Dysfunctional neurocognition in individuals with clinically significant psychopathic traits

Robert James R. Blair, PhD

The main goal of this review is to consider the main forms of dysfunctional neurocognition seen in individuals with clinically significant psychopathic traits (ie, reduced guilt/empathy and increased impulsive/antisocial behavior). A secondary goal is to examine the extent to which these forms of dysfunction are seen in both adults with psychopathic traits and adolescents with clinically significant antisocial behavior that may also involve callous-unemotional traits (reduced guilt/empathy). The two main forms of neurocognition considered are emotional responding (to distress/pain cues and emotional stimuli more generally) and reward-related processing. Highly related forms of neurocognition, the response to drug cues and moral judgments, are also discussed. It is concluded that dysfunction in emotional responsiveness and moral judgments confers risk for aggression across adolescence and into adulthood. However, reduced reward-related processing, including to drug cues, is only consistently found in adolescents with clinically significant antisocial behavior, not adults with psychopathy.

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Introduction

The term psychopathy characterizes an increased risk for antisocial behavior coupled with pronounced emotional deficits reflecting reduced guilt, remorse, and empathy. In children this emotional component is typically referred to as callous-unemotional (CU) traits. Children and youth with CU traits are at notably increased risk for meeting criteria for psychopathy as adults. Psychopathic traits are a source of considerable concern as they are associated with particularly heightened levels of aggression that may be less amenable to treatment than other factors increasing the risk for violence. The goal of this review is to consider the main neurocognitive impairments seen in individuals with clinically significant psychopathic traits. Given the necessity for brevity, several sections of the literature will not be considered: First, there will be no consideration of data from healthy participants who vary in levels of psychopathic traits. While it is useful to know the extent to which a form of pathology associated with specific symptoms is seen in healthy individuals, it is probably unwise to assume that data from healthy individuals is informative for understanding individuals with a clinically significant condition. The clearest example of the necessity for caution is provided by the literature relating reward responsiveness to impulsiveness (a core symptom of Attention Deficit-Hyperactivity Disorder [ADHD]). In a critical meta-analytic review of the literature, the authors concluded that, while increased str...
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Emotional processing

Emotional facial expressions

Emotional processing

Emotional facial expressions have a com m unicative function: they both m odulate ongoing behavior and allow the rapid transmission of valence information regarding objects and actions. This is seen, for example, in social referencing where the observer learns the value of a stimulus based on another individual’s emotional reaction to it (e.g., the negative value of a novel threat because the caregiver shows fear towards it). There has been a considerable amount of work that has investigated the processing of emotional facial expressions in adolescent and adult populations with psychopathic traits. This is related to suggestions that psychopathic traits might particularly relate to a reduced

Attention-based views, dominant in the 1980s and 1990s, and still very prominent today, will receive less attention but will be briefly considered.

The review will concentrate on two related main foci of the fMRI literature on clinically significant psychiatric traits, emotional and reward processing, and implications of these functions for responding to drug cues and moral judgements. Emotional/reward processing captures a series of highly interconnected regions including the amygdala, striatum, anterior insula, anterior cingulate/dorsal striatum, rostromedial, ventromedial front and posterior cingulate cortices (Figure 1). These regions in turn have a web of connections with other brain areas. The amygdala and striatum are particularly important for form s of rein forcement-based learning. Anterior insula and dorsal striatum are particularly important for representing the value (and possibly with respect to rostromedial frontal cortex, in particular, maintaining the value) of response choices.

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According to this view, such a reduced response should be associated with reduced learning to avoid actions that harm other individuals (the individual finds the “punishment” of the other individual’s distress less aversive) and thus reduced avoidance of the commission of actions that might harm other individuals.

Face stimuli are processed by a series of neural regions including those related to emotional processing listed above as well as temporal cortical regions (e.g., fusiform and superior temporal cortex) that are particularly involved in processing faces relative to inanimate objects. Many of these regions (e.g., the amygdala, anterior insula, and fusiform cortex) show stronger responses to emotional relative to neutral faces. Moreover, there are indications of regional specification regarding particular emotional expressions; the amygdala appears particularly responsive to fearful, sad, and happy expressions but not angry and disgusted expressions, while anterior insula cortex is particularly responsive to disgust and anger expressions.

Youth and adults with conduct problems, particularly those with psychopathic or CU traits, have been reported to show deficits in expression recognition, perhaps particularly for fearful, sad, and happy expressions, though this is debated. The impaired recognition of fearfulness and sadness is pervasive, applying also to vocal tones and body postures.

