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Impaired decision-making on the basis of both reward and punishment information in individuals with psychopathy

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Abstract

In this study, we examined decision-making to rewarding or punishing stimuli in individuals with psychopathy ($n = 21$) and comparison individuals ($n = 19$) using the Differential Reward/Punishment Learning Task. In this task, the participant chooses between two objects associated with different levels of reward or punishment. Thus, response choice indexes not only reward/punishment sensitivity but also sensitivity to reward/punishment level according to inter-stimulus reinforcement distance. Individuals with psychopathy showed significant impairment when choosing between objects associated with differential levels of reward but also significantly greater impairment when choosing between objects associated with differential levels of punishment. However, the two groups were comparably affected by inter-stimulus reinforcement distance. The results are discussed with reference to current models of psychopathy.

Keywords: Psychopathy; Decision-making; Reward; Punishment

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1. Introduction

Psychopathy is characterized by a callous, shallow and manipulative affective-interpersonal style combined with antisocial and reckless behavior (Hare, 1991). Individuals with psychopathy show little concern about the effects of their actions on other individuals or even themselves. They often commit impulsive, poorly planned crimes where the likelihood of being caught is high and fail to avoid behaviors which have previously been punished (Hare, 1991).

In line with this, research has indicated that individuals with psychopathy are impaired at learning about and appropriately responding to stimuli associated with punishment. Thus, they show impairments in aversive conditioning (Flor, Birbaumer, Hermann, Ziegler, & Patrick, 2002) and passive avoidance learning (Blair, Mitchell, Leonard, et al., 2004; Newman & Kosson, 1986). In addition, they show impaired augmentation of the startle reflex following visual threat primes (Levenston, Patrick, Bradley, & Lang, 2000), impaired recognition of negative affect emotional facial expressions (Blair, Mitchell, Peschardt, et al., 2004), and impaired skin conductance responses (SCR) to negative vocal expressions (Verona, Patrick, Curtin, Bradley, & Lang, 2004).

It is less clear whether individuals with psychopathy are comparably impaired in learning about and appropriately responding to stimuli associated with reward. They do show appropriate suppression of the startle reflex following a positive visual prime (Levenston et al., 2000), suggesting that the processing of appetitive information is intact in individuals with psychopathy. However, relative to comparison individuals, individuals with psychopathy present with reduced SCRs to positive auditory cues (Verona et al., 2004) and reduced interference from positive distracters on goal-directed processing (Mitchell, Richell, Leonard, & Blair, in press). In addition, individuals with psychopathy show a generalized reduction of the affect-driven facilitation for both positive and negative words in lexical decision (Kiehl, Hare, McDonald, & Brink, 1999; Lorenz & Newman, 2002; Williamson, Harpur, & Hare, 1991) and reduced affective priming for both positive and negative words (Blair et al., in press). These studies suggest that individuals with psychopathy are impaired in processing aversive and appetitive information.

Many studies have examined aversive and appetitive stimuli in a 'crystallized' form where the emotional learning about, and formation of, appetitive and aversive conditioned stimuli (CS) occurred prior to the study. These studies therefore are not informative regarding the ability of individuals with psychopathy to learn about reward and punishment information. In this paper we examine decision-making on the basis of reward/punishment associations learnt within the content of the study.

Emotional learning accounts of psychopathy make clear predictions regarding the ability of individuals with psychopathy to learn stimuli-punishment associations. Thus, accounts emphasizing the reduced ability to process punishing cues in individuals with psychopathy due to reduced anxiety or fear (Fowles, 1988; Lykken, 1957; Patrick, 1994) clearly predict that they should be impaired at learning stimuli-punishment associations but not necessarily stimulus-reward associations. However, Fowles has suggested that individuals with psychopathy 'show no deficit in reward learning' (Fowles, 1988, p. 377). These accounts then would predict that individuals with psychopathy show impaired response choice to stimuli associated with punishment but normal or superior response choice to stimuli associated with reward.

