Psychological Medicine (2013), **43**, 825–835. © Cambridge University Press 2012
doi:10.1017/S0033291712001547

ORIGINAL ARTICLE

Reduced cortical call to arms differentiates psychopathy from antisocial personality disorder

L. E. Drislane, U. Vaidyanathan and C. J. Patrick*

Florida State University, Tallahassee, FL, USA

Background. Psychopathy and antisocial personality disorder (ASPD) are both characterized by impulsive, externalizing behaviors. Researchers have argued, however, that psychopathy is distinguished from ASPD by the presence of interpersonal–affective features that reflect an underlying deficit in emotional sensitivity. No study to date has tested for differential relations of these disorders with the brain's natural orienting response to sudden aversive events.

Method. Electroencephalography was used to assess cortical reactivity to abrupt noise probes presented during the viewing of pleasant, neutral and unpleasant pictures in 140 incarcerated males diagnosed using the Psychopathy Checklist – Revised and DSM-IV criteria for ASPD. The primary dependent measure was the P3 event-related potential response to the noise probes.

Results. Psychopaths showed significantly smaller amplitude of P3 response to noise probes across trials of all types compared with non-psychopaths. Follow-up analyses revealed that this overall reduction was attributable specifically to the affective–interpersonal features of psychopathy. By contrast, no group difference in general amplitude of probe P3 was evident for ASPD *versus* non-ASPD participants.

Conclusions. The findings demonstrate a reduced cortical orienting response to abrupt aversive stimuli in participants exhibiting features of psychopathy that are distinct from ASPD. The specificity of the observed effect fits with the idea that these distinctive features of psychopathy reflect a deficit in defensive reactivity, or mobilization of the brain's defensive system, in the context of threat cues.

Received 4 January 2012; Revised 15 June 2012; Accepted 18 June 2012; First published online 31 July 2012

Key words: Antisocial personality disorder, brain response, differential diagnosis, ERP, psychopathy.

Introduction

Psychopathy and antisocial personality disorder (ASPD) have been of longstanding interest to researchers and practitioners alike because of the costly toll they exact on society. Given that these disorders share many common features, a crucial question concerns what distinguishes one from the other. This question is currently at the forefront of major developments in diagnostic nosology, with proposed revisions to the upcoming Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5; APA, 2012) including a 'callous–unemotional' variant of child conduct disorder and a revised ASPD diagnosis incorporating better representation of psychopathic features.

Researchers maintain that what distinguishes psychopathy from ASPD is a characteristic set of interpersonal–affective symptoms (Hare *et al*. 1991; Rogers *et al*. 1994). Besides exhibiting unrestrained, aggressive behavior, psychopaths display features such as glibness, superficial charm, callousness and shallow affectivity (Hare, 2003; Patrick *et al*. 2009) that are not represented in the current criteria for ASPD. In the dominant clinical assessment instrument for psychopathy, the Psychopathy Checklist – Revised (PCL-R; Hare, 2003), these features are encompassed by items associated with PCL-R Factor 1 (Harpur *et al*. 1989; Hare *et al*. 1990). The presence of such affective–interpersonal traits in conduct-disordered children serves as a crucial predictor of the later development of psychopathy, as distinct from adult antisocial behavior (Frick, 1998). In contrast, ASPD is associated predominantly with items indexing the antisocial deviance (Factor 2) component of the PCL-R (Patrick *et al*. 1997).

Further, there is increasing evidence for separate neurobiological underpinnings to these psychopathy-specific features, distinct from those associated with general antisocial–externalizing tendencies (Patrick & Bernat, 2009). While both disorders are marked by dysfunction in the frontal regions of the brain

* Address for correspondence: C. J. Patrick, Ph.D., 1107 West Call Street, Tallahassee, FL 32306-4301, USA.
(Email: cpatrick@psy.fsu.edu)

necessary for impulse control, executive function and planning, brain structures implicated in the processing of fear (e.g. amygdala) appear aberrant in psychopathic individuals, and not in individuals with ASPD (Blair, 2003). The current study sought to extend understanding of these high-impact disorders by examining, for the first time, differential relations of psychopathy and ASPD with brain reactivity to aversive noise probes occurring in isolation or in the context of visual foreground processing. Specifically, the noise probe-elicited P300 response ('probe P3'; Roth *et al*. 1984; Schupp *et al*. 1997) – an event-related potential (ERP) component that occurs in relation to sudden, startling acoustic stimuli – was examined during and in between presentations of affective and neutral pictures in a large sample of incarcerated males assessed for these disorders.

The probe P3 has typically been measured in relation to abrupt noise probes presented to subjects during the processing of visual foregrounds. The occurrence of an unexpected intense noise evokes a rapid-onset startle reflex that functions to interrupt ongoing cognitive–behavioral processing and reorient the individual toward the intrusive event (Graham, 1979; Herbert *et al*. 2006). The probe P3 is a cortical response following the initial startle reflex that indexes the extent to which the individual attends to and ascribes meaning to the aversive noise probe following its initial interruptive impact (Lang *et al*. 1992).[1]† In this sense, the probe P3 response reflects a cortical 'call to arms' (Graham, 1979; Herbert *et al*. 2006) – an index of the brain's dedication of resources toward processing and coping with the unexpected event. Recent research indicates that activity underlying the probe P3 originates from fronto-central regions of the cortex and the temporoparietal junction (Keil *et al*. 2007) – brain regions associated with action orientation (Hauk & Pulvermüller, 2004) and empathy/morality (Decety & Lamm, 2007). Since psychopaths have been described as deficient in normal affective reactions including empathy and fear, the probe P3 response could serve as a valuable index of emotional reactivity deficits underlying this disorder. Further, to the extent that probe P3 is modulated by attentional engagement with foreground stimuli, this response may be helpful for evaluating hypotheses regarding attentional *versus* emotional dysfunction in psychopaths (Newman *et al*. 1997).

The current study examined P3 reactivity to aversive noise probes within a picture-viewing task in prisoners assessed for psychopathy and ASPD, in order to test for affective reactivity and attentional processing differences between the two disorders. Two aspects of probe P3 response were examined. The first was the general amplitude of the P3 response to noise probes, measured during intertrial intervals (ITIs) when no picture was present (i.e. as an index of baseline reactivity) and during picture-viewing trials (i.e. as an index of reactivity during visual foreground processing). Inasmuch as the P3 response to auditory events is presumed to reflect processes of stimulus evaluation and cognitive analysis of informational aspects of the stimulus (Lovrich *et al*. 1988), amplitude of the P3 to noise probes indexes the degree to which the brain continues to process the noise as a meaningful event following initial perceptual registration of the noise stimulus (Graham, 1979; Herbert & Kissler, 2010). Given the intense, unexpected nature of the noise-probe stimulus, probe P3 amplitude can be viewed as indexing allocation of cognitive resources for purposes of ascertaining the need for sustained defensive mobilization (Herbert *et al*. 2006; Czigler *et al*. 2007).

