The Journal of Child Psychology and Psychiatry

Journal of Child Psychology and Psychiatry 59:3 (2018), pp 247–257 doi:10.1111/jcpp.12795

Facial emotion recognition and eye movement behaviour in conduct disorder

N.A. Martin-Key,[1] E.W. Graf,[1] W.J. Adams,[1,†] and G. Fairchild[2,†]

[1]Department of Psychology, University of Southampton, Southampton; [2]Department of Psychology, University of Bath, Bath, UK

Background: Conduct Disorder (CD) is associated with impairments in facial emotion recognition. However, it is unclear whether such deficits are explained by a failure to attend to emotionally informative face regions, such as the eyes, or by problems in the appraisal of emotional cues. **Method:** Male and female adolescents with CD and varying levels of callous-unemotional (CU) traits and age- and sex-matched typically developing (TD) controls (aged 13–18) categorised the emotion of dynamic and morphed static faces. Concurrent eye tracking was used to relate categorisation performance to participants' allocation of overt attention. **Results:** Adolescents with CD were worse at emotion recognition than TD controls, with deficits observed across static and dynamic expressions. In addition, the CD group fixated less on the eyes when viewing fearful and sad expressions. Across all participants, higher levels of CU traits were associated with fear recognition deficits and reduced attention to the eyes of surprised faces. Within the CD group, however, higher CU traits were associated with *better* fear recognition. Overall, males were worse at recognising emotions than females and displayed a reduced tendency to fixate the eyes. **Discussion:** Adolescents with CD, and particularly males, showed deficits in emotion recognition and fixated less on the eyes when viewing emotional faces. Individual differences in fixation behaviour predicted modest variations in emotion categorisation. However, group differences in fixation were small and did not explain the much larger group differences in categorisation performance, suggesting that CD-related deficits in emotion recognition were not mediated by abnormal fixation patterns. **Keywords:** Conduct disorder; callous-unemotional traits; emotion recognition; eye tracking; sex differences.

Introduction

Conduct disorder (CD) is a pervasive and persistent form of disruptive behaviour that is characterised by the violation of other people's rights or age-appropriate societal norms (American Psychiatric Association, 2013). CD is more common in males than in females (Moffitt, Caspi, Rutter, & Silva, 2001), and reflecting this, most research on this disorder has been conducted using male-only samples. However, CD is associated with similar neuropsychological impairments in males and females, including lower verbal IQ (Lynam, Moffitt, & Stouthamer-Loeber, 1993; Moffitt & Silva, 1988; Pajer et al., 2008), deficits in autonomic fear conditioning (Fairchild, Stobbe, van Goozen, Calder, & Goodyer, 2010; Fairchild, Van Goozen, Stollery, & Goodyer, 2008) and reduced eye-blink startle responses (Fairchild et al., 2008, 2010). While research has demonstrated that CD is associated with impairments in facial emotion recognition in males and females (Fairchild, Van Goozen, Calder, Stollery, & Goodyer, 2009; Fairchild et al., 2010; Schwenck et al., 2012, 2014; Short, Sonuga-Barke, Adams, & Fairchild, 2016; Sully, Sonuga-Barke, & Fairchild, 2015), the underlying cause(s) of these deficits are not well understood. They could reflect difficulties with attention (e.g., impaired orienting to the eye region of the face) and/or appraisal (interpretation of stimuli that have been successfully encoded).

There is accumulating evidence that young people with callous-unemotional (CU) traits, i.e., a lack of concern for other people's feelings, superficial affect and a reduced ability to feel guilt (Pardini & Frick, 2013), are impaired in recognising fearful facial expressions (Marsh & Blair, 2008). This has been associated with a failure to attend to emotionally relevant regions of the face, such as the eyes (Dadds, El Masry, Wimalaweera, & Guastella, 2008; Dadds et al., 2006). Healthy individuals, and particularly females, show a preference for the eyes when viewing faces (Hall, Hutton, & Morgan, 2010). Moreover, this preference has been positively associated with facial expression recognition accuracy (Hall et al., 2010); attending to the eyes appears to be important for recognition of all emotions (Spezio, Adolphs, Hurley, & Piven, 2007).