Youth with conduct problems, particularly when marked with psychopathic or CU traits, consistently show reduced responses to facial expression stimuli (particularly fearful and sad expressions) in emotional processing regions, including the amygdala. In a particularly interesting study, and consistent with theory, Lozier and colleagues revealed that the positive relationship between CU traits

Figure 1. Regions implicated in emotional and reward-related processing. These regions have been implicated as critical for specific functional processes and selectively interact to allow specific functional processes to occur. Studies have reported dysfunctional responses within these regions in adolescents with conduct problems and adults with psychopathy during emotional and reward-related processing.
and aggression was mediated by the reduced responsiveness of the amygdala to the distress of other individuals. Work with adults with psychopathy also reports similarly reduced BOLD responses in affect/face processing regions to facial expressions relative to comparison adults. However, only one of these studies specifically reported reduced amygdala responses.

In summary, the existing literature relatively reliably indicates reduced responsiveness to facial expressions, particularly distress cues, in children and adults with conduct problems that may be particularly marked in those with psychopathic traits. The regions implicated across studies are not always consistent—and the reduced amygdala responsiveness is seen much more in the work with adolescents than that with adults—but the basic finding of reduced neural responsiveness appears robust.

Pain stimuli
The facial expressions of another individual in pain can also be considered a distress cue. However, many studies examining responsiveness to the pain of another individual in individuals with psychopathic/CU traits have often used visual stimuli depicting painful events (a hand caught in a slam door) rather than facial expressions of pain. These are depictions of events associated with another individual’s pain, and require either interpretation or some association with the aversiveness of such events in the viewer’s past.

A series of studies have identified a “pain matrix”; a network of brain regions that respond to the sight of another individual in pain. These regions include the neural regions related to emotional processing listed above as well as supplem entary motor area (for a meta-analytic review of this literature, see ref 24). The activation of the supplementary motor area is interesting as it probably reflects activity relating to the association of the visual image with comparable events in the observer’s past.

It has been known for some time that individuals with psychopathy show reduced emotional (autonomic) responses to the sight of other individuals in apparent pain. Recent fMRI studies have examined the neural basis of this dysfunction in youth with conduct problems. These studies have reported that observing others in pain was associated with reduced activity within rostral medial/dorsomedial and anterior cingulate cortex, the amygdala and insula cortices and, though less often, the amygdala.

Emotional stimuli generally and the role of attention
In addition to the above evidence of reduced responding to emotional expressions and pain stimuli, there is some work indicating that responding during aversive conditioning and to emotional stimuli may be generally compromised in youth with callous and unemotional traits and adults with psychopathy. With respect to aversive conditioning, behavioral work has indicated that this is reduced in adults with psychopathy relative to comparison adults (i.e., reduced differentiation in autonomic responding between the stimuli associated with the punishment and the one not associated with the punishment) though findings in adolescents have been rather mixed. IMRI work has indicated that CU traits in youth and psychopathy in adults are associated with reduced amygdala and anterior cingulate responding. With respect to emotional responding, work has indicated that both youth with CU traits and adults with psychopathic traits show reduced responses to negative pictures within the amygdala, ventromedial frontal cortex, and other emotional-associated regions relative to comparison individuals.

The latter two studies, together with other work, are interesting because they indicate that attentional manipulations can, under certain circumstances, influence the extent to which individuals with psychopathic traits show reduced neural responses to emotional stimuli. Most of the studies...
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reviewed above, indicating reduced responsiveness, have used passive viewing conditions, or conditions where the participant is engaged in a low attentional load task such as gender identification. However, two studies revealed that any reduced responding to emotional images in adults with psychopathy was effectively “normalized” when the participants were explicitly asked to attend to the emotional content of the picture and classify the picture as emotional or nonemotional or enhance their emotional responding. A third study reported that this also occurred if participants were encouraged to “empathize” with the actors in a video. However, it should be noted that two further studies reported, in contrast, that the association with psychopathy and reduced responding to pain stimuli was most marked during the empathy for others condition.

These findings are of interest given views that psychopathy might reflect a problem in attention rather than emotion. The attention-based views effectively suggest that individuals with psychopathy attend to other features of the stimulus array than the emotional ones and thus show weaker responses to the emotional stimuli. Clearly, such a view is compatible with several of the above findings though inconsistent with others. Of course, an alternative speculation is that individuals with psychopathy do show reduced responding to emotional stimuli. However, if the intensity of this stim ulus is sufficiently heightened, via an attentional manipulation that increases the emotional stim ulus’ representational strength, group differences are reduced (because the individuals with lower psychopathic traits reach an asymptote level in responding). This latter view is also compatible with the absence of findings, indicating that individuals with higher psychopathic traits show heightened recruitment of regions implicated in top-down attention during passive viewing and other task manipulations.

Reward responsiveness

The second main focus of the fMRI literature on clinically significant psychiatric traits considered here is on reward responsiveness. There is a considerable animal and human literature on regions involved in responding to reward. An adequate review of this literature is beyond the scope of the current paper (see instead ref 38). However, the regions typically implicated are those previously considered with respect to emotional processing; eg, the amygdala, striatum, anterior insula, anterior cingulate/dorsal striatum, rostromedial prefrontal cortex, ventromedial frontal, and posterior cingulate cortices.