The Integrated Emotion System (IES) model can be considered an extension of the punishment positions (Blair, 2004). The model consists of a series of systems operating in specific integrated ways to perform specific tasks. The first of these systems (neural level: temporal cortex and hippocampus) consists of representational units coding potential CS. These units form weighted connections with affect units (neural level: the amygdala) representing reward and punishment. The affect units allow emotional learning to occur. The third system (neural level: the insula) stores the sensory valence representations. The fourth system (neural level: medial frontal cortex) receives information about the expected reward/punishment associated with a particular stimulus and allows decision-making between competing stimuli. Importantly, the computational properties of the 'selection' units within this fourth system suggest a clear prediction: error rates should be inversely related to inter-stimulus reinforcement difference. That is, participants should make more selection errors when deciding between stimuli associated with similar levels of reward/punishment than when deciding between stimuli associated with less similar levels of reward/punishment.

With respect to psychopathy, the main claim of the IES model is that individuals with psychopathy have impaired affect representations; i.e., they are impaired in learning stimulus-reinforcement associations. Within the model, the system that allows affect representations (the amygdala) represents both positive and negative affect. Indeed, there is considerable data that the amygdala is implicated in the processing of both positive and negative stimuli (Baxter & Murray, 2002). Two sets of predictions can be generated from the IES model with respect to psychopathy. The system for affect representations may be generally impaired leading to reduced processing of both appetitive and aversive material, or it may only be impaired for aversive representations leading to reduced processing of aversive, but not appetitive, material.

Given these contrasting sets of predictions from the emotional learning accounts of psychopathy, we designed a graded stimulus-reinforcement decision-making task: the Differential Reward/Punishment Learning Task (DRPLT). In this task, the participant chooses between two objects presented on a computer screen. The participants decisions can either involve two objects associated with different levels of reward, two objects associated with different levels of punishment or one object associated with reward and one object associated with punishment (see below). The participant has to choose the object that will gain the most points or, on trials involving two punishing objects, lose the least points. In our recent fMRI work, we have confirmed the involvement of the amygdala, anterior cingulate cortex, insula and medial frontal cortex in this task (Blair, Marsh, Morton, Drevets, & Blair, in preparation).

If individuals with psychopathy have reduced ability to learn stimulus-reward and stimulus-punishment associations, they should show a general impairment relative to comparison individuals for all three decision types. In contrast, if individuals with psychopathy are impaired only at associating stimuli with punishment, they should show impairment only when choosing between stimuli associated with different levels of punishment. In addition, if they are hyper-sensitive to appetitive stimuli, they should show improved response choice between two rewarding stimuli relative to comparison individuals. The current study tests these predictions.

2. Method

2.1. Participants

Participants were 40 adult males selected from a pool of 250 individuals residing in Category B (second highest security level) institutions in England. In accordance with the established criteria of the literature and the established guidelines of the PCL-R (Hare, 1991), individuals with a PCL-R score of 30 or above were included in the psychopathic group, while individuals with a PCL-R score of 20 or less were included in the comparison group. The Raven's Advanced Matrix-Set I (Raven, 1965) was used as an estimate of general intelligence and the National Adult Reading Test (NART) was used as an estimate of verbal intelligence. There was no significant group difference in either age, Ravens, or NART scores; see Table 1 for full participant details. The sample was made up of 31 Caucasian, seven Afro-Caribbean, and two Asian participants (five Afro-Caribbean participants in the psychopathic group, and two Afro-Caribbean and two Asian participants in the comparison group). In addition to satisfying PCL-R criteria for high and low levels of psychopathy, psychiatric files were screened for evidence of psychosis or neurological disorder (including head injury), and individuals who had received diagnoses for psychosis or organic brain damage were excluded from testing.

2.2. Measures

2.2.1. The Psychopathy Checklist-Revised (PCL-R) (Hare, 1991)

The PCL-R consists of 20 behavioral items and individuals can score between 0 and 2 on each item. PCL-R scores are typically obtained on the basis of a file review and a semi-structured interview but can also be reliably obtained from file notes alone (Hare, 1991; Wong, 1988). In this study, five participants (three psychopathic and two comparison) were unavailable for interview and were scored on the basis of file notes only. Participants were scored independently by two raters. Inter-rater reliability was established by means of a Spearman rank correlation. The correlation, $r_{\text{ranks}} = 0.94$ ($p < 0.001$), is similar to that reported in the literature (Hare, 1991).