The P3 response in more standard cognitive processing (e.g. oddball) tasks shows reliable reductions in relation to disinhibitory disorders generally (Iacono *et al*. 2002; Patrick *et al*. 2006), including ASPD (Bauer *et al*. 1994; O'Connor *et al*. 1994). Findings for cognitive-task P3 in psychopathy have been more mixed, with some older studies reporting enhanced amplitude in psychopathic offenders (see Raine, 1993) and more recent studies reporting reduced amplitude in PCL-R defined psychopaths (e.g. Kiehl *et al*. 1999, 2006). By contrast, the noise-probe P3 has emerged as a focus of study more recently, and thus limited data are available regarding its individual difference correlates. The one individual difference study that has been reported to date (Drislane *et al*. 2011) found enhanced overall probe P3 amplitude in a picture viewing task among adult participants scoring high as compared with low on a measure of dispositional fear. Notably, the measure of dispositional fear/fearlessness in this study (see Kramer *et al*. 2012; see also Vizueta *et al*. 2012) consisted of items from existing fear scales and affective–interpersonal items from the Psychopathic Personality Inventory (Lilienfeld & Andrews, 1996) reflecting fearlessness (Benning *et al*. 2003, 2005).

The second aspect of P3 we examined was modulation of the response as a function of foreground stimulus meaningfulness or significance. Prior studies with normal adult participants have revealed a diminished amplitude of probe P3 response to noise probes occurring during viewing of either pleasant or unpleasant pictures as compared with neutral pictures (Cuthbert *et al*. 1998). In neural terms, this quadratic modulation pattern reflects enhanced allocation of cortical processing resources to foreground stimuli

† The notes appear after the main text.

https://doi.org/10.1017/S0033291712001547 Published online by Cambridge University Press

that are attentionally engaging – resulting in diminished availability of resources to process intervening noise probes (Lang *et al*. 1997; Cuthbert *et al*. 1998). This modulatory effect on probe P3 provides an index of the degree to which greater *versus* lesser engagement due to visual foreground salience moderates cortical–elaborative processing of the aversive probe stimulus.

Our major hypothesis, based on prior evidence indicating that psychopathy is distinguished from ASPD by diminished sensitivity to aversive events (Patrick *et al*. 1993; Blair *et al*. 1997), and evidence for enhanced probe P3 amplitude in relation to dispositional fear (Drislane *et al*. 2011), was that individuals diagnosed as psychopathic would show generally reduced amplitude of probe P3 response – reflecting diminished cortical post-processing of noise-probe stimuli (i.e. reduced cortical 'call to arms') relative to non-psychopaths. In contrast, participants diagnosed with ASPD were not expected to demonstrate this deficit. As a corollary, based on evidence linking emotional deficits in psychopathy to the core interpersonal–affective features of the disorder (Blair, 2001; Blonigen *et al*. 2005; Patrick & Bernat, 2009; Vaidyanathan *et al*. 2011), we hypothesized that scores on Factor 1 of the PCL-R – rather than Factor 2, which is more closely associated with ASPD (Harpur *et al*. 1989; Hare *et al*. 1990, 1991) – would account for psychopathy-related reductions in probe P3 amplitude.

In evaluating these specific hypotheses, the current design enabled us to assess for psychopathy- and ASPD-related differences in allocation of attention to foreground stimuli through two condition contrasts: (1) comparison of probe P3 amplitude during neutral pictures as compared with no-picture (intertrial) intervals; and (2) comparison of probe P3 amplitude during viewing of affective (pleasant, unpleasant) as compared with neutral pictures. The first of these contrasts permitted evaluation of whether the predicted diminution in overall probe P3 response might reflect a psychopathy-related deficit in the ability to process noise probes specifically during competing picture-foreground engagement (e.g. per the response modulation hypothesis of Newman *et al*. 1997), as opposed to a general deficit in post-processing of probes attributable to weak defensive (fear) reactivity. The second contrast enabled us to evaluate whether psychopathy-related diminution of probe P3 during picture-viewing might reflect overcommitment of attentional resources to the processing of affective scenes in particular – in which case, psychopathic participants would be expected to show exaggerated probe P3 inhibition for affective *versus* neutral pictures.

Method

Participants

Participants were 143 male prisoners recruited from a state prison in Minnesota who received $20, deposited to their institutional accounts, for participating. The mean age of participants was 32.31 years (S.D. = 8.68, range = 19–59). With regard to race, the majority of inmates were Caucasian (56.9%), African American (28.5%) and Hispanic (9.0%), with the remaining 5.6% of other or mixed race. Following a detailed description of the study procedures, written informed consent was obtained. A pre-test questionnaire was administered to screen for the presence of visual or hearing impairments, which were the only exclusionary criteria employed in the study. Data for three participants were dropped due to equipment malfunction.

The study was approved by the Institutional Review Board of the University of Minnesota, and by the Research Review Committee of the Minnesota Department of Corrections.

Measures

Psychopathy Checklist – Revised

Subjects were assigned scores on the PCL-R using information from a semi-structured interview and prison file records. Primary diagnostic ratings were assigned by the interviewer. Secondary ratings were provided by an independent diagnostician who reviewed a video recording of the diagnostic interview and file information. Inter-rater reliability for PCL-R scores was very high (Cronbach's $\alpha = 0.98$, 0.94 and 0.95 for PCL-R total, Factor 1 and Factor 2 scores, respectively). PCL-R total and factor scores for the two raters were averaged for each participant. Overall sample means for PCL-R total, Factor 1 and Factor 2 scores were 25.62, 9.62 and 12.46, respectively (S.D. = 7.73, 3.59 and 3.74). Consistent with prior research, scores on PCL-R Factors 1 and 2 were moderately correlated ($r = 0.59$). For analyses of psychopathy groups (see below), subjects with overall PCL-R scores $\geqslant 30$ ($n = 49$) were classified as psychopathic and those with overall scores $\leqslant 20$ ($n = 29$) were classified as non-psychopathic (Hare, 2003).

ASPD

Subjects were also assessed for child and adult symptoms of ASPD using interview questions patterned after relevant items from the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II; First *et al*. 1997), in conjunction with collateral information from prison file records. Primary diagnostic ratings for ASPD were assigned by the

https://doi.org/10.1017/S0033291712001547 Published online by Cambridge University Press

interviewer, and secondary ratings were assigned by an independent diagnostician. A participant was considered to have met criteria for the diagnosis if both independent raters assigned a diagnosis of ASPD. Inter-rater reliability for ASPD diagnoses as indexed by the κ statistic was 0.78. One subject could not be diagnosed due to missing diagnostic information from one rater, leading to a total of 139 subjects assessed for ASPD. A total of 91 participants were diagnosed with ASPD, whereas 48 were not. Of the 91 participants diagnosed with ASPD, 46 also met criteria for a diagnosis of psychopathy. Only three of the inmates diagnosed as psychopathic did not meet criteria for ASPD.

