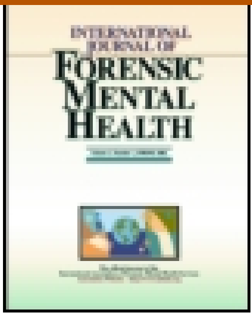

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Neuroscience in Forensic Psychiatry and Psychology: An Introduction to the Special Issue

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ABSTRACT

This special issue is dedicated to the potential role of neuroscience in forensic psychiatry and psychology. Although neuroscientific insights are increasingly incorporated in clinical practice, they received less attention in forensic mental healthcare and in the forensic mental health literature. In the last decade there has been an increased interest in using neuroscientific knowledge in the assessment and treatment of psychopathology related to antisocial and violent behavior. Consequently, neuroscientific methods may, for example, be used in detecting psychiatric problems in defendants, one of the topics covered by the scientific field of *neurolaw*. This current article introduces this special issue by providing an introduction to the neurobiology of antisocial and criminal behavior and will set off discussing how neuroscientific insights may be used in forensic clinical practice.

KEYWORDS

Neuroscience; neurolaw; neurobiology; antisocial behavior

Although neuroscientific insights are increasingly incorporated in clinical mental health practice, these have been somewhat neglected in forensic mental healthcare. Recent developments in neuroscience not only have led to increased knowledge about the etiology of psychopathology, but it has also contributed to an increased awareness of the potential role of neuroscience in forensic psychiatry and psychology. For instance, neuroscientific methods may be used for detecting psychiatric problems in defendants. This is one of the topics covered in the emerging new scientific field of *neurolaw*. Additionally, there is an increased interest in using neuroscientific knowledge concerning the assessment and treatment of psychopathology related to antisocial and violent behavior. And although neurolaw has gained more and more interest in English-speaking countries, Garcia-López and colleagues (this issue) shown their review article, that in Latin America, no *empirical* study on this topic is published yet. They state that, at least in Latin America, there is a need for more work on this topic of neurolaw. Because of a need of more work on neurolaw in certain countries and the fact that insights from neurolaw are emerging and developing, this current special issue is dedicated to the topic of neuroscience in forensic psychiatry and psychology.

In the last decade, opportunities, threats, and limitations of the introduction of neuroscience in forensic psychiatry and psychology have been previously discussed in the literature (Buckholtz & Faigman, 2014; Dror, 2015). For this special issue on neuroscience in forensic psychiatry and psychology of the *International Journal of Forensic Mental Health*, we included both research and theoretical papers covering a broad domain of topics such as ethical considerations of the use of neuroscience in forensic mental health, neurobiological correlates of aggression, and neuroscience in forensic psychiatric examination.

This special issue aims to present the current status and add to the current empirical and theoretical knowledge on the promises and pitfalls of neuroscience in forensic psychiatry and psychology. By introducing this special issue, we would like to provide a short introduction to the neurobiology of antisocial and criminal behavior and discuss how neuroscientific insights may be used in forensic clinical practice. We want to stress that this is not a complete overview, but we will address some timely issues in the research area of "Neuroscience in Forensic Psychiatry and Psychology."

Neurobiological mechanisms of antisocial behaviour

"Antisocial behavior" is an overarching term, which is often operationalized in most neurobiological studies

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by regarding offenders as prototypical criminals. Although this approach results in useful information with regard to antisocial behavior in general, it seems preferable to further subdivide antisocial behavior into better defined subgroups. Research has demonstrated that different subgroups of antisocial individuals and behaviors are associated with different neurobiological correlates (see Brazil, van Dongen, Maes, Mars, & Baskin-Sommers, 2018). Brazil and colleagues postulate that using latent biocognitive factors underlying transdiagnostic processes, for example cognitive control, could be used in classifying different types of antisocial individuals.

Nevertheless, previous research has focused on antisocial individuals more broadly by looking at antisocial individuals and psychopathic individuals. Also, previous neuroscientific research largely focused on research on aggression/violence and psychopathy/antisociality. In the following paragraphs, different neuroscientific findings with respect to antisocial behavior and aggression in general, and to psychopathic personality more specifically will be discussed.

