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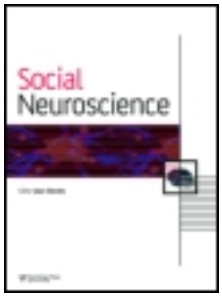

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Affective startle potentiation in juvenile offenders: The role of conduct problems and psychopathic traits

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Emotion processing difficulties are observed in antisocial individuals exhibiting serious antisocial behavior. This study examined emotion processing in 40 male juvenile offenders (JOs) and 52 male controls by measuring startle reflex responses to aversive sounds during the passive viewing of affective and neutral images. JOs as a group exhibited reduced startle-elicited blinks across all slide categories compared to normal controls. Moreover, within the offender group those with more conduct disorder symptoms and higher levels of psychopathic traits displayed reduced startle amplitudes compared to lower-scoring offenders. The finding that startle magnitudes were inversely related to severity of conduct problems supports a dimensional or continuous approach to understanding externalizing disorders. Reductions in amygdala activity could lead to blunted startle magnitudes. The current findings not only provide further evidence that antisocial children have a general defensive motivational system dysfunction and present with impairments in neural systems that subserve emotion processing, but also show for the first time that those with more severe conduct problems have reduced startle responses compared to those who are less severely affected. The implications of these findings for interventions with JOs are discussed.

Keywords: Juvenile delinquency; Emotion; Psychopathy; Conduct problems; Startle.

Emotional impairments, specifically those related to learning and processing, play an important role in explanations of antisocial behavior. Abnormal emotion processing is reported in different antisocial populations, such as adolescents with psychopathic tendencies (Blair, Colledge, Murray, & Mitchell, 2001), adolescents with early-onset or adolescence-onset conduct disorder (CD; Fairchild, van Goozen, Stollery, & Goodyer, 2008, 2010; Passamonti et al., 2010), and children with disruptive behavior disorders (DBDs; van Goozen, Snoek, Matthys, van Rossum, & van Engeland, 2004). The observation that emotion processing difficulties are present in those who exhibit antisocial behavior has stimulated researchers to find objective measures, such as psychophysiological indices, to better understand the relationship between emotion processing impairments and antisocial behavior.

Although research in children with CD or callous–unemotional traits, using a wide range of methods (including the recognition of emotional faces, autonomic reactivity, and fMRI) generally supports the notion that they have deficits in the processing and experience of negative affect, it is unclear to what

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extent this deficit is a general one (e.g., Fairchild et al., 2008, 2009; Glass & Newman, 2006; Herpertz et al., 2001, 2005; Marsh & Blair, 2008), or one specifically related to fear (e.g., Dadds et al., 2006; Jones, Laurens, Herba, Barker, & Viding, 2009; Marsh et al., 2008) or sadness (e.g., Blair, 1999; Dolan & Fullam, 2006; Fairchild et al., 2010).

Another important theoretical issue involves the role of psychopathic traits in children's conduct problems. Only a minority of those with conduct problems score high on psychopathic traits and it has been claimed that this subgroup in particular shows a severe and violent pattern of behavior (Frick & White, 2008; Leistico, Salekin, DeCoster, & Rogers, 2008) and distinct cognitive and emotional deficits compared with other antisocial individuals. Although there is support for this latter claim (e.g., Blair, Mitchell, & Blair, 2005; Blair, Peschardt, & Budhani, 2006; Frick & White, 2008; Patrick, 2007), other studies have failed to find clear neurocognitive or emotional differences between CD children with and without psychopathic traits (Fairchild et al., 2009, 2010, 2011; Passamonti et al., 2010).

It is possible that the discrepancy in findings may result from differences in population and measurement. For example, some studies used clinic-referred children and psychiatric assessments (Fairchild et al., 2008, 2010; Herpertz et al., 2005; Sterzer, Stadler, Poustka, & Kleinschmidt, 2007; van Goozen et al., 2004), whereas others involved children recruited from the community (e.g., schools), focused on personality features (e.g., callous–unemotional traits), and used less thorough screenings for conduct problems (Frick, Cornell, Barry, Bodin, & Dane, 2003; Jones et al., 2009). An important goal of the present study was to investigate whether it was possible to disaggregate conduct problems and psychopathic traits, and their associated emotion deficits, in a sample of juvenile offenders (JOs), a community-based group with elevated criminal and externalizing behaviors, that has been studied less than clinic-referred groups (but see Popma et al., 2007; Syngelaki, Moore, Savage, Fairchild, & Van Goozen, 2009).