Procedure

Picture stimuli consisted of 66 digitized scenes from the International Affective Picture System (IAPS; Lang *et al*. 1999), presented for 6 s each. Noise probes were 50-ms, 105-dB white-noise bursts with abrupt ($<10\,\mu$s) rise time, generated by an S81-02 Coulbourn white noise generator, and presented binaurally through insert earphones (Etymotic Research Inc., USA). Habituation probes (excluded from analyses) were presented during the first three pictures of the task (Bradley *et al*. 1993). During 54 of the remaining 63 picture trials, noise probes occurred between 3 and 5 s after picture onset. To provide a no-picture comparison and to reduce predictability of the probe stimuli, nine additional noise probes were presented during intervals between picture stimuli.

The 54 probed pictures consisted of 18 pleasant, 18 neutral and 18 unpleasant IAPS scenes.[2] Pleasant pictures included erotic and action/adventure scenes (e.g. bungee-jumping, skydiving); unpleasant pictures included direct-threat scenes (e.g. aimed weapons, menacing figures) and victim (vicarious attack) scenes. Neutral scenes depicted innocuous people, buildings, kitchen utensils and other common objects (e.g. truck, fire hydrant). Pleasant and unpleasant picture sets were selected to be equivalent in average rated arousal according to IAPS norms (Lang *et al*. 1993), and comparably more arousing than neutral pictures.

A total of 12 slide presentation orders were used. Within and between orders, pictures and noise probes were counterbalanced such that valence categories (pleasant, neutral, unpleasant) were represented equally across orders at each serial position, with the following constraints: no more than two slides of the same valence occurred consecutively within any stimulus order; pictures of the same content category never appeared consecutively or across orders; and pictures were rotated so as to serve in both probed and unprobed trials.

Physiological data acquisition and reduction

Pictures were viewed at a distance of 100 cm on a 52-cm computer monitor positioned at eye level. Data collection was performed using two computers configured with E-Prime software (MEL Inc., USA) for stimulus control and SCAN software (Neuroscan, Inc., USA) for physiological data acquisition.

Electroencephalographic (EEG) scalp potentials were recorded from multiple scalp sites using a Neuroscan 32-channel Quick-Cap system. Data were collected at a sampling rate of 2000 Hz with an online analog band pass filter of 0.05–500 Hz. EEG signal activity was referenced offline to the average of left and right mastoid electrodes. Following referencing, epochs from -500 ms to 1000 ms were extracted from the continuous recordings using Neuroscan EDIT software and corrected algorithmically for eye movements (Semlitsch *et al*. 1986). The epoched and corrected EEG data were exported to Matlab (Mathworks, Inc., USA) for subsequent data processing. After applying a 5 Hz high-pass third-order Butterworth filter to reduce low frequency artifacts, the data were downsampled to 256 Hz. Trials in which EEG activity exceeded $\pm100\,\mu$V, relative to a 500-ms pre-probe baseline, were excluded from further processing. Across participants, 1.83% of total trials were excluded due to artifacts.

Consistent with prior work (Schupp *et al*. 2004), analyses focused on the P3 component of the probe-elicited ERP measured at electrode site Pz, the site at which probe P3 occurs with maximal amplitude. The P3 response was coded from the average EEG waveform for each condition as the maximum positive deflection (from pre-probe baseline) evident between 250 and 450 ms following the onset of the probe stimulus.

Data analysis

An initial analysis was performed to evaluate modulatory effects of picture foregrounds on probe P3 amplitude in the sample as a whole. To test for a modulatory effect of foreground attention in relation to picture valence, a one-way repeated-measures analysis of variance (ANOVA) was performed in which probe P3 amplitude at electrode site Pz was compared across viewing of each picture category (pleasant, neutral, unpleasant). Following prior work (Cuthbert *et al*. 1998), the predicted diminution in probe P3 during viewing of affective scenes as compared with neutral was evaluated as a quadratic trend contrast (i.e. average of pleasant/unpleasant against neutral). This contrast was predicted to be highly significant (Schupp *et al*. 1997; Cuthbert *et al*. 1998). Scalp topography plots ('head maps'; see Fig. 1) are