Relevant brain regions

Psychopathy is associated with various structural aberrations in particularly in both gray and white matter of the frontal and temporal regions of the brain. This corresponds with the functional imaging literature, showing that most robust functional aberrations occur in the frontal (i.e., vmPFC and OFC) and temporal (i.e., the amygdala) regions (Koenigs, Baskin-Sommers, Zeier, & Newman, 2011). In recent years, indications for a striatal dysfunction in psychopathy have also emerged (see Murray, Waller, & Hyde, 2018 for a review).

With respect to psychopathic personality and aggressive behavior, several studies (see Blair, 2005) have shown that the frontal lobe is less active in psychopaths, leading to disinhibited behavior and subsequently to aggression. Imaging studies have also shown that these regions of the frontal and temporal lobes are associated with dysfunctional empathy and moral decision making in psychopathy (Glenn, Raine, & Schug, 2009; Yoder & Decety, 2018).

Neurotransmitters and hormones

Antisocial and aggressive behavior has traditionally been associated with serotonin, cortisol and testosterone levels (Montoya, Terburg, Bos, & Van Honk, 2012). Previous research has shown that there is substantial evidence for reduced cortisol levels (in combination with higher levels of testosterone, Terburg, Morgan, & Van Honk, 2009) to be associated with antisocial behavior, especially when confronted with stressful situations. There are also indications that the serotonin system is not in equilibrium in this group. Serotonin seems to enables a more effectively control over aggression and impulsivity. For example, serotonin reuptake inhibitors reduce aggression and impulsivity in individuals with psychopathic tendencies (Coccaro, Sripada, Yanowitch, & Phan, 2011), but there is also some criticism about this presumed effectiveness (Dadds & Rhodes, 2008; Rodrigo, Rajapakse, & Jayananda, 2010).

Evidence regarding the role of testosterone in aggression is found to be inconsistent. Although there is a clear relationship between testosterone and aggression in laboratory animals, it hardly seems to account for aggressive behavior in humans. A meta-analysis shows that the relationship between testosterone and aggression is very weak (Book, Starzyk, & Quinsey, 2001). However, there are indications that it is the combination of low serotonin levels and high testosterone/cortisol ratio that could result in higher levels of aggression (Glenn & Raine, 2008; Terburg et al., 2009). For example, research (Higley et al., 1996) has shown that although monkeys with a low serotonin level displayed higher levels of aggression, the frequency and intensity of their aggression particularly increased when this was combined with high testosterone levels.

Heritability

With regard to vulnerability to antisocial behavior, a meta-analysis (Ferguson, 2010) shows that genetic influences can account for the major part (56%) of antisocial behavior, unique non-genetic influences (such as brain injuries and infections) for a third, and shared, non-genetic influences (such as upbringing) for only a small part (11%). There is strong evidence that genetic factors, at least to a degree, are key in explaining individual differences in antisocial behavior. Although a large number of genes are associated with antisocial/psychopathic behavior, the MAOA (monoamine oxidase) and 5HTT (serotonin transporter) genes in particular seem to be candidate genes that are involved in antisocial behavior (Baskin-Sommers, 2016; Glenn, 2011; Gunter, Vaughn, & Philibert, 2010), because of their involvement in relevant cathecholamines such as serotonine and dopamine.

Furthermore, the catechol O-methyltransferase (COMT) enzyme plays a major role in modulating dopamine levels in the PFC, and therefore is found to be associated with subtypes of antisocial behavior, depending on the functional dysregulation associated with these subtypes (Hirata, Zai, Nowrouzi, Beitchman, & Kennedy, 2013; van Dongen, van Schaik, Van Fessem, & Van Marle, 2018).

Neurocognitive mechanisms of antisocial behaviour

Cognitive control

Studies among various populations show that poor cognitive control is associated with aggressive behavior (Wilkowski & Robinson, 2007), and violence-related offenses (Piquero, MacDonald, Dobrin, Daigle, & Cullen, 2005). Violent delinquents have a reduced capacity to suppress undesirable responses (Chen, Muggleton, Juan, Tzeng, & Hung, 2008). It might be helpful to make a relevant distinction between premeditated and impulsive delinquents, since research (Raine et al., 1998) showed that the prefrontal cortex function of impulsive murderers was suboptimal. However, the prefrontal cortex function of premeditated murderers did not show any aberrations. It is clear that cognitive control is a function of the prefrontal cortex and that the prefrontal cortex, in particular the orbitofrontal region, of people prone to aggressive behavior shows less activity (Wilkowski & Robinson, 2007). This suggests that the prefrontal cortex of people displaying antisocial behavior functions in a suboptimal way.

