as observed by reduced activation in areas important in moral decision-making, are they to blame for their actions? Advances in neuroscience that have raised such ethical issues have resulted in the development of a new field termed "neuroethics" (Marcus, 2002). Farah (2005) points out that we would not blame Phineus Gage for his bad behavior resulting from physical damage to his ventromedial prefrontal cortex. If we can detect differences in the brains of psychopathic individuals, would this not be analogous to excusing the behavior of Gage?

We would argue that neurobiological impairments should be considered risk factors for antisocial behavior, similar to evidence from any other biological, psychological, or psychosocial source, but should not be over-interpreted as representing a causal, one-to-one relationship with behavior. An abnormality in a particular brain region does not imply that the abnormality was the cause of a specific behavior or crime. Rather, it should be taken into consideration as one of many factors, biological or social, that may increase an individual's risk for criminal behavior. However, given the present state of research in this area, the applicability of neurobiological findings to individual cases is very limited. Currently, the neurobiological studies of psychopathy involve examining differences between groups - the findings represent the average of many individuals and do not suggest that all psychopathic individuals exhibit a particular abnormality. Thus, applying this type of research on an individual case basis may be difficult to achieve reliably. It is this type of information that should be emphasized by scientists taking part in legal cases in order to ensure that brain imaging evidence is not over-interpreted in these settings. At some point in the future it may be possible to build up normative datasets so that significant differences in brain structure or functioning could be quantifiable, increasing the potential for use in courts.

Brain imaging evidence has already been implemented in over 130 court cases (Feigenson, 2006) and its use is likely to continue. Mobbs, Lau,Jones, and Frith (2007) have outlined some of the limitations to the use of brain imaging courts: first, brain imaging cannot tell what a person was thinking at the time of an action; second, information about brain functioning represents only one source of information regarding influences on behavior; third, the interpretation of brain scans on an individual basis is subjective and individually variable; and finally, brain imaging evidence currently lacks diagnostic and predictive validity. In addition, Mobbs et al. and others (e.g. Farah, 2004) warn that the use of brain images in the courtroom may be too influential for jurors, who may view the brightly colored images as more accurate and objective than they actually are. Although these are limitations that should be taken into consideration, brain imaging evidence, when presented appropriately, may still be able to provide extremely valuable information in some cases. Ultimately, brain imaging evidence may have implications for cases involving the insanity defense, determining criminal intent, detecting deception by witnesses or defendants, or in determining the appropriateness of punishments such as the death penalty. However, a high level of communication between scientists and legal officials will be important in integrating findings from brain imaging research into the way society views, and deals with, criminal behavior.

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