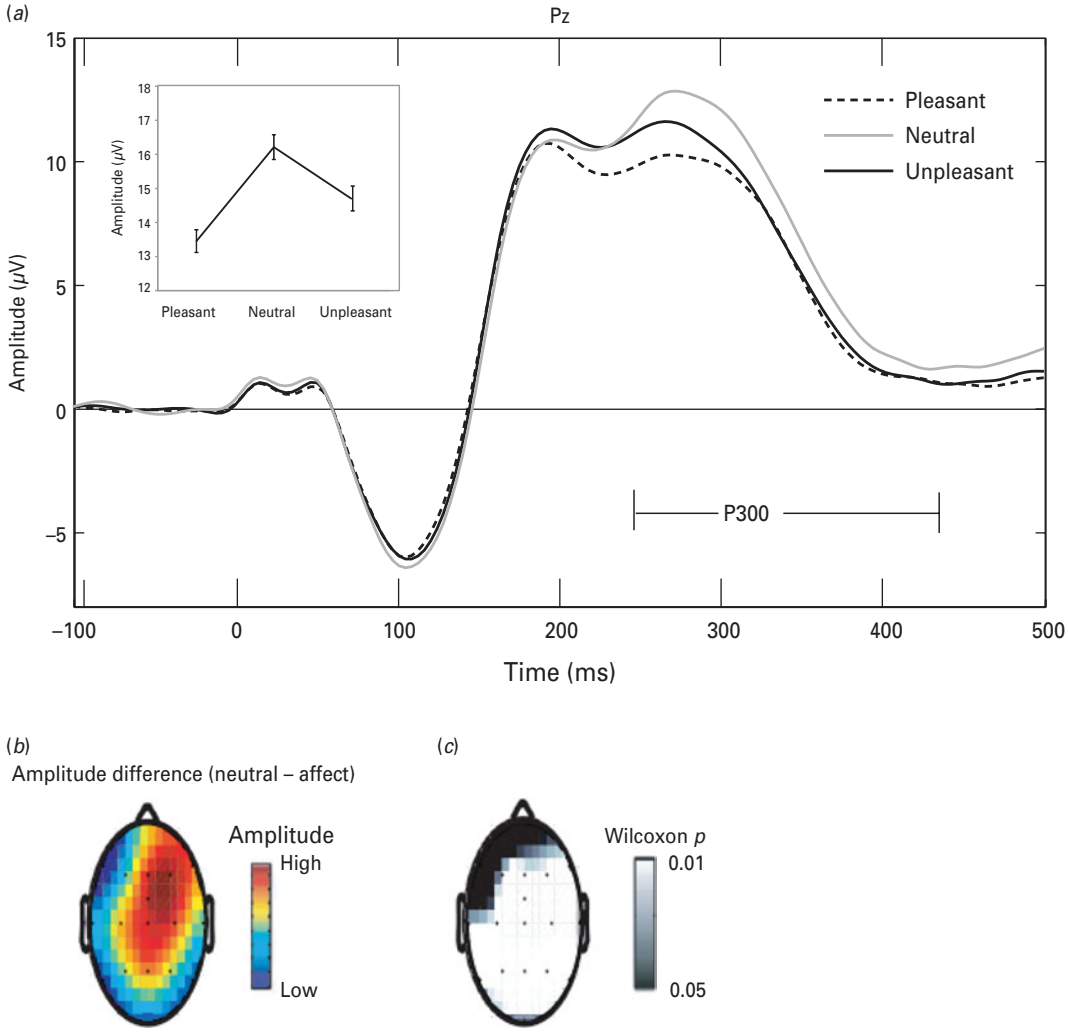

Fig. 1. (*a*) Average event-related potential (ERP) waveforms for participants as a whole at electrode site Pz for noise probes presented during pictures of differing types (pleasant, neutral, unpleasant). Inset line plot depicts mean probe P3 amplitude (defined as peak of waveform between 250 and 450 ms) for pictures of these three types. (*b*) Color topographic plot ('head map') depicts relative magnitude of the neutral minus affective (pleasant/unpleasant) difference for probe P3 amplitude at varying scalp recording sites. (*c*) Grayscale topographic plot depicts scalp sites at which statistically significant ($p < 0.05$) differences in probe P3 amplitude were observed for affective (pleasant/unpleasant) as compared with neutral pictures. From these topographic plots, it can be seen that the inhibition of probe P3 response for affective *versus* neutral pictures was maximal at central-parietal scalp locations, and somewhat right-lateralized.

provided as a supplement to the primary analysis of P3 at electrode Pz, in order to illustrate the distribution and significance of this effect across differing recording sites.

Following these analyses for the overall study sample, effects of diagnostic group were evaluated using a series of two-way (group × picture category) ANOVAs, with group (APSD/non-ASPD, or psychopath/non-psychopath) serving as a between-subjects factor, and foreground condition (ITI *v.* neutral picture, or pleasant/unpleasant picture *v.* neutral picture) as a within-subjects factor. To test for possible interactive effects of psychopathy and ASPD diagnoses on probe P3 amplitude, the two diagnoses were entered concurrently as binary (present *v.* absent) between-subject factors in a supplemental ANOVA evaluating probe P3 amplitude across pleasant, neutral and unpleasant picture categories. In addition to the ANOVAs for extreme PCL-R groups (psychopath, non-psychopath), effects for the two distinct factors of the PCL-R were evaluated through correlational analyses utilizing continuous Factor 1 and 2 scores as predictors of probe P3 summary scores reflecting either general amplitude of P3 response, or degree of foreground-attentional modulation of response. As indices of general response, we utilized mean

https://doi.org/10.1017/S0033291712001547 Published online by Cambridge University Press

amplitude of P3 during ITI trials, and mean across all picture trials. As indices of foreground-attentional modulation of probe P3, we examined: (1) average P3 amplitude during ITI trials minus average during neutral scenes and (2) average P3 during neutral scenes minus average for pleasant and unpleasant scenes.

Results

Overall sample: effects of picture condition on probe P3

Replicating prior findings with non-incarcerated samples, a one-way ANOVA revealed highly significant modulation of P3 response as a function of picture condition in the overall prisoner sample (omnibus $F_{2,278} = 37.21$, $p < 0.001$), with amplitude markedly reduced during viewing of pleasant and unpleasant pictures compared with neutral (quadratic contrast $F_{1,139} = 58.49$, $p < 0.001$; see Fig. 1).[3]

Diagnostic groups: effects of ASPD and psychopathy on probe P3

In the two-way ANOVA evaluating ASPD group effects for neutral-picture and ITI trials, no main effect of group on probe P3 amplitude was evident ($F_{1,137} = 0.33$, $p = 0.57$). The ASPD group × ITI/neutral-picture interaction was likewise non-significant ($F_{1,137} = 0.03$, $p = 0.87$). In the counterpart analysis examining group effects for differing picture categories, neither the main effect of ASPD group nor the group × picture category interaction emerged as significant ($F_{1,137} = 0.34$, $p = 0.56$ and $F_{2,274} = 0.99$, $p = 0.37$), though the aforementioned main effect of picture category on probe P3 amplitude was clearly evident (omnibus $F_{2,274} = 30.58$, $p < 0.001$; quadratic contrast $F_{1,137} = 50.16$, $p < 0.001$). The results of these analyses indicate no differences in probe P3 reactivity or modulation for subjects with *versus* without ASPD.

In the two-way ANOVA evaluating psychopathy group effects for neutral-picture and ITI trials, the main effect of group approached significance ($F_{1,76} = 3.79$, $p = 0.055$), reflecting a trend toward diminished probe P3 amplitude across the two trial conditions for psychopathic as compared with non-psychopathic participants. The group × ITI/neutral-picture interaction was negligible ($F_{1,76} = 1.56$, $p > 0.2$), indicating no group difference in comparative response to ITI *versus* neutral-picture probes. In the analysis of group effects for pictures of differing types, the main effect of psychopathy group emerged as significant ($F_{1,76} = 4.53$, $p < 0.05$), reflecting reduced amplitude of P3 response to probe stimuli across pictures as a whole in psychopathic as compared with non-psychopathic subjects. However, the group × picture category interaction was not significant ($F_{2,152} = 0.37$, $p = 0.69$), indicating no difference in degree of P3 amplitude reduction during viewing of affective *versus* neutral scenes in psychopaths as compared with non-psychopaths (see Fig. 2). Together, these analyses demonstrate decreased P3 reactivity to noise probes in general (i.e. across all trial types), but intact foreground-attentional modulation of probe P3 response (i.e. for affectively engaging as compared with neutral scenes), in psychopathic participants.