Attentional processes

Another neurocognitive line of research concerns the study of attention in delinquents. Here the assumption is that an impaired attentional function is an important contributor to aggressive and antisocial behaviors. Several studies have indeed shown that aggressive people pay more attention to hostile stimuli (e.g., angry faces) than non-aggressive persons (Wilkowski & Robinson, 2007). In other words, aggressive behavior is related to an attentional bias for hostile or aggressive stimuli. It also appears that persons who have been convicted of a violent offense have an attentional bias for aggressive stimuli. Similarly, a study published in this special issue by McDonagh, Travis, and Bramham (this issue) shows that individuals diagnosed with attention-deficit/hyperactivity disorder (ADHD) and higher levels of anger, have for instance more difficulties in shifting attention. This overall positive relation between anger/hostility and attention and could be interpreted as an over-sensitivity to aggressive stimuli (Chan, Raine, & Lee, 2010). Such an attentional bias is also observed in sexual violence as it has been found that people who commit sexual violence pay an excessive amount of attention to stimuli related to this violence (Price & Hanson, 2007).

On the other hand, there is evidence that psychopathic personality is associated with a reduced affective attention bias. That is, studies in youth with callous-unemotional traits were found to show reduced attentional bias towards threatening stimuli (Kimonis, Graham, & Cauffman, 2018; Kosson, McBride, Miller, Riser, & Whitman, 2018). Also interesting, the study by Tillem and Baskin-Sommers (this issue) shows that offenders with psychopathic traits display greater inhibitory devaluation, meaning that they ascribe more negative valence to stimuli that are irrelevant to their goal. They argue that they findings support the relevance of attentional abnormalities in psychopathic individuals.

Reward processing

Lykken's (1995) theory regarding psychopathy states that secondary psychopaths (i.e., psychopathy as an indirect consequence of stress and negative emotions) are more sensitive to rewards. However, the empirical evidence for this view is rather mixed. People with impulsive-antisocial traits seem to be more motivated to seek out rewards. This is shown by higher levels of dopamine release in the nucleus accumbens and increased neural activity in the reward anticipation phase (Buckholz et al., 2010). However, research has also shown that the caudate nucleus of Cluster B patients (e.g., borderline and antisocial personality disorder) is hypoactivated in response to a small reward (Völlm et al., 2007). This rather seems to suggest a relative insensitivity to small financial rewards. Persons with antisocial personality traits, like addicts, may continually seek out "strong" stimuli that stimulate their reward system because this system is relatively insensitive to small, natural rewards.

In addition, various aspects of antisocial behavior and psychopathic personality have been related to a hypersensitive/hyperreactive response to reward in the brain (see for example, Buckholtz et al., 2010). For example, studies have shown that aggressive behavior can result from a frustrating situation, i.e., the emotional state that results from the omission of an expected reward (Blair, 2010). Although this has yet to be properly studied, it is quite conceivable that psychopaths run an increased risk of ending up in frustrating situations as a result of the previously mentioned aberrations in the frontal and temporal regions (Blair, 2010).

Also, studies found differences reward processing using EEG in individuals scoring higher and lower on psychopathic traits (Salim, van der Veen, van Dongen, & Franken, 2015), and that antisocial and psychopathic individuals have difficulties in monitoring and incorporating error-related feedback in learning (Brazil et al., 2009, 2011; von Borries et al., 2013). These findings suggest a deficit in early attentional processing and updating context in reward and punishment processing. These deficits might explain why individuals with high psychopathic traits show difficulties in adapting to the environmental changes when the motivational goals are not met.

Empathy and mentalizing

With respect to harmful behavior posed by antisocial and/or psychopathic individuals, avoiding harm to others requires an understanding of how much pain others may feel as a consequence of one's actions. A number of functional neuroimaging studies have demonstrated that attending to the pain of others leads to activation in brain regions that are also engaged during the first-hand experience of pain (see Lamm and Majdandžić (2015) and Zaki, Wager, Singer, Keysers, and Gazzola (2016) for a critical discussion of this topic), including the anterior insula (AIC), anterior mid and dorsal anterior cingulate cortex (ACC), and periaqueductal gray (for a meta-analysis see Lamm, Decety, & Singer, 2011).