2.2.2. The Differential Reward/Punishment Learning Task (DRPLT)

The DRPLT consists of 10 images each depicting a different object (house, cup, fork, duck, pineapple, necklace, raccoon, door, torch, or shoe) from the Snodgrass and Vanderwart picture set (Snodgrass & Vanderwart, 1980). To prevent systematic task interference from any existing valence attached to the objects (e.g., pineapple might have a preexisting positive valence), each

Table 1
Participant characteristics, SD, and ranges in brackets ()

Group	PCL-R	Age	Raven	NART
Psychopathic group ($n = 21$)	32.05 (2.16; 30–36)	36.71 (7.52; 22–51)	8.15 (2.03; 3–11)	22.43 (9.06; 9–45)
Comparison group ($n = 19$)	7.81 (4.48; 1.65–16)	32.16 (9.13; 22–50)	7.53 (2.48; 4–12)	23.16 (7.54; 15–36)

PCL-R = Psychopathy Checklist-Revised; NART = national adult reading test.

object was randomly assigned a value (−1600, −800, −400, −200, −100, 100, 200, 400, 800, or 1600) before the participant began the task (i.e., not every participant received 1600 points for choices of the shoe for example). During the task, the objects were presented together in pairs, appearing in two of four different locations positioned around the middle of the screen. At the viewing distance of 60 cm, the visual angle was 10 arc min horizontally and 12 arc min vertically. The participant was told that on each trial one of the two objects must be chosen, and that some objects would result in losing points and that some objects would result in winning points. Following object selection (with the click of a mouse), its assigned value was revealed. Thus, choosing the object assigned the value 100 resulted in the feedback: 'You have WON 100 points'. Conversely, choosing the object assigned the value −100, resulted in the feedback: 'You have LOST 100 points'. Feedback stayed on the screen for 1000 ms and was then replaced by the two objects for the subsequent trial (see Fig. 1 for example trial). There was no time limit for making a response.

Although participants were told how many points they have won or lost on any one trial, they did not receive feedback as to whether their object choice was correct or incorrect. For example, in Fig. 1 choosing the raccoon for 100 points would be an incorrect response even though the participant won points because they could have won more points by choosing the duck. At the end of the study participants were told how many points they had accumulated.

All objects were paired with each other, leading to three task conditions: Reward/Reward (RewRew), Punishment/Punishment (PunPun) and Reward/Punishment (RewPun). In the RewRew condition, both objects were associated with reward (see Fig. 1 for example stimuli involving a RewRew trial). In the PunPun condition, both objects were associated with punishment. Finally, in the RewPun condition, one object was associated with reward and one object

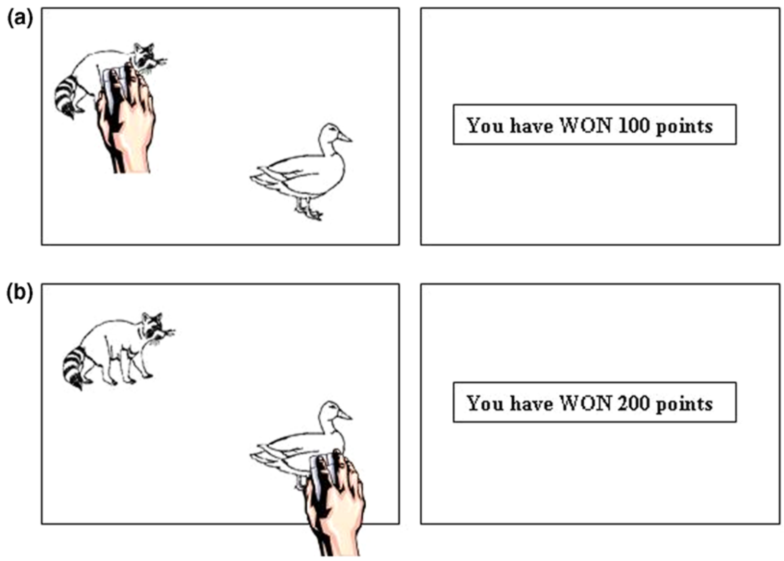

Fig. 1. Example of RewRew trial. Choosing either object results in a point reward. However, whereas choosing the raccoon results in a gain of 100 points, choosing the duck results in a gain of 200.

was associated with punishment. Again, the participant's goal was to choose the object that will gain them the most points or lose them the least points.