In the supplemental ANOVA incorporating both psychopathy and ASPD diagnosis (present *v.* absent) as between-subject factors, the interaction between psychopathy and ASPD diagnoses was not significant ($F_{1,74} = 0.09$, $p = 0.77$). The main effect of ASPD group was also negligible ($F_{1,74} = 1.42$, $p = 0.25$); however, the main effect of psychopathy group emerged as significant ($F_{1,74} = 4.86$, $p < 0.05$). Neither of the group (psychopathy, or ASPD) × picture category interactions was significant, nor was the three-way (ASPD × psychopathy × picture category) interaction (p's > 0.40). These results indicate that reduced overall amplitude of probe P3 response is specific to psychopathy and does not depend on the presence *versus* absence of co-morbid ASPD.

PCL-R psychopathy factors and probe P3

For ITI-probe trials and picture-probe trials as a whole, the correlation between probe P3 amplitude and continuous scores on PCL-R Factor 1 was significant and negative (r's = –0.23 and −0.26, respectively, p's = 0.007 and 0.002). By contrast, corresponding correlations between general P3 amplitude and continuous scores on PCL-R Factor 2 were weak and non-significant, (r's = –0.11 and −0.11, respectively, p's = 0.21 and 0.21). These findings indicate that the observed reduction in general P3 amplitude for psychopathic as compared with non-psychopathic participants was attributable primarily to the affective–interpersonal features embodied in PCL-R Factor 1.

For the difference-score variable indexing probe P3 modulation for neutral scenes relative to ITI trials (i.e. average amplitude during ITIs minus average during neutral pictures), neither PCL-R factor evidenced significant prediction (r's for Factors 1 and 2 = 0.05 and −0.07, respectively, p's = 0.59 and 0.40). Similarly, for the difference-score variable indexing modulation for affective scenes relative to neutral (i.e. average amplitude during neutral pictures minus average during pleasant and unpleasant pictures), neither factor evidenced significant prediction (r's = –0.02

https://doi.org/10.1017/S0033291712001547 Published online by Cambridge University Press

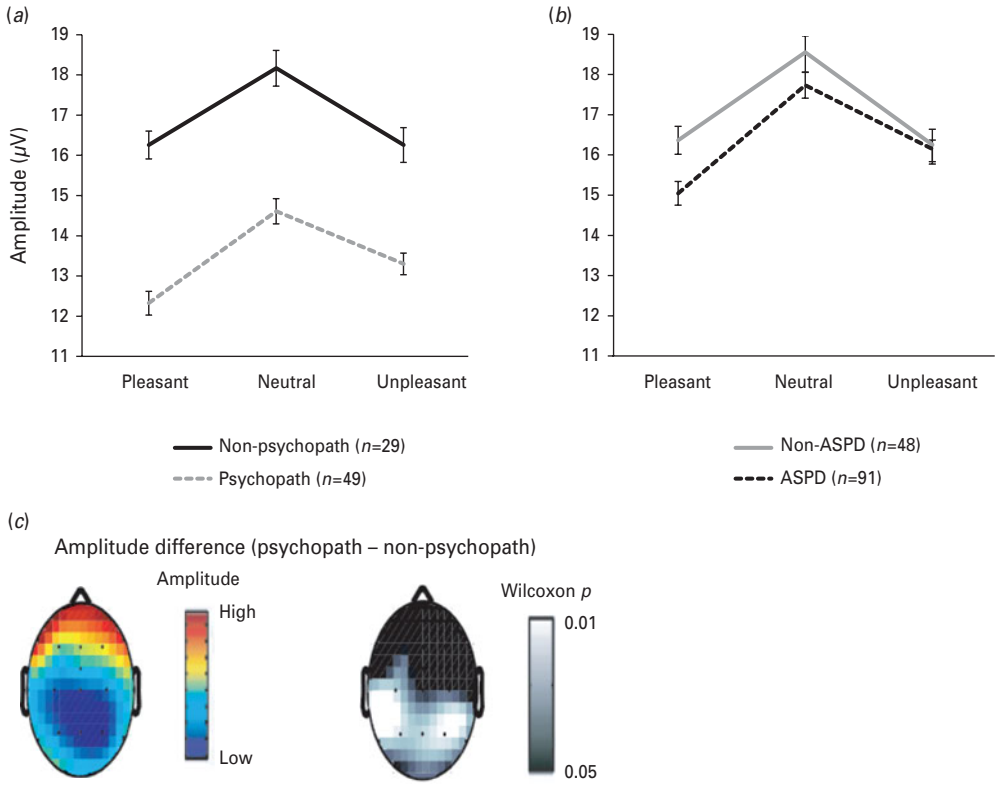

Fig. 2. Average probe P3 amplitude at electrode site Pz, by picture category (pleasant, neutral, unpleasant), for psychopathy groups [psychopathic, Psychopathy Checklist – Revised (PCL-R) total score $\geqslant 30$; non-psychopathic, PCL-R total score $\leqslant 20$] (*a*) and antisocial personality disorder (ASPD) groups (*b*). Error bars reflect standard errors for specific picture means (pleasant, neutral, unpleasant) within each participant group. A main effect was evident for psychopathy group (psychopath < non-psychopath) ($F_{1,76} = 4.53$, $p < 0.05$), but not for ASPD group. (*c*) Color topographic plot ('head map') depicts relative magnitude of overall probe P3 amplitude at varying scalp recording sites for psychopaths *versus* non-psychopaths. Grayscale topographic plot depicts scalp sites at which statistically significant ($p < 0.05$) differences in probe P3 amplitude were observed in psychopaths as compared with non-psychopaths. From these topographic plots, it can be seen that the amplitude reduction in probe P3 response for psychopaths as compared with non-psychopaths was maximal at parietal scalp locations.

and 0.02, respectively, p's = 0.78 and 0.78). This latter finding indicates that participants scoring high on Factor 1 of the PCL-R, while exhibiting overall diminished P3 response to the noise-probe stimulus, showed comparable foreground-attentional modulation of probe P3 as a function of picture content.

Discussion

The findings of the present study demonstrate that offenders diagnosed with psychopathy show diminished cortical orienting to abrupt noxious stimuli, as indexed by diminished probe P3 reactivity to unwarned noise bursts occurring within or between picture-viewing intervals; in contrast, those diagnosed with ASPD do not evince this effect. Our results provide evidence for reduced evaluative post-processing of aversive noise probes in psychopathic individuals – that is, a reduction in the normal cortical 'call to arms' instigated by intense sensory events of an unexpected nature (Graham, 1979; Herbert *et al*. 2006). In the context of this overall reduction in probe P3 response, psychopathic participants showed the expected relative decrement in probe P3 during viewing of affective as compared with neutral pictures, interpretable as increased allocation of attentional resources to more engaging perceptual foregrounds (Lang *et al*. 1997; Cuthbert *et al*. 1998).