While most neuroscientific studies on empathy included fMRI measures, recent work has pointed out that empathy can be studied adequately using electroencephalography (EEG). Studies investigating event-related potentials (ERPs) of the EEG related to empathy in psychopathy have mostly been limited to the assessment of pain-related empathy (see Cheng, Hung, & Decety, 2012; Decety, Lewis, & Cowell, 2015). In these studies, it is found that individuals with higher levels of psychopathic traits, show reduced amplitudes of the relevant ERPs when they watch pain stimuli. Recently, van Dongen, Brazil, van der Veen, and Franken (2018) added to these findings by showing that individuals scoring higher on meanness traits (a psychopathic trait the most associated with a lack of empathy) showed lower amplitudes of the ERPs when they viewed victims in aggression scenes. These electrophysiological findings suggest that individuals with psychopathic traits have altered affective empathic responding to stimuli depicting pain and aggression interactions with victims.

The role of neuroscience in clinical practice

Neurocognitive classification of antisocial individuals and interventions

One of the leading theoretical frameworks in forensic mental health and risk assessment and management in particular is the "What Works" principle (Andrews, 1995). This approach can provide tools for optimizing interventions within the forensic system and the judicial setting in general. This principle is based on the assumption that a person can be treated if certain interventions fit in well (i.e., Responsivity) on the criminogenic factors (i.e., Needs) of a person to lower the factors that lead to a higher risk (Risk) (Risk-Need-Responsivity Model; Andrews, Bonta, & Hoge, 1990). The idea is that when a specific intervention matches the specific criminogenic needs of a detainee, the treatment intervention is actually effective for that detained person. In addition, the risk of recidivism will also decrease.

In mental health care, including within the correctional setting, it is common to assess persons psychologically on the basis of overt behavior. For example, on the basis of certain "symptoms" one is divided into categories (for example certain mental disorders according to the DSM-5) and the treatment is then tailored to that classification. However, some authors postulate that a different classification, one based on biocognitive factors on different levels, might be more effective, because it is necessary that interventions connect with latent (underlying) biocognitive mechanisms (Brazil et al., 2018). The principle that the (detained) person must be "susceptible" (responsivity principle) to certain treatment that is tailored to his or her needs would be much more effective. Neuroscientific insights can thus be used to uncover the risks and needs in individuals that can be used to improve the responsivity in risk assessment and management.

To illustrate the above need for neurocognitive profiles, Shumlich, Reid, Hancock, and Hoaken (this issue) show that the executive function profiles of forensic patients is different from correctional offenders and a normative sample. This illustrates the need for neurocognitive assessment and its consequences for offenders' needs and responsivity to treatment.

Yet another article published in this current special issue (Fielenbach, Donkers, Spreen, & Bogaerts, this issue), reports pilot data showing some evidence for the use of neuro-feedback in forensic patients with an addiction. Although the findings are preliminary, it does support the need for examining neurobiological based interventions in forensic settings.

Neurocognitive risk assessment/neuroprediction

Meta-analytic work has shown that risk assessment tools have a positive likelihood ratio (pLR: the ratio of the likelihood of a positive prediction for those who do to those who do not subsequently offend) ranging from approximately 3.5–8 (Singh, Grann, & Fazel, 2011). Attempts at prevention are more likely to succeed when they are based on accurate predictions of who will engage in violence and under what circumstances. However, our ability to accurately identify individuals who pose a future threat to society has been very limited until recently. New insights into the neurobiological correlates of antisocial behavior (see above paragraphs) have generated interest about the potential utility of neuroscientific methods for predicting future violent behavior (Nadelhoffer & Sinnott-Armstrong, 2012), and the use of neuroscientific information in forensic assessment and in the courtroom. This is illustrated by Noyon, van der Wolf, Mevis, and van Marle (this issue), who examine how neuroscientific information can be used in forensic assessments and in court, by using the Dutch legal system as an example (for a more general discussion of the use of neuroscientific and genetic evidence in the courtroom, see Farahany, 2016). However, a study by Kempes, Berends, Duits, and van den Brink (this issue) shows that during the last years, neurobiological information is not increasingly used in Dutch pretrial forensic reports and in considerations for future risk and risk management in adolescent and young adult offenders. They argue that it is important that forensic expert do take into account neurobiological information more often when conducting pretrial forensic reports.