In addition to the three overall task conditions, the task also involved different inter-stimulus reinforcement distances (e.g., 100 vs. 200; 100 vs. 800). The point distance was divided into three different object-reinforcement distances: Far (e.g., 100 vs. 1600); Medium (e.g., 100 vs. 400), and Close (e.g., 100 vs. 200). The task therefore involved a 2 (Group: psychopathic vs. comparison) by 3 (Trial type: RewRew, PunPun, RewPun) by 3 (Distance: Far, Medium, Close) design. The DRPLT was programmed in VisualBasic and presented on a Dell Inspiron 8100 laptop.

2.3. Procedure

Each participant was tested individually in a quiet interview room within the institution. Following written consent, each participant was presented with the DRPLT presented within a larger neuro-cognitive test battery. The duration of the study was approximately 22 min for each participant.

3. Results

On any trial, choosing the superior object over the more inferior object was scored as 'correct'. Thus, on RewRew trials where both objects represented a gain (e.g., 100 and 200), choosing the object representing the greater gain of 200 would be correct. On PunPun trials where both objects represented a loss (e.g., −100 and −200), choosing the object representing the smaller loss of −100 would be correct. Finally, on RewPun trials where one object represented a gain and one a loss (e.g., −200 and 200), choosing the object representing a gain of 200 would be correct. The data points pertaining to the first time any object was presented were excluded from the analysis. As there were more RewPun trials than either RewRew and PunPun trials, participants' error scores were converted into error percentages.

A 2 (Group: psychopathic vs. comparison) by 3 (Trial type: RewRew, PunPun, RewPun) by 3 (Distance: Far, Medium, Close) ANOVA was conducted on the data. There was a significant main effect of trial type ($F(2, 76) = 19.13$; $p < 0.001$; $\eta_p^2 = 0.34$); participants committed a significantly greater number of errors PunPun trials relative to RewRew trials and on RewRew trials relative to RewPun trials ($p < 0.005$); (M[PunPun] = 15.69; s.e. = 1.78, M[RewRew] = 10.88;

Table 2
Percentage of errors committed by the two groups on the PunPun, RewPun, and RewRew trials with s.e. in brackets ()

Group	PunPun	RewPun	RewRew
Psychopathic group ($n = 21$)	22.43 (2.46)**	8.82 (1.84)*	13.33 (2.11)*
Comparison group ($n = 19$)	8.94 (2.58)	4.01 (1.94)	8.42 (1.94)

** $p < 0.001$; * $p < 0.05$ one-tailed. The significance levels pertain to differences between the groups on the PunPun, RewPun, and RewRew conditions.

Table 3
Percentage of errors committed by the two groups on the three different inter-stimulus reinforcement distances with s.e. in brackets ()

Group	Close	Medium	Far
Psychopathic group ($n = 21$)	16.84 (1.83)	14.10 (1.98)	13.64 (1.91)
Comparison group ($n = 19$)	9.27 (1.92)	7.02 (2.08)	5.08 (2.01)

s.e. = 1.53), (M[RewPun] = 6.42; s.e. = 1.34). There was also a significant main effect distance ($F(2,76) = 10.41$; $p < 0.001$; $\eta_p^2 = 0.22$), with the linear contrast being significant ($F(1,38) = 21.51$; $p < 0.001$; $\eta_p^2 = 0.36$); the number of errors increased as the inter-stimulus reinforcement distance decreased; (M[Far] = 9.36; s.e. = 1.39, M[Medium] = 10.56; s.e. = 1.44), (M[Close] = 13.05; s.e. = 1.33); see Table 3. The main effect of group was also significant ($F(1,38) = 8.88$; $p < 0.005$; $\eta_p^2 = 0.19$); the psychopathic group committed a significantly greater number of errors on this task relative to the comparison group (M[psychopathic group] = 14.86; s.e. = 1.79, M[comparison group] = 7.13; s.e. = 1.88).