With regard to brain function, the amygdala is thought to play a critical role in emotion processing. Both neuropsychological (e.g., Angrilli et al., 1996; Bechara, Tranel, Damasio, & Damasio, 1996) and neuroimaging studies (e.g., Birbaumer et al., 2005; Buchel, Morris, Dolan, & Friston, 1998) have emphasized the critical role of the amygdala in emotion processing. Amygdala damage disproportionately affects the recognition of fear and anger (e.g., Adolphs, Tranel, Damasio, & Damasio, 1995; Calder et al., 1996), and heightened amygdala activation is observed when individuals view fearful faces or negatively valenced images (Adolphs et al., 1999; Morris et al., 1996; Schaefer et al., 2002; Whalen et al., 1998). Evidence suggestive of a relationship between amygdala volume and antisocial behavior were reported in structural neuroimaging studies showing that gray matter volume in the left amygdala is reduced in CD patients (Fairchild et al., 2011; Huebner et al., 2008; Sterzer et al., 2007). Recent functional neuroimaging studies have found reduced amygdala activation when CD adolescents view aversive images, when controlling for anxiety/depression symptoms (Sterzer, Stadler, Krebs, Kleinschmidt, & Poustka, 2005), and amygdala hypoactivity when conduct-disordered youngsters with callous–unemotional traits view images of fearful faces (Jones et al., 2009; Marsh et al., 2008).

Deficits in orbitofrontal cortex (OFC) function are associated with emotion regulation problems. Blair (2004) has suggested that OFC dysfunction might occur as a consequence of amygdala dysfunction. Angrilli, Bianchin, Radaelli, Bertagnoni, and Pertile (2008) found reduced startle amplitudes and lower self-reported unpleasantness in participants with polar OFC lesions who were presented with an abrupt burst of white noise. This finding suggests that the OFC is not only involved in secondary aspects of emotions, as previously thought (Adolphs, 1999), but may also regulate primary emotional responses in tandem with the amygdala. In addition, the amygdala and OFC are part of a motivational neural circuit (Lang, Davis, & Öhman, 2000) that comprises the brain's threat response system. This defense system is activated by fear as evidenced in the "fear-potentiated startle" paradigm where viewing unpleasant images elicits an exaggerated startle reflex in response to an abrupt aversive auditory probe (Lang et al., 2000). OFC findings with fMRI/SMRI in CD children show reduced OFC activity to reward in early-onset CD (Rubia et al., 2009), and abnormal OFC responses during facial emotion processing in both early- and adolescence-onset CD (Passamonti et al., 2010); Huebner et al. (2008) observed lower OFC volumes in early-onset CD.

The startle paradigm differentiates between psychophysiological responses to positively and negatively valenced stimuli. Electromyographic (EMG) recording methods are sensitive to different affective states: larger startle responses occur when participants react to acoustic probes as they view negatively valenced stimuli, whereas they show smaller responses when viewing positively valenced stimuli (Levenston,

Patrick, Bradley, & Lang, 2000; Vrana, Spence, & Lang, 1988).

Until now, only three studies examined the affective potentiation of the startle reflex in antisocial youths (Fairchild et al., 2008, 2010; van Goozen et al., 2004). In all the three studies, startle magnitudes were lower in children or adolescents with CD across valence categories when compared with normal control (NC) participants, but the clinical groups appeared to show a normal pattern of affective modulation. These data suggest that augmentation of the startle reflex by negative visual stimuli is broadly intact in those with CD, in contrast with adult psychopaths [Patrick, Bradley, & Lang, 1993; but see Herpertz et al. (2001) for a similar general deficit in processing affective information in psychopathic offenders] and may be interpreted as evidence for reduced tonic innervation of the brainstem startle circuit by the amygdala in CD, because previous studies have shown reduced startle magnitudes in those with circumscribed amygdala lesions (Angrilli et al., 1996; Kettle, Andrewes, & Allen, 2006).