As mentioned above, another way in which neuroscience could add to forensic practice, would be by *neuroprediction* (see Poldrack et al., 2018, for a recent review). To date, only two studies directly examined the predictive utility of neuroimaging data for future rearrest. In one study, Aharoni et al. (2013) included 96 adult offenders were tested before release on a go/no-go task using fMRI, and the relation between task-related activity in the anterior cingulate cortex (ACC) and rearrests over up to 4 years was examined. The results showed that the odds that an offender with relatively low anterior cingulate activity would be rearrested were approximately double that of an offender with high activity in this region, holding constant other observed risk factors. A further analysis reported prediction accuracy of this finding (Aharoni et al., 2014) using a receiver operating characteristic (ROC) analysis and bootstrap resampling to estimate and correct for shrinkage (over-optimism bias). It provided additional support for the utility of neurobiological measures in predicting rearrests (but see also Poldrack et al., 2018).

In the other study, Kiehl et al. (2018), demonstrate the utility of using brain-based measures of cerebral aging to predict recidivism. It has been shown that age is one of the best predictors of antisocial behavior, and risk models of recidivism often combine chronological age with demographic, social and psychological features to aid in judicial decision-making. In the study by Kiehl et al. (2018), independent component analyses (ICA) and machine learning techniques were used to developed a brain-age model that predicted chronological age based on structural MRI data from incarcerated males ($n=1332$). Subsequently, they test the model's ability to predict recidivism in a new sample of offenders with longitudinal outcome data ($n=93$). They found that inclusion of brain-age measures of the inferior frontal cortex and anterior-medial temporal lobes (i.e., amygdala) improved risk prediction models when compared with models using chronological age; and models that combined psychological, behavioral, and neuroimaging measures provided the most robust prediction of recidivism.

Of course there are also some pitfalls when applying neuroscientific research to legal settings, one of which is known as the "group to individual" (G2i) problem (Faigman, Monahan, & Slobogin, 2014), which has its roots in a key difference between the goals of science and the legal system. Science is focused on characterizing generalizable phenomena to establish mechanistic explanations that apply within definable population groups and, hence, are generalizable to other members of those populations (who may not yet have been observed). By contrast, law is concerned with making concrete and definitive determinations about particular individuals and circumstances (Treadway & Buckholtz, 2011). Thus, in science, individuals are generally incidental to the general insights they support, while, in law, the individual is paramount: group- or population-level scientific data are only relevant to the extent that the data bolster or weaken the evidence provided in an individual case. Unfortunately, however, observations about groups only rarely apply universally to their individual members, such that group-level findings may provide only very weak support for individual determinations.

Additionally, ethical considerations have to be taken into account. In the current special issue, these ethical objections are discussed by Jurjako, Malatesti, and Brazil (this issue). They argue for instance that the inappropriate use of biomarkers of antisocial behavior in the present context might lead to contributing to the so called "psycholegal fallacy." This is a phenomenon in which the identification of a biomechanical cause is used as an excuse for behavior (Aspinwall, Brown, & Tabery, 2012), and this would imply that nobody is accountable for his/her behavior. But dispute some ethical considerations that we have to take into account, Jurjako et al. (this issue) conclude that both classifications based on biocognitive factors as well as neuroprediction are found to have no basic ethical objections against it.

This special issue on neuroscience in forensic psychiatry and psychology

In this introductory article, we have briefly summarized neuroscientific findings with regard to antisocial behavior and also discussed possible clinical implications and utility of the use of neuroscientific data in forensic psychiatric and psychological practice.

Although we think that above mentioned practical implementations are very promising, as also mentioned, there are of course some pitfalls, and ethical considerations to take into account. Altogether, this special issue includes different types of articles (covered in the text above), including both empirical studies, theoretic papers, and review papers. Moreover, it is very interdisciplinary, covering law, ethics and neurosciences, and includes contributions ranging from West Europe, East Europe, North America, and South America, making it a very inclusive special issue on this topic.

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