Importantly, there was also a group by trial type interaction ($F(2,76) = 5.52$; $p < 0.01$; $\eta_p^2 = 0.13$). As can be seen in Table 2, while the psychopathic group overall committed more errors relative to the comparison group, the two groups in particular differed on the number of errors committed on the PunPun condition. This impression was confirmed by planned comparisons. Thus, while the psychopathic group showed significantly greater impairment on all three conditions relative to the comparison group, this difference was particularly significant for PunPun trials; see Table 2. In addition, the psychopathic group presented with considerably greater difficulty with PunPun trials relative to RewRew trials ($F(1,20) = 13.19$; $p < 0.005$; $\eta_p^2 = 0.40$); (Psychopathic group: M[PunPun trials] = 22.43; s.e. = 2.46, M[RewRew trials] = 13.33; s.e. = 2.11). In contrast, the comparison group did not ($F < 1$; ns); (Comparison group: M[PunPun trials] = 8.94; s.e. = 2.58, M[RewRew trials] = 8.42; s.e. = 1.94). There was no significant distance by group, trial type by distance or trial type by distance by group interaction. In short, while the individuals with psychopathy showed general impairment on the task, their impairment was particularly marked for PunPun trials. In addition, the effect of inter-stimulus reinforcement distance impacted comparably on the two groups.

3.1. Correlational analyses with PCL-R Factor 1, PCL-R Factor 2, and total PCL-R score

Factor analyses of the PCL-R have revealed a two factor structure (e.g., Harpur, Hakstian, & Hare, 1988) although other factor solutions have also been offered (e.g., Cooke & Michie, 2001). We used correlational analyses to examine the relationships between performance on respectively the RewRew, RewPun and PunPun trials and score on the constituent factors of the PCL-R. This revealed a significant relationship between both Factor 1 and Factor 2 and number of PunPun errors ($r = 0.442$ and 0.405, $p < 0.005$ and 0.05 respectively). Neither factor correlated significantly with number of RewRew or RewPun errors. A multiple regression using both factors to predict PunPun errors revealed that a model including only Factor 1 score accounted for the data ($p < 0.005$). The inclusion of Factor 2 information did not improve predictive power.

4. Discussion

This study investigated response choice to stimuli associated with reward/punishment in individuals with psychopathy. Individuals with psychopathy showed impaired response choice and this impairment was particularly marked when they had to choose between two stimuli that engendered punishment.

Emotional learning models of psychopathy (Blair, 2004; Fowles, 1988; Lykken, 1957; Patrick, 1994) all suggest that individuals with psychopathy are impaired at learning to associate stimuli with punishment. These models therefore predict the observed impaired decision-making in the individuals with psychopathy on the PunPun trials. Moreover, these data are consistent with other demonstrations of impaired stimulus-punishment association formation in individuals with psychopathy (Blair, Mitchell, Leonard, et al., 2004; Newman & Kosson, 1986).

The emotional learning models of psychopathy differ in their predictions regarding the ability to choose between stimuli associated with different levels of reward in psychopathy. Some variants suggest that only punishment processing is impaired (Lykken, 1957) or that reward-related processing may be superior in individuals with psychopathy (Fowles, 1988). Our data support neither of these variants. We found that individuals with psychopathy were impaired at choosing between stimuli associated with reward (although this impairment was less marked than that for stimulus choice associated with punishment).