To date, only one study has examined eye movements in male adolescents with CU traits. The authors found selective deficits in fear recognition in those who were high in CU traits (Dadds et al., 2008). Notably, this group fixated less on the eyes than the low CU traits group. Interestingly, when instructed to look at the eye region, the deficit in fear recognition in the high CU traits group was ameliorated (Dadds et al., 2008), suggesting underlying problems with attentional allocation, rather than appraisal. Notably, this pattern of orienting is similar to that displayed by patients with amygdala damage:

[†]Equal contribution.

Conflict of interest statement: No conflicts declared.

these individuals also demonstrate fear-specific recognition impairments that are improved by asking them to attend to the eyes (Adolphs et al., 2005).

The existing literature raises a number of important questions. First, given that adolescents with clinically diagnosed CD have generally been reported to show global impairments in facial emotion recognition (Fairchild et al., 2009, 2010; Short et al., 2016; Sully et al., 2015), rather than specific difficulties with fear, it is unclear whether these broader difficulties are also explained by attentional deficits. It is therefore of interest to examine whether adolescents with CD show atypical eye movements across a wider range of emotional expressions, and whether atypical fixation patterns explain the more global deficits that have been reported in CD populations. Second, while research has shown similar emotion recognition impairments in males and females with CD (although see Pajer, Leininger, & Gardner, 2010), no studies have included males and females in the same experiment to examine whether the relationship between CD and emotion recognition differs by gender, and it is unclear whether comparable deficits in attention and/or appraisal are present in both sexes. Finally, the majority of studies in this area have used high intensity static facial stimuli that do not resemble the subtlety of expressions that we encounter in everyday life (although see Bowen, Morgan, Moore, & van Goozen, 2013; Schwenck et al., 2012, 2014). By presenting static stimuli across a range of emotional intensities, as well as *dynamic* facial expressions of emotion, we can examine whether individuals with CD show impairments when processing more naturalistic stimuli.

Accordingly, the present study investigated facial emotion recognition in male and female adolescents with CD and varying levels of CU traits, and typically developing (TD) controls. Static facial expressions morphed to display varying emotional intensities and dynamic, full-intensity facial expressions were included. Importantly, the emotion categorisation task was paired with eye tracking methods to assess whether CD-related deficits in emotion recognition could be explained by atypical fixation patterns (e.g., fixating less on the eyes). The secondary aim was to investigate whether CU traits are associated with impaired emotion recognition performance and attention to the eyes, in line with Dadds et al.'s (2008) findings, and whether atypical fixation patterns mediate fear recognition deficits in those with high levels of CU traits.

We predicted that adolescents with CD would show deficits in emotion recognition, particularly for negative emotions such as anger, sadness, and fear, and lower intensity static expressions. In addition, we hypothesised that CD individuals with elevated CU traits would show particularly marked impairments for fear. We predicted that, overall, having CD would be related to a reduced tendency to fixate the eyes and that those with CD and elevated CU traits would show the most pronounced deficits in attending to the eyes, given Dadds et al.'s (2008) findings. Lastly, we hypothesised that deficits in facial emotion recognition in the CD group would be mediated by a failure to fixate the eyes, and that this relationship would be strongest for expressions that are principally communicated via the eyes, such as fear.

Method

Participants

One hundred and twenty-eight adolescents aged 13–18 years were recruited through Youth Offending Services and pupil referral units across Southampton and Hampshire, via referrals from caseworkers, and through mainstream schools and colleges in Southampton via mail-shots. Of these 128, five did not meet the inclusion criteria (see below), six TD and four CD participants could not be successfully eye tracked (either due to technical difficulties or issues with eye tracker calibration), and two TD and 10 CD participants opted not to take part in the laboratory experiment after being interviewed. Thus, the final sample of 101 participants consisted of 50 adolescents (26 male) who met diagnostic criteria for CD, and 51 TD adolescents (26 male). All participants and the parents of those aged below 16 provided written informed consent to participate in the study, which was approved by the University Ethics Committee and the Hampshire County Council Children's Services Research Governance Committee.