As mentioned above, it is currently unclear whether CD/psychopathic children have a general deficit in processing negatively valenced stimuli or a specific deficit in the processing of threat- or distress-related information (e.g., fearful or sad facial expressions or images of others in distress). In the current study, we used different categories of negatively valenced pictures with the aim of dissociating startle reflex primes to fearful, disgust-related, and sad images. The significance of identifying startle reflex potentiation by different negative stimuli can have important implications in terms of assessing and interpreting potential impairments. We examined emotion processing in antisocial adolescents recruited through youth offending services rather than mental health services. Community-based services would typically see a large number of youngsters whose combined offending produces the majority of harm, compared to juveniles identified as in need of specialist treatment. Community services are also a locus that has received little systematic attention into what might construe theoretically robust interventions. If emotion impairments are systematically related to seriousness of antisocial behavior in community-based JOs, this would not only have important implications for the development and design of interventions targeting prolific offender groups, but would also provide further evidence that insights developed with clinically significant groups generalize to a much larger group of youngsters who come into contact with the offending services for a wide range of different types of antisocial behavior.

The motivation behind carrying out research on JOs is to ultimately inform the provision of resources that can reduce harm endured by victims and their communities. Clearly, there are important differences in the frequency and severity of harm inflicted by JOs, and it seems theoretically plausible to predict that more prolific or more serious offenders might have more severe impairments in emotion processing. Thus, another important goal of the study was to examine the effect of severity of antisocial problems on emotion processing by investigating whether level of CD symptoms and/or psychopathic traits could explain variance in startle responses within the JO group.

We predicted, first, that reductions in affective startle magnitudes would be more pronounced in JOs than in male controls and, second, that these reductions would be more pronounced in offenders with more serious conduct problems and those scoring high in psychopathic traits.

MATERIALS AND METHODS

Participants

The research was conducted after obtaining ethical clearance from the Cardiff University's School of Psychology Research Ethics Committee. All participants and their parents or carers provided written informed consent. Participants were 42 young males, aged 12–18 years (mean age = 15.96, SD = 1.57) recruited from the Youth Offending Service (YOS) in Cardiff. These participants were required by the local courts to attend the YOS for rehabilitation. Eligibility criteria were only that participants demonstrated an IQ greater than 75, as estimated using the Vocabulary and the Block Design subtests of the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999). For the purpose of comparing startle reflex responses with the JO group, control participants were recruited from local secondary schools and the student population ($n = 52$).

Severity of antisocial behavior and psychopathic traits

Youth Psychopathic Traits Inventory

The Youth Psychopathic Traits Inventory (YPI; Andershed, Kerr, Stattin, & Levander, 2002) measured JOs' psychopathic tendencies. The total score, which ranges from 50 to 200, is divided by 50 to give a score of 1–4, with a higher score indicating more psychopathic traits. Participants scoring above a cut-off of 2.5 are classified as high in psychopathic

traits (Skeem & Cauffman, 2003). Using this cut-off score, we created high and low psychopathic trait groups within the JO subgroup (JO/PS+ and JO/PS–, respectively).

Youth Self-Report

The Youth Self-Report (YSR; Achenbach, 1991) assesses a range of behavioral problems following DSM-IV criteria and is widely used in community-based and clinical researches on problem behavior in youths. Each item is rated on a scale of 0–2, with 0 corresponding to "not true," 1 corresponding to "sometimes true," and 2 corresponding to "very or often true." The Conduct Disorder and Attention Deficit Hyperactivity Disorder (ADHD) symptom subscales of the YSR were used to classify young offenders in terms of the borderline/clinical ($\geq$67) or normal range ($<$67) of clinically defined symptoms of CD and ADHD based on their individual standardized *t*-scores (Achenbach, 1991).

Substance use

Information on substance misuse for each young person was taken from the section on "substance use" in the Asset interview (Baker, Jones, Roberts, & Merrington, 2002) as conducted by the young persons' case worker at the YOS. Information is provided about different substance-use categories, ranging from tobacco and alcohol, to more serious use of cocaine, crack or heroin, age at first use, and whether use is recent. Other information conveyed in this section relates to whether the young person has a positive attitude toward using substances, whether substance use is affecting daily functioning, and whether there are any links with offending behavior, such as offending to obtain money for substances. Based on this information, a score of 0–4 is given, which reflects the rating by the case worker of the young person's substance use being associated with the likelihood of further offending in the future (0 = not associated, 4 = very strongly associated).

Fast Alcohol Screening Test

The Fast Alcohol Screening Test (FAST; Hodgson, Alwyn, John, Thom, & Smith, 2002) is a four-item, self-report questionnaire designed to screen for hazardous, harmful, and dependent drinking. The FAST was developed from the longer Alcohol Use Disorders Identification Test (AUDIT) and validated in over 3000 patients in various medical settings. The FAST score ranges between 0 and 16, and the measure has good internal (Cronbach's alpha = 0.77) and test–retest reliability ($>$0.80).