The finding that psychopathic participants did not differ from non-psychopathic participants in relative amplitude of probe P3 during neutral-picture trials as compared with no-picture (ITI) trials argues against a 'foreground attentional focus' explanation of the reduction in probe P3 for these participants during picture-viewing trials as a whole (i.e. an inability to shift attention toward the intervening probe stimulus once attention was engaged by foreground picture stimuli; see Newman *et al*. 1997). If reduced probe P3 in these participants were attributable to this sort of attentional anomaly, more pronounced inhibition

https://doi.org/10.1017/S0033291712001547 Published online by Cambridge University Press

of P3 would have been observed for probes occurring during neutral pictures as compared with ITIs. Moreover, the finding of normal inhibition of probe P3 during affective as compared with neutral pictures in psychopathic participants indicates that the observed attenuation of probe P3 amplitude for these participants occurred separately from alterations in attention–allocation related to differences in the saliency of visual foregrounds. That is, the observed reduction in cortical post-processing was not dependent on the degree of attention devoted to processing of picture stimuli, which exerted a separate effect on probe P3 amplitude, unrelated to psychopathy status.

A further important finding was that the overall reduction in probe P3 response was attributable specifically to the affective–interpersonal (Factor 1) component of PCL-R psychopathy. This adds to a growing body of data establishing the centrality of affective–interpersonal traits for distinguishing psychopathy from other forms of externalizing psychopathology – including child conduct disorder and adult antisocial personality (Frick, 1998; Blair, 2001; Blonigen *et al*. 2005; Viding *et al*. 2005; Patrick & Bernat, 2009; Vaidyanathan *et al*. 2011). Whereas other externalizing disorders typically entail heightened negative emotionality (Blonigen *et al*. 2005; Patrick & Bernat, 2009; Patrick *et al*. 2009), psychopathy is reliably associated with deficits in emotional processing and reactivity as indexed by physiological measures of differing types across a range of tasks. For example, psychopaths exhibit deficient fear as evidenced by an absence or attenuation of fear-potentiated startle, in contrast with ASPD-diagnosed individuals who exhibit normal potentiation of startle during aversive cuing (Vaidyanathan *et al*. 2011). As with the reduction in probe P3 reported here, the deficit in aversive startle potentiation has been linked specifically to the affective–interpersonal component of psychopathy (Patrick *et al*. 1993; Patrick, 1994; Vaidyanathan *et al*. 2011).[4] Similarly, research indicates that individuals high in core psychopathic features display reduced electrodermal reactivity to distress cues (Blair *et al*. 1997) and during anticipation of stressors (Hare, 1978; Dindo & Fowles, 2011) along with reduced amygdala reactivity to fear-relevant stimuli (Marsh *et al*. 2008). The present study, however, is the first to demonstrate reduced amplitude of mid-latency cortical response to abrupt, noxious-probe stimuli in offenders exhibiting these core psychopathic features.

This reduction in noise-probe P3 in relation to affective–interpersonal features of psychopathy can be contrasted with reductions in target stimulus P3 in more standard cognitive (e.g. oddball) tasks observed for individuals exhibiting ASPD (Bauer *et al*. 1994; O'Connor *et al*. 1994) and other externalizing disorders (Iacono *et al*. 2002; Patrick *et al*. 2006), and for high-psychopathic individuals in some studies (e.g. Kiehl *et al*. 1999, 2006). Extrapolating from the findings for P3 and externalizing and the close connection between externalizing proneness and psychopathy factor 2 (Patrick *et al*. 2005), Gao & Raine (2009) hypothesized that the reduced cognitive-task P3 for psychopathy in some studies is probably attributable to Factor 2 as opposed to Factor 1 features. Although further work is needed to effectively evaluate this hypothesis, some evidence has emerged recently to support it (Carlson *et al*. 2009; Venables *et al*. 2010). Integrating these results with current findings, it appears likely that differing processes underlie the P3 response to abrupt startling noises in the context of picture viewing compared with P3 to infrequent stimuli in a standard oddball task. Recent research demonstrating enhanced amplitude of probe P3 during picture viewing in high- *v*. low-fear adults (Drislane *et al*. 2011) points to a distinct component of dispositional fear, entailing sensitivity to the occurrence of intense unexpected events, contributing to noise-probe P3 amplitude.

Considered together with prior published work, the current findings indicate that along with deficits in impulse control that occur also in ASPD, psychopathy is specifically characterized by impaired reactivity of the brain's defensive motivational system (Patrick, 1994; Patrick & Bernat, 2009). In turn, observed differences in neurobiological correlates of psychopathy and ASPD suggest crucial differences in the nature and etiology of these disorders, with important implications for psychiatric nosology. In particular, the current results lend support to proposals for greater consideration of psychopathic features in the diagnosis of ASPD and a 'callous–unemotional' variant of conduct disorder in DSM-5. While traditional descriptions of these disorders focus predominantly on aggressive externalizing tendencies, increasing evidence points to the existence of a distinct subgroup of antisocial individuals for whom affective–interpersonal traits including indomitability, callousness and low dispositional fear are integral to manifest behavioral pathology.

Acknowledgements

We are grateful to the residents of Minnesota Correctional Facility – Lino Lakes for their participation, the officials and staff of the facility for their support of the project, and the Minnesota Department of Corrections for authorizing this research. In addition, we thank Noah Venables for his role in coordinating this project and his scholarly input on this article, Jason Hall, Marianna Bayevsky, Dan Blonigen,

Meredith Cadwallader, Brian Hicks, Ben Steffen, Noah Venables and Melinda Ward for their assistance with data collection, and Edward Bernat for his assistance with data processing and preliminary analyses.

This research was supported by grants no. MH52384, MH65137, MH072850 and MH089727 from the National Institute of Mental Health.

Declaration of Interest

None.

Notes

[1] In terms of its evocation by unexpected events and its timing, the noise-probe P3 response has more in common with the P3a response in standard oddball tasks (i.e. the earlier-peaking, more frontal response to infrequent novel stimuli in such tasks) than the P3b response (i.e. the later-peaking, more parietal response to attended target stimuli). However, probe P3 also differs in notable ways from the oddball P3a response (e.g. noise stimuli that elicit it are noxious due to their abruptness and intensity, and occur frequently rather than infrequently within the task context). No research has yet been undertaken to measure and directly compare P3a, P3b and noise-probe P3 responses within the same task procedures. Research of this kind would help to further clarify similarities and differences between the probe P3 and these other P3 variants.