Two possibilities might be considered with respect to the impact of reward on antisocial behavior. First, excessive reward responses to objects in the immediate environment might increase impulsive behavior towards these objects, including aggression; or Second, reduced reward sensitivity/responsiveness, particularly within regions critical for the representation of long-term goals, should result in an individual who makes poorer decisions (response choices will be less well guided by goal-directed reward expectations). Such an individual is also more likely to be impulsive and more likely to become frustrated and aggressive as a function of their frustration.

Very little work supports the suggestion of increased reward responsiveness in adolescents with conduct problems/CU traits. One study reported increased striatal responsiveness to reward in a small sample of youth with externalizing difficulties relative to comparison youth while a second found that within a group of adolescents with conduct problem, increasing CU traits were associated with increased striatal responses to watching another win reward—though CU traits did not relate to reward responding when the participant won a reward (ie, there were no indications of heightened responsiveness for reward for the self). In contrast, a series of studies have reported that youth with conduct problem, some of whom also had elevated psychopathic traits, show reduced neural responsiveness to reward/reward omission within striatum and ventromedial prefrontal cortex.

However, most of this literature has not indicated a relationship between reward responsiveness and CU/psychopathic traits in particular. The only exception to this is a report of an inverse relationship between rostroventral striatal and ventromedial responses during reward anticipation and level of CU traits in a large adolescent sample.

The literature with adults is less clearcut. Three studies have reported that psychopathy, or antisocial personality disorder, were associated with increased reward responsiveness. These studies reported that: (i) psychopathy was associated with stronger subjective value-related activity within the nucleus accumbens during inter-temporal choice; (ii) individuals with antisocial personality disorder show increased responses in right orbitofrontal and subgenual cingulate

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cortices to the receipt of reward\textsuperscript{46}; and (iii) individuals with psychopathy show increased nucleus accumbens responses during reward anticipation.\textsuperscript{50} However, it is notable that this last result held only if the individuals with psychopathy were compared against healthy participants who scored below the healthy participant sample median for impulsivity on a personality measure. There were no group differences between those with psychopathy and healthy participants who scored above the healthy participant median for impulsiveness. Two further studies reported no group differences in reward responsiveness.\textsuperscript{51,52} Pujara and colleagues found no significant relationship between psychopathy and nucleus accumbens response to reward relative to neutral reinforcement.\textsuperscript{51} However, they showed a significant inverse relationship between psychopathy and loss relative to neutral reinforcement. Gregory and colleagues,\textsuperscript{52} similar to an earlier study with youth with psychopathic tendencies using the same reversal learning task,\textsuperscript{53} observed a failure in adults with psychopathy to suppress responding within posterior cingulate and insula cortex to unexpected punishment. Finally, an additional study reported diminished responding within rostral anterior cingulate cortex during high, relative to low uncertainty, choice conditions in a decision-making task.\textsuperscript{54}

In summary, the literature relatively clearly indicates that adolescents with conduct problems show reduced reward responsiveness, though whether this relates to severity of CU traits is less certain. Currently, the literature with respect to adults with psychopathy is currently equivocal.

Drug cues

One further way to examine the relationship between reward responsiveness and psychopathy is by examining the relationship between psychopathy and neural responsiveness to drug cues. Substance abuse is associated with a heightened response to drug reward cues and a diminished response to non-drug rewards within regions including dorsomedial prefrontal and anterior insula cortex and striatum, the amygdala but that this differentiation was decreased as a function of length of substance abuse within left dorsomedial prefrontal and right anterior insula cortex and striatum. Instead, individuals with higher psychopathic traits showed a decreasing differentiation in their drug vs food cues response within these regions. In short, this third study indicated a heightened differentiation in individuals with psychopathy in response to drug versus food cues within the right anterior insula cortex and the left amygdala but that this differentiation was decreased as a function of duration of drug use. This was seen within left dorsomedial prefrontal and right anterior insula cortex and striatum. In contrast to the previous two studies, this study reported that psychopathic traits were positively correlated with responsiveness to drug relative to food cues within the right anterior insula cortex and the left amygdala. However, only individuals with lower psychopathic traits showed an increasing differentiation in their response to drug vs food cues as a function of duration of drug use. This was seen within left dorsomedial prefrontal and right anterior insula cortex and striatum. Instead, individuals with higher psychopathic traits showed a decreasing differentiation in their drug vs food cues response within these regions. In short, this third study indicated a heightened differentiation in individuals with psychopathy in response to drug versus food cues within the right anterior insula cortex and the left amygdala but that this differentiation was decreased as a function of length of substance abuse within left dorsomedial prefrontal and right anterior insula cortex and striatum as a function of psychopathy level.