Measurement of the startle reflex

Startle-elicited blinks in response to an aversive tone were assessed while participants viewed differently valenced pictures taken from the International Affective Pictures System (IAPS; Lang, Bradley, & Cuthbert, 2008). Forty-five slides were shown, of which nine were positive, nine neutral, nine depicted disgust, nine depicted sad, and nine depicted fearful images (see Appendix for relevant slide numbers). The mean normative arousal ratings on a scale of 1, for lowest arousal, to 9, for highest arousal possible were: positive (5.5), neutral (2.6), sad (4.9), disgust (6.0), and fear (6.3). Similarly, for the affective valence dimension, ranging from unpleasant to pleasant, the mean normative ratings were: positive (7.6), neutral (5.1), sad (2.3), disgust (2.0), and fear (3.2). Thirty-one slides were paired with a loud (99 dB) aversive white noise, with six startled slides for each emotional category (the first slide paired with the white noise was a neutral one and its response was not included in the analyses). The order in which the slides were shown was pseudo-random and identical for all participants. The slides were shown for 10 seconds with an inter-trial interval of 10 seconds.

Electromyographic (EMG) measurements were taken by placing Ag/AgCl electrodes on the surface of the skin; one electrode was placed on the forehead and two others over the orbicularis oculi muscle under the left eye, according to the guidelines (Tassinary & Cacioppo, 2000). On startle trials, a white noise lasting 0.4 seconds was presented binaurally through headphones either 2.5, 3.5, or 4.5 seconds after slide onset. EMG was recorded with a range of 200 μV and a bandpass of 30–500 Hz, using an EMG amplifier (PSYCHLAB Contact Precision Instruments, Cambridge, MA, USA).

Data analyses

In order to examine differences in IQ, one-way analyses of variance (ANOVAs) were used. Startle reflex magnitudes were normally distributed for all of the emotional categories. Slide valence was used as a within-subjects factor for the repeated-measures ANOVA conducted to test for differences in startle reflex amplitude, with group (NC vs. JO) as a between-subjects factor. Dependent measures were startle reflex

magnitudes to different affective pictures. Simple main effects were used for post hoc comparisons between the two groups.

For the purpose of within-group comparisons, repeated-measures ANOVAs were conducted within the offender group (with JO/CD+ vs. JO/CD–, and JO/PS+ and JO/PS–) as between-subject factors and slide valence as within-subject factor.

Degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity, where the assumption of sphericity was violated. Effect sizes are reported as partial eta squared (η_p^2; small ≥ 0.01, medium ≥ 0.06, large ≥ 0.14; Cohen, 1988). Analyses were carried out using SPSS 14.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Demographic information

An ANOVA indicated that startle amplitudes did not differ between the control groups (i.e., secondary school pupils and students) for any emotion category [i.e., neutral: $F(1,51) < 1$; positive: $F(1,51) < 1$; fear: $F(1,51) = 1.708$, $p = .197$; sad: $F(1,51) = 2.186$, $p = .146$; disgust: $F(1,51) < 1$], nor were there significant associations between age and startle response. Therefore, the data from these groups were collapsed for analytic purposes and a single-control group was used subsequently.

Similar to the well-established association between lower verbal IQ and delinquency/antisocial behavior (Lynam, Moffitt, & Stouthamer-Loeber, 1993), we observed a difference in estimated IQ between the NC and JO groups [IQ: $F(1,56) = 13.91$, $p < .01$] with the control group having significantly higher estimated IQs [mean NC = 107.13 (SD = 9.93)] than the JO group [mean JO = 94.69 (SD = 11.70)]. There was also a significant difference in age [mean NC = 17.9 (SD = 1.86), mean JO = 16.0 (SD = 1.59), $p < .05$]. However, because neither IQ nor age was associated with EMG response to slides (with r's between IQ and EMG amplitudes to the five valence categories ranging between 0.026 and 0.096 (ns.), and r's with age ranging between −0.09 and 0.103, ns.), these variables were not regarded as confounding factors and therefore not accounted for in subsequent analyses.