Alternatively, there have been suggestions that psychopathy is associated with generalized affective deficits (Hare, 1998) or problems with "somatic marker" formation/use (Damasio, 1994). While the current data do suggest general disruption of affect representations in psychopathy, the impact was greater for aversive stimuli. Moreover, considerable data demonstrates that the affect impairment in psychopathy can be highly selective; i.e., impairment is seen when reinforcement information is used in the context of stimulus-reinforcement association formation but not stimulus-response association formation (see Blair, 2004). With respect to the somatic marker hypothesis in particular, it is worth noting that several predictions generated by the model regarding the incidence of instrumental aggression and the absence of aversive conditioning impairment have not been supported (see Blair, 2004).

It is also worth considering the current results in the context of the response modulation hypothesis (Newman, 1998). According to this hypothesis, the poor performance of individuals with psychopathy on emotional learning tasks is related to their inability to shift attention from their goal of responding to gain reward to the punishment information. It could be argued that this position should predict impaired performance only when the individuals with psychopathy were choosing between stimuli associated with punishment. Such a prediction is not supported by the current data; the individuals with psychopathy showed significant impairment when choosing between stimuli associated with reward.

Our data appear to contrast with data from the startle reflex literature indicating that appetitive visual primes suppress the startle response comparably in individuals with psychopathy and comparison individuals. However, other data also suggest impaired reward processing in psychopathy (Mitchell et al., in press; Verona et al., 2004); see above. The lexical decision and affective priming findings are particularly interesting with respect to the current results. Across the three studies examining lexical decision, individuals with psychopathy were 46 ms slower at responding to negative words, but only 14 ms slower at responding to positive words relative to comparison individuals (Kiehl et al., 1999; Lorenz & Newman, 2002; Williamson et al., 1991). Similarly, in the affective priming study, individuals with psychopathy showed no affective priming for negative target words, but did show affective priming for positive target words (although significantly less so than comparison individuals); (Blair et al., in press). In short, like the current study these studies suggest that while individuals with psychopathy are impaired at processing appetitive material, they are even more impaired at processing aversive material.

The data have clear implications for the IES model. One of the purposes of this study was to help distinguishing between two specifications of this model: that the system for affect representations is generally impaired or alternatively that affect representations responding to aversive stimuli are particularly, or only, disrupted in individuals with psychopathy. The current data suggest that there is general disruption of the affect representations in psychopathy but that those responsive to aversive stimuli are particularly compromised.

The IES model however also predicted that individuals with psychopathy should be differentially affected by inter-stimulus reinforcement distance than comparison individuals. We did not find support for this suggestion in the current study. The behavioral data collected during our fMRI investigation of the DRPLT indicated that RTs may be more sensitively indexing inter-stimulus reinforcement distance than error rates. It is therefore possible that any subtle group difference might only be apparent in RT data. In the current study, RTs were not obtained. However, future work investigating inter-stimulus reinforcement distance effects in psychopathy will include both RTs and error rates to index task performance.

Three caveats should be noted with respect to these results. First, we did not include a measure of anxiety. However, in our own on-going work and in the literature more generally, there are no indications that patients with anxiety disorders show any impairment on the differential reward punishment task.

The second is that the individuals with psychopathy were unmotivated/inadequately compensated/too fatigued to perform the task and that this is what caused the group differences. However, a motivation-based account has difficulty explaining why individuals with psychopathy are particularly disturbed for trials involving two punishing objects. We therefore do not believe that a motivation-based account can account for the current data.

The third caveat is that due to limitations in what was permissible to ask our participants, we could not obtain a full substance abuse history. However, while possible group differences in substance abuse could have contributed towards the current results, it is worth noting that no data exists suggesting that any current recreational drugs differentially impact on decision-making on the basis of punishment relative to reward information.

In conclusion, this study examined decision-making between objects associated with different levels of reward or punishment in individuals with psychopathy. The individuals with psychopathy showed impaired response choice on the basis of both learnt stimulus-reward/stimulus-punishment associations but their impairment was significantly worse for decision-makings involving stimulus-punishment associations. These results suggest that models of psychopathy stressing emotional learning impairment need qualification. Individuals with psychopathy do not appear to be superior at reward processing, in contrast to some suggestions. The data suggest that the coding of punishment information necessary for the stimulus-punishment associations is particularly compromised in individuals with psychopathy while that for the coding of reward information for stimulus-reward associations is less so.

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