If psychopathy is associated with heightened reward responsiveness, one might predict that this learning would occur more rapidly and underlie the emergence of the substance abuse disorders which are often comorbid in this population.\textsuperscript{56} Individuals with psychopathy should show heightened responsiveness to drug cues. Alternatively, if psychopathy is associated with reduced reward responsiveness, one might predict that individuals with psychopathy should show reduced responsiveness to drug cues. The high comorbidity of psychopathic traits with substance abuse disorders would reflect dysfunction in systems representing anticipated rewards and punishments associated with their decision-making impairment.\textsuperscript{56}

Currently, only three studies have examined this issue. Two, one in an adult\textsuperscript{57} and the other in an adolescent\textsuperscript{58} sample, are clearly consistent with the second position. Both studies reported a negative correlation between psychopathic traits and neural response to drug versus neutral images within anterior cingulate cortex, amygdala, and striatum.\textsuperscript{57,58} The results of the third study were somewhat more complex.\textsuperscript{56} In contrast to the previous two studies, this study reported that psychopathic traits were positively correlated with responsiveness to drug relative to food cues within the right anterior insula cortex and the left amygdala. However, only individuals with lower psychopathic traits showed an increasing differentiation in their response to drug vs food cues as a function of duration of drug use. This was seen within left dorsomedial prefrontal and right anterior insula cortex and striatum. Instead, individuals with higher psychopathic traits showed a decreasing differentiation in their drug vs food cues response within these regions. In short, this third study indicated a heightened differentiation in individuals with psychopathy in response to drug versus food cues within the right anterior insula cortex and the left amygdala but that this differentiation was decreased as a function of length of substance abuse within left dorsomedial prefrontal and right anterior insula cortex and striatum as a function of psychopathy level.

In summary, the literature on responsiveness to drug cues has not clarified the situation with respect to reward responsiveness and psychopathy in adults. The Vincent et al\textsuperscript{59} study is consistent with the previous work with adolescent sample indicating reduced reward responsiveness as a function of conduct disorder/psychopathic traits.\textsuperscript{42-46} The results with adults are again relatively inconsistent.\textsuperscript{56,57}
Moral judgments
Moral judgments involve both emotional responses to the emotional content of the moral/imoral action and decisions making on the basis of this content. Youth with conduct problem and CU traits and adults with psychopathy are compromised in at least some form of moral judgment (for a more detailed review of the behavioral literature, see ref 59). While they typically show no difficulty in recognizing which acts are transgressions,60,61 they: (i) distinguish less in their permissibility judgments between acts that harm others relative to those that simply cause social disorder in the absence of rules60; (ii) endorse less such harm-based norms though their endorsement of social-disorder based rules remains intact62; and (iii) are more likely to allow actions that indirectly harm another.63

Moral judgments involve the recruitment of the regions depicted in Figure 1 (for a meta-analytic review of the moral judgment/MRI literature, see ref 64). Consistent with the behavioral findings, the fMRI literature has relatively consistently documented in studies using a variety of paradigms that youth and adults with CU/psychopathic traits show reduced responding within these regions during moral judgment tasks relative to comparison individuals.8,65-67

Conclusions
The two main goals of this review were to examine the main neurocognitive impairments seen in individuals with clinically significant psychopathic traits and the extent to which they were seen in adolescent and adult samples. Of course, the nature of the disorders in the populations identified in the research on adolescents relative to the research on adults. As noted above, the adolescent literature typically starts with the DSM diagnosis of conduct disorder and then may examine the influence of CU traits. The adult literature typically starts with the psychopathy checklist and may, on the basis of this, examine relationships with particular psychopathic factors (ie, the emotional factor 1 and the more antisocial/imulsive behavior factor 2). Importantly, though, despite these concerns it should by now be clear that the adolescent and adult literature, at least with respect to emotional responding, are consistent with one another. A population, seen in adolescents and adults, marked by high levels of aggression and disrupted empathy/guilt is associated with weaker responding to facial distress cues, indications of pain (perhaps particularly when these are represented as occurring to another individual) and emotional stimuli in the regions depicted in Figure 1. Moreover, a putative functional process thought to be reliant on this emotional processing, particularly appropriate responding to the distress others, moral judgment is disrupted in this population. This form of reasoning is likely increases the risk that these individuals will engage in antisocial behavior that harms others.

In conclusion, this review highlights two forms of dysfunctional neurocognition in psychopathy - Blair

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tion confers risk for aggression across adolescents and into adulthood. The second concerns reduced reward responsiveness. This is deficient in adolescents with significant conduct problem s and probably exaggerates their behavioral difficulties as a function of poor decision-making. It is likely deficient in at least some adults with conduct problem s but how pervasive this is the case and whether there is any relationship with psychopathy is currently unclear. 

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