Effects of habituation on startle response

A repeated-measures ANOVA showed a main effect of time [$F(5,390) = 7.86$, $p < .001$, $\eta_p^2 = 0.09$], a main effect of group [$F(1,90) = 10.31$, $p < .01$, $\eta_p^2 = 0.12$], but no group–time interaction in startle response to the neutral slides. Both the groups showed habituation, but the JO group responded with lower blink magnitudes than the NC group across all neutral slides.

Effect of startle potentiation on valence

There was a main effect of slide valence on startle response amplitudes [effect of valence: $F(3.36,90) = 13.77$, $p < .001$, $\eta_p^2 = 0.13$]. Post hoc comparisons showed that blink amplitudes were smaller when viewing positive slides relative to most of the negatively valenced slides ($p < .001$ compared to disgust and fear; no significant difference for sad), with no significant difference relative to the neutral slides ($p > .05$). When viewing disgust and fearful slides, participants showed larger startle amplitudes, relative to positive, neutral, and sad slides ($p < .001$ for neutral and positive, $p < .05$ for sad).

Between group comparisons: NC vs. JO

There was a main effect of group on startle magnitude [$F(1,90) = 17.12$, $p < .001$, $\eta_p^2 = 0.16$], but no interaction between slide valence and group ([$F(4,90) = 1.06$, $p = .38$, $\eta_p^2 = 0.01$]. Thus, the JO group showed a similar pattern of affective potentiation as the controls, but with consistently lower startle responses across all emotional categories (see Figure 1).

Within-group comparisons: Effects of CD symptoms and psychopathic traits within JOs

The mean conduct problem t-score on the YSR for the JO group was 65.24. Twenty-one JOs scored in

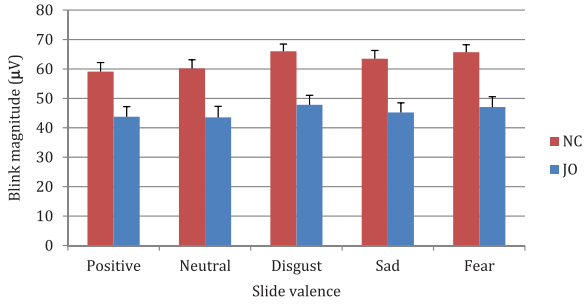

Figure 1. Effect of slide valence on mean startle magnitude according to group status.
NC = normal control; JO = juvenile offender.

the borderline/clinical range (mean JO/CD+ = 73.52, SD = 6.27) and 19 JOs scored in the normal range (mean JO/CD− = 56.95, SD = 4.69). We directly compared these YSR-categorized subgroups and observed a significant effect of CD subgroup [$F(1,38) = 4.89$, $p = .03$; $\eta_p^2 = 0.11$] and slide category [$F(4, 38) = 3.48$, $p < .01$; $\eta_p^2 = 0.08$], but no interaction between CD subgroup and slide category [$F(4, 38) = 1.01$, $p = .40$] (Figure 2).

The mean YPI total score for the group of JOs was 2.36; 26 JOs scored below the mean YPI cut-off score of 2.5 and were classified as being low in psychopathic traits (mean YPI total score for JO/PS– = 2.11, SD = 0.26) whereas 14 YOs scored above this criterion (mean YPI total score for JO/PS+ = 2.86, SD = 0.28). When directly comparing the high and low YPI subgroups, there was a significant effect of slide category [$F(4, 38) = 2.63$, $p < .05$; $\eta_p^2 = 0.07$], and YPI subgroup [$F(1,38) = 4.67$, $p < .05$, $\eta_p^2 = 0.11$], but no interaction between YPI subgroup and slide category [$F(4, 38) = 0.76$, $p = .55$] (Figure 3).

When the startle responses to the five categories of slides were entered in a stepwise linear regression, the startle response to fearful slides emerged as the only significant predictor of YSR conduct problem *t*-scores ($\beta = -0.39$, $t = -2.60$, $p < .02$) and YPI psychopathy scores ($\beta = -0.38$, $t = -2.59$, $p < .02$). When we simultaneously entered YSR conduct problem *t*-scores and YPI psychopathy scores in a regression predicting startle magnitudes to fearful slides, only YSR conduct problem scores were a significant predictor ($\beta = -0.39$, $t = -2.60$, $p < .02$; YPI score: $t = -1.23$, ns).