[2] IAPS numbers for these stimuli were as follows:
Pleasant: 2381, 4000, 4233 (4617), 4274, 4230, 4653 (4750), 4690, 4687, 4290 (4651), 4533 (8032), 8041, 8033, 5622 (8250), 5626, 5623, 8370 (8180), 8080, 8042
Neutral: 2190, 2210, 2214, 2372, 2480, 2495, 2850, 2890, 9700, 7002, 7030, 7034, 7040, 7050, 7150, 7205, 7705, 7710
Aversive: 6010, 2520, 9594 (4621), 6571, 9400, 6530 (3550), 9250, 3400, 6350 (3500), 2100 (6241), 2682, 2130, 6242 (6244), 6370, 6243, 6510 (6250), 6260, 6230
Pictures in parentheses are alternate exemplars from the same content category that were substituted within some stimulus orders to achieve counterbalancing of conditions across run orders.

[3] There was a trend toward reduced probe P3 amplitude for neutral pictures as compared with ITIs in the sample as a whole, but this effect did not achieve significance ($F_{1,139} = 2.19$, $p = 0.14$).

[4] Effects of psychopathy on aversive potentiation of startle for the current offender sample (i.e. enhancement of probe-blink reactivity during viewing of unpleasant *versus* neutral pictures) were reported in an earlier paper (Vaidyanathan *et al*. 2011), prior to undertaking the analyses of probe P3 response reported here. To evaluate whether the effect for probe P3 (reflecting reduced cortical post-processing of noxious noise stimuli) accounted for aberrant startle potentiation in psychopathic individuals – in particular, those high on Factor 1 of the PCL-R – we included probe P3 amplitude and aversive/neutral startle potentiation together in a regression model as predictors of PCL-R Factor 1 scores. The analysis revealed that the probe P3 amplitude reduction did not account for the observed relationship between aversive startle potentiation and PCL-R Factor 1. The implication is that core psychopathy features exerted separate effects on reflex priming (degree of startle potentiation during aversive picture viewing) and cortical alerting (general amplitude of P3 response to noise probes).

References

APA (2012). Proposed draft revisions to DSM disorder and criteria. American Psychiatric Association: Washington, DC.

Bauer LO, O'Connor S, Hesselbrock VM (1994). Frontal P300 decrements in antisocial personality disorder. *Alcoholism: Clinical and Experimental Research* **18**, 1300–1305.

Benning SD, Patrick CJ, Hicks BM, Blonigen DM, Krueger RF (2003). Factor structure of the psychopathic personality inventory: validity and implications for clinical assessment. *Psychological Assessment* **15**, 340–350.

Benning SD, Patrick CJ, Iacono WG (2005). Psychopathy, startle blink modulation, and electrodermal reactivity in twin men. *Psychophysiology* **42**, 753–762.

Blair RJR (2001). Neurocognitive models of aggression, the antisocial personality disorders, and psychopathy. *Journal of Neurology, Neurosurgery and Psychiatry* **71**, 727–731.

Blair RJR (2003). Neurobiological basis of psychopathy. *British Journal of Psychiatry* **182**, 5–7.

Blair RJR, Jones L, Clark F, Smith M (1997). The psychopathic individual: a lack of responsiveness to distress cues? *Psychophysiology* **34**, 192–198.

Blonigen DM, Hicks BM, Krueger RF, Patrick CJ, Iacono WG (2005). Psychopathic personality traits: heritability and genetic overlap with internalizing and externalizing psychopathology. *Psychological Medicine* **35**, 637–648.

Bradley MM, Lang PJ, Cuthbert BN (1993). Emotion, novelty, and the startle reflex: habituation in humans. *Behavioral Neuroscience* **107**, 970–980.

Carlson SR, Thái S, McLarnon ME (2009). Visual P3 amplitude and self-reported psychopathic personality traits: frontal reduction is associated with self-centered impulsivity. *Psychophysiology* **46**, 100–113.

Cuthbert BN, Schupp HT, Bradley M, McManis M, Lang PJ (1998). Probing affective pictures: attended startle and tone probes. *Psychophysiology* **35**, 344–347.

Czigler I, Cox TJ, Gyimesi K, Horváth J (2007). Event-related potential study to aversive auditory stimuli. *Neuroscience Letters* **420**, 251–256.

Decety J, Lamm C (2007). The role of the right temporoparietal junction in social interaction: how low-level computational processes contribute to meta-cognition. *Neuroscientist* **13**, 580–593.

Dindo L, Fowles D (2011). Dual temperamental risk factors for psychopathic personality: evidence from self-report and skin conductance. *Journal of Personality and Social Psychology* **100**, 557–566.

Drislane LE, Lucy MD, Yancey JR, Vaidyanathan U, Patrick CJ (2011). Heritability of probe P3 amplitude and

affect modulation in a community twin sample. *Psychophysiology* **48**, S99.

First MB, Spitzer RL, Williams JBW, Gibbon M (1997). *Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II) User's Guide and Interview*. American Psychiatric Press: Washington, DC.

Frick PJ (1998). *Conduct Disorders and Severe Antisocial Behavior*. Plenum Press: New York.

Gao Y, Raine A (2009). P3 event-related potential impairments in antisocial and psychopathic individuals: a meta-analysis. *Biological Psychiatry* **82**, 199–210.

Graham FK (1979). Distinguishing among orienting, defense, and startle reflexes. In *The Orienting Reflex in Humans* (ed. H. D. Kimmel, E. H. van Olst and J. F. Orlebeke), pp. 137–167. Erlbaum: Hillsdale, NJ.

Hare RD (1978). Electrodermal and cardiovascular correlates of psychopathy. In *Psychopathic Behavior: Approaches to Research* (ed. R. D. Hare and D. Schalling), pp. 107–143. Wiley: Chichester, UK.

Hare RD (2003). *The Hare Psychopathy Checklist – Revised*, 2nd edn. Multi-Health Systems: Toronto.

Hare RD, Harpur TJ, Hakstian AR, Forth AE, Hart SD, Newman JP (1990). The Revised Psychopathy Checklist: reliability and factor structure. *Psychological Assessment: A Journal of Consulting and Clinical Psychology* **2**, 338–341.

Hare RD, Hart SD, Harpur TJ (1991). Psychopathy and the DSM-IV criteria for antisocial personality disorder. *Journal of Abnormal Psychology* **100**, 391–398.

Harpur TJ, Hare RD, Hakstian AR (1989). Two-factor conceptualization of psychopathy: construct validity and assessment implications. *Psychological Assessment: A Journal of Consulting and Clinical Psychology* **1**, 6–17.

Hauk O, Pulvermüller F (2004). Neurophysiological distinction of action words in the fronto-central cortex. *Human Brain Mapping* **21**, 191–201.

Herbert C, Kissler J (2010). Motivational priming and processing interrupt: startle reflex modulation during shallow and deep processing of emotional words. *International Journal of Psychophysiology* **76**, 64–71.

Herbert C, Kissler J, Junghöfer M, Peyk P, Rockstroh B (2006). Processing of emotional adjectives: evidence from startle EMG and ERPs. *Psychophysiology* **43**, 197–206.