In terms of substance misuse data, 28 JOs received an Asset rating of 0 and 12 JOs received a rating of 1–4; in terms of the FAST score 18 JOs reported low levels of drinking (FAST < 2) and 22 JOs reported hazardous alcohol consumption (FAST > 2). When we compared these Asset and FAST subgroups in terms of their startle responses to the five categories of slides, we found no significant difference between the high and low Asset/FAST subgroups on any of the slide categories. Similarly, with respect to ADHD symptoms 12 JOs scored in the borderline/clinical range and 28 JOs scored in the normal range, but these groups did not differ in startle responses to the five slide categories.

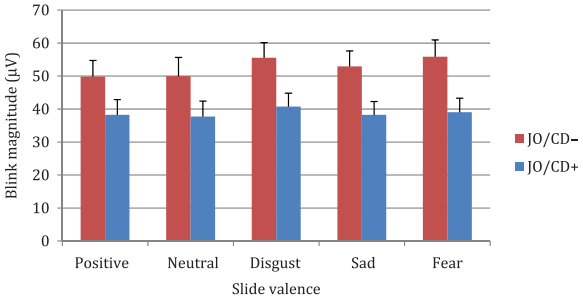

Figure 2. Effect of slide valence on mean startle magnitude in juvenile offenders with and without borderline/clinical CD.
JO/CD+ = juvenile offender with borderline/clinical CD; JO/CD– = juvenile offender without borderline/clinical CD.

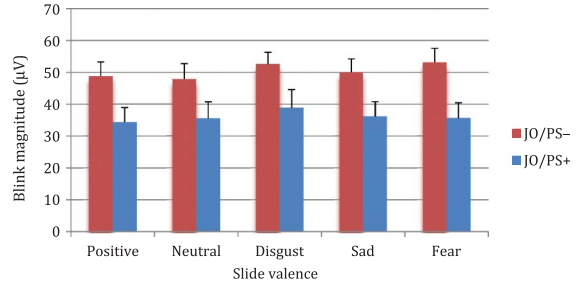

Figure 3. Effect of slide valence on mean startle magnitude in juvenile offenders high and low in psychopathic traits.
JO/PS+ = juvenile offender high in psychopathic traits; JO/PS– = juvenile offender low in psychopathic traits.

Do less serious offenders differ from control subjects?

Lastly, we wanted to investigate whether young offenders with less serious conduct problems and young offenders low in psychopathic traits showed altered patterns of affective modulation or reduced startle magnitudes relative to NCs. To that end, we compared NC vs. JO/CD– and NC vs. JO/PS–. There was a marginally significant main effect of group for the former comparison [$F(1, 69) = 3.63$, $p = .06$; $\eta_p^2 = 0.05$]. A separate analysis comparing low psychopathic offenders with NCs again indicated a main effect of group [$F(1, 76) = 6.76$, $p = .01$; $\eta_p^2 = 0.08$], with simple effects comparisons showing that the JO/PS– group displayed significantly lower responses than the controls on disgust ($p < .01$), sad ($p < .01$), fear ($p = .01$), and neutral ($p = .026$) slides.

DISCUSSION

The aim of this study was to investigate emotion processing in JOs by assessing startle reflex modulation by different categories of emotional stimuli. We also investigated whether overall startle reflex magnitudes

were reduced in JOs given previous findings showing attenuated startle magnitudes across all slide categories in clinic-referred children with DBDs (van Goozen et al., 2004) or adolescents with CD (Fairchild et al., 2008, 2010). Additionally, the potential effects of within-group variations in conduct problems and psychopathic traits were examined, providing novel findings of the effect of CD severity and variation in psychopathic traits on startle magnitudes.

Young offenders demonstrated lower eye-blink responses across all five emotion categories relative to controls, but no differences in the pattern of affective modulation. These findings suggest a general reduction in autonomic responses in JOs, similar to prior research on children or adolescents with DBDs (Fairchild et al., 2008, 2010; Herpertz et al., 2005; van Goozen et al., 2004), while research in adult psychopaths has shown abnormal startle modulation by negatively valenced pictures (Levenston et al., 2000; Patrick et al., 1993). Our findings are in line with electrodermal data reported by Herpertz et al. (2005), who showed autonomic hyporeactivity to all categories of IAPS slides in boys with CD. The current results, together with evidence from research in children (van Goozen et al., 2004) and adolescents with CD (Fairchild et al., 2008, 2010), show that antisocial youngsters exhibit lower blink magnitudes generally, rather than specifically during the presentation of negative slides, and suggest that different groups of antisocial youngsters show a similar pattern of reduced physiological reactivity. This is the first time that such a study has been conducted with a group of JOs. The findings from the current study provide support for reduced physiological arousal in response to affective stimuli in adolescent males, who have been in contact with the criminal justice system. Tonic reductions in amygdala activity could lead to blunted startle magnitudes when viewing all slide categories (Angrilli et al., 1996; Kettle et al., 2006). The current findings provide further evidence that antisocial children have a general defensive system dysfunction and present with impairments in neural systems that subserve emotion processing (Fairchild et al., 2008, 2010; Herpertz et al., 2005).

Separate analyses were carried out in order to investigate whether differences in startle reflex modulation existed between more and less serious JOs. More delinquent CD children have been found to show lower startle responses to negative slides (van Goozen et al., 2004), a pattern similar to that in adult psychopaths (Levenston et al., 2000). Lower startle magnitudes were indeed observed in offenders scoring in the borderline/clinical range on the YSR CD scale and in those with high levels of psychopathic traits relative to low-scoring young offenders, and the differences were most striking when comparing responses with negatively valenced slides. Importantly, there was no effect of substance misuse or ADHD symptoms on emotion processing within the group of JOs.

The fact that startle magnitudes were found to be negatively related to the severity of antisocial problem behavior, specifically (NC > low JOs > high JOs) supports a dimensional or continuous approach to externalizing disorders rather than a categorical one, as even the JOs with low levels of CD symptoms, who would probably not meet full diagnostic criteria for CD, differed from controls. The fact that startle magnitudes were also significantly lower in young offenders with low psychopathy scores is also interesting, as it implies that antisocial behavior is more important than being high in psychopathy in explaining abnormalities in startle responses. This conclusion is supported by the results of the regression analyses, which showed that variation in fear-potentiated startle responses was better predicted by CD problem severity than psychopathic trait scores.

The current data do not fit well with current psychopathy-based theories in this area (Frick & Viding, 2009; Moffitt et al., 2008), which either argue that emotion/neurological deficits should *only* be present in antisocial individuals who are high in psychopathic or CU traits, or propose qualitatively different patterns of emotional impairment in low versus high psychopathic trait CD groups (increased vs. reduced emotional reactivity, respectively; Hodgins, de Brito, Simonoff, Vloet, & Viding, 2009).

A limitation of our study is that the JO group had a significantly lower estimated IQ score than the control group. School in-attendance and educational failure in general are well-known phenomena in JOs, and it is therefore hardly surprising that they differed in this respect from our controls (Lynam et al., 1993). However, IQ did not correlate with EMG responding, and we therefore concluded that this factor was not a confounding factor in our main analyses.

For ethical reasons, we applied positive and negative stimuli from the IAPS that were rather low in arousal ratings, and it is possible that this particular selection of slides may have played a role in the absence of a group–valence interaction found in this sample.

Recently, there has been much interest in the role of biological risk factors in the prediction of antisocial and criminal behavior later in life (Pine, 2010; Sterzer, 2010). As pointed out by Sterzer (2010), attempts to identify subgroups of at-risk individuals based on

distinct neurobiological profiles can crucially influence the development of preventive and therapeutic interventions.

The present study could have important implications for policy in the criminal justice system and practitioners working with young offenders. For example, risk assessments involving different aspects of emotion functioning should be considered. The current findings also stress the need for taking offenders' individual differences into account when setting up programs to tackle the young person's behavioral problems (van Goozen & Fairchild, 2008). Still, more research is needed to better understand how these emotion processes relate to behavior. While we showed that young offenders generally show lower physiological arousal, a next step could be to evaluate how these processes might affect intervention/treatment and longer-term outcome. Such evaluations could prove helpful in ensuring that limited resources are deployed in a more efficient way and lead to theoretically robust interventions.

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APPENDIX

The following were the 45 pictures employed, by International Affective Pictures System (IAPS) identification number: positive: 1440, 1710, 2352, 8190, 8380, 8461, 8490, 8496, 8531; neutral: 6150, 7000, 7002, 7006, 7009, 7080, 7090, 7140, 7150; sad: 2800, 2900, 3300, 9040, 9041, 9421, 9560, 9561, 9921; disgust: 3000, 3060, 3071, 3110, 3150, 3400, 9181, 9042, 9320; and fear: 1050,1201, 1280, 1300, 1931, 3500, 6244, 6260, 6370.