Iacono WG, Carlson SR, Malone SM, McGue M (2002). P3 event-related potential amplitude and the risk for disinhibitory disorders in adolescent boys. *Archives of General Psychiatry* **59**, 750–757.

Keil A, Bradley M, Junghöfer M, Russmann T, Lowenthal W, Lang P (2007). Cross-modal attention capture by affective stimuli: evidence from event-related potentials. *Cognitive, Affective and Behavioral Neuroscience* **7**, 18–24.

Kiehl KA, Bates AT, Laurens KR, Hare RD, Liddle PF (2006). Brain potentials implicate temporal lobe abnormalities in criminal psychopaths. *Journal of Abnormal Psychology* **115**, 443–453.

Kiehl KA, Hare RD, Liddle PF, McDonald JJ (1999). Reduced P300 responses in criminal psychopaths during a visual oddball task. *Biological Psychiatry* **45**, 1498–1507.

Kramer MD, Patrick CJ, Krueger RF, Gasperi M (2012). Delineating physiologic defensive reactivity in the domain of self-report: phenotypic and etiologic structure of dispositional fear. *Psychological Medicine* **42**, 1305–1320.

Lang P, Bradley M, Cuthbert B (1999). *International Affective Picture System (IAPS): Technical Manual and Affective Ratings*. University of Florida, Center for Research in Psychophysiology: Gainsville.

Lang PJ, Bradley MM, Cuthbert BN (1992). A motivational analysis of emotion: reflex-cortex connections. *Psychological Science* **3**, 44–49.

Lang PJ, Bradley MM, Cuthbert BN (1997). Motivated attention: affect, activation, and action. In *Attention and Orienting: Sensory and Motivational Processes* (ed. P. J. Lang, R. F. Simons and M. T. Balaban), pp. 97–135. Lawrence Erlbaum Associates Publishers: Mahwah.

Lang PJ, Greenwald MK, Bradley MM, Hamm AO (1993). Looking at pictures: affective, facial, visceral, and behavioral reactions. *Psychophysiology* **30**, 261–273.

Lilienfeld SO, Andrews BP (1996). Development and preliminary validation of a self-report measure of psychopathic personality traits in noncriminal populations. *Journal of Personality Assessment* **66**, 488–524.

Lovrich D, Novick B, Vaughan HG (1988). Topographic analysis of auditory event-related potentials associated with acoustic and semantic processing. *Electroencephalography and Clinical Neurophysiology/Evoked Potentials Section* **71**, 40–54.

Marsh AA, Finger EC, Mitchell DGV, Reid ME, Sims C, Kosson DS, Towbin KE, Leibenluft E, Pine DS, Blair RJR (2008). Reduced amygdala response to fearful expressions in children and adolescents with callous–unemotional traits and disruptive behavior disorders. *American Journal of Psychiatry* **165**, 712–720.

Newman JP, Schmitt WA, Voss WD (1997). The impact of motivationally neutral cues on psychopathic individuals: assessing the generality of the response modulation hypothesis. *Journal of Abnormal Psychology* **106**, 563–575.

O'Connor S, Bauer L, Tasman A, Hesselbrock V (1994). Reduced P3 amplitudes are associated with both a family history of alcoholism and antisocial personality disorder. *Progress in Neuro-Psychopharmacology and Biological Psychiatry* **18**, 1307–1321.

Patrick CJ (1994). Emotion and psychopathy: startling new insights. *Psychophysiology* **31**, 319–330.

Patrick CJ, Bernat EM (2009). Neurobiology of psychopathy: a two process theory. In *Handbook of Neuroscience for the Behavioral Sciences*, vol. **2** (ed. G. G. Berntson and J. T. Cacioppo), pp. 1110–1131. John Wiley & Sons Inc.: Hoboken.

Patrick CJ, Bernat EM, Malone SM, Iacono WG, Krueger RF, McGue M (2006). P300 amplitude as an indicator of externalizing in adolescent males. *Psychophysiology* **43**, 84–92.

Patrick CJ, Bradley MM, Lang PJ (1993). Emotion in the criminal psychopath: startle reflex modulation. *Journal of Abnormal Psychology* **102**, 82–92.

Patrick CJ, Fowles DC, Krueger RF (2009). Triarchic conceptualization of psychopathy: developmental origins of disinhibition, boldness, and meanness. *Development and Psychopathology* **21**, 913–938.

Patrick CJ, Zempolich KA, Levenston GK (1997). Emotionality and violent behavior in psychopaths: a biosocial analysis. In *Biosocial Bases of Violence* (ed. A. Raine, P. A. Brennan, D. P. Farrington and S. A. Mednick), pp. 145–161. Plenum Press: New York.

Raine A (1993). *The Psychopathology of Crime: Criminal Behavior as a Clinical Disorder*. Academic Press: San Diego.

Rogers R, Duncan JC, Lynett E, Sewell KW (1994). Prototypical analysis of antisocial personality disorder: DSM-IV and beyond. *Law and Human Behavior* **18**, 471–484.

Roth WT, Dorato KH, Kopell BS (1984). Intensity and task effects on evoked physiological responses to noise bursts. *Psychophysiology* **21**, 466–481.

Schupp HT, Cuthbert BN, Bradley MM, Birbaumer N, Lang PJ (1997). Probe P3 and blinks: two measures of affective startle modulation. *Psychophysiology* **34**, 1–6.

Schupp HT, Cuthbert BN, Bradley MM, Hillman CH, Hamm AO, Lang PJ (2004). Brain processes in emotional perception: motivated attention. *Cognition and Emotion* **18**, 593–611.

Semlitsch HV, Anderer P, Schuster P, Presslich O (1986). A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. *Psychophysiology* **23**, 695–703.

Vaidyanathan U, Hall JR, Patrick CJ, Bernat EM (2011). Clarifying the role of defensive reactivity deficits in psychopathy and antisocial personality using startle reflex methodology. *Journal of Abnormal Psychology* **120**, 253–258.

Venables NC, Patrick CJ, Hohman K, Tennenbaum R, Bernat EM (2010). Coherence among variants of P3 from differing tasks as indicators of the antisocial deviance factor of criminal psychopathy. *Psychophysiology* **47**, S53–S54.

Viding E, Blair RJR, Moffitt TE, Plomin R (2005). Evidence for substantial genetic risk for psychopathy in 7-year-olds. *Journal of Child Psychology and Psychiatry* **46**, 592–597.

Vizueta N, Patrick CJ, Jiang Y, Thomas KM, He S (2012). Dispositional fear, negative affectivity, and neuroimaging response to visually suppressed emotional faces. *Neuroimage* **59**, 761–771.