Inclusion criteria for the study were: (a) fluency in English; (b) no hard contact lenses or bi/tri-focal glasses; (c) an Intelligence Quotient (IQ) ≥70 (assessed via the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999)); and (d) being free of psychosis or Autism Spectrum Disorder (ASD). All participants were assessed for CD, Oppositional Defiant Disorder (ODD), Attention-Deficit/Hyperactivity Disorder (ADHD), Major Depressive Disorder (MDD), Generalised Anxiety Disorder (GAD), Obsessive Compulsive Disorder (OCD), Psychosis, Post-Traumatic Stress Disorder (PTSD), and Alcohol and Substance Use Disorders using the Schedule of Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime version (K-SADS-PL; Kaufman et al., 1997), a semistructured diagnostic interview based on DSM-IV criteria. ASDs were assessed using the ASD module of the unpublished DSM-5 version of the K-SADS-PL.

Following extensive training and shadowing by experienced staff members, postgraduate students carried out separate diagnostic interviews with participants and caregivers. Regular case conferences were held to discuss difficult or borderline cases and we assessed the inter-rater reliability of CD and other disorders (Cohen's kappas ranged from .87–1.00). Data were combined across informants such that a symptom was considered present if endorsed by either informant, as suggested by Kaufman et al. (1997). CU traits were assessed using the self-report Inventory of Callous-Unemotional traits (ICU; Frick, 2003; Cronbach's alphas = .81 (entire sample), .82 (CD group)).

Procedure

Emotional face categorisation. We assessed participants' ability to categorise dynamic and static facial expressions of emotion. Our dynamic stimuli were drawn from the Amsterdam Dynamic Facial Expression Set (ADFES; Van der Schalk, Hawk, Fischer, & Doosje, 2011). Fifty-six stimuli (eight models (four males) expressing seven emotions (anger, sadness, fear, happiness, surprise, disgust, and neutral)) were selected from the full set. The original ADFES sequences are approximately 6,000 ms in duration, with the final ~5,000 ms consisting of the

actor holding the full emotion expression. We removed this final section such that our dynamic stimuli depicted a neutral to full emotion transition lasting 1,000 ms, broadly consistent with prior reports relating to the timing of emotion expressions from neutral poses (Yoshikawa & Sato, 2008).

In preparing the static stimuli, a bespoke morphing algorithm (Adams, Gray, Garner, & Graf, 2010) combined each full expression static stimulus from the ADFES with the same model's neutral face. In total, 100 static stimuli were used (four models (two males, two females) × six facial expressions (plus neutral) × four emotion intensities (30%, 50%, 70%, 100%)). The images were scaled, aligned, masked (to hide external features, e.g., hair) and matched for mean luminance and root-mean-square contrast. Stimuli were displayed on a 1,024 × 768 monitor and subtended 10.5° of visual angle at a viewing distance of 60 cm.

Participants completed four experimental blocks of 39 randomly interleaved trials, taking breaks between blocks as necessary. Each trial began with a 500 ms fixation cross. Following a 1,000 ms stimulus presentation, participants were presented with seven emotion labels (anger, sadness, happiness, fear, surprise, disgust, and neutral) and used a mouse to select the emotion that best described the displayed expression (see Figure 1B). Participants were given an unlimited time to respond, but were instructed to be as quick and accurate as possible.

Eye tracking. Eye position was recorded using an EyeLink 1000 eye tracker (SR Research Ltd, Canada), with a monocular sampling rate of 1,000 Hz and mean spatial accuracy of ~.25–.50°. A chin and forehead rest stabilised the head. For each participant, an initial tracker calibration was performed, in which participants sequentially fixated nine target points on the screen. In addition, during the experiment, each trial was preceded by a drift correction to ensure that the accuracy of the calibration parameters was maintained. This procedure was repeated when the drift error exceeded >1°, and the trial was only continued after a further calibration.

Data analytic strategy

Demographic characteristics. Socioeconomic status (SES) was categorised according to the profession of the parent(s) using UK Office for National Statistics (ONS) guidelines (2010). Participants whose parents' professions fell under 'high or intermediate' ONS categories were classified as high SES, whilst those categorised as 'routine, manual or unemployed' were classified as low SES. Due to the limited variation in ethnicity in the sample, participants were categorised as Caucasian or non-Caucasian. Group differences in continuous variables were explored using one-factor ANOVAs, whereas comparisons of binary variables were conducted using Chi-Square tests.

Emotion categorisation data. We employed linear mixed-effects model (LMM) analyses[1] in Matlab 8.5.0 (The MathWorksInc. Natick, MA) using the '*fitlme*' function to examine the effects of CD status, gender, CU traits, IQ, SES, stimulus type (dynamic vs. static), emotional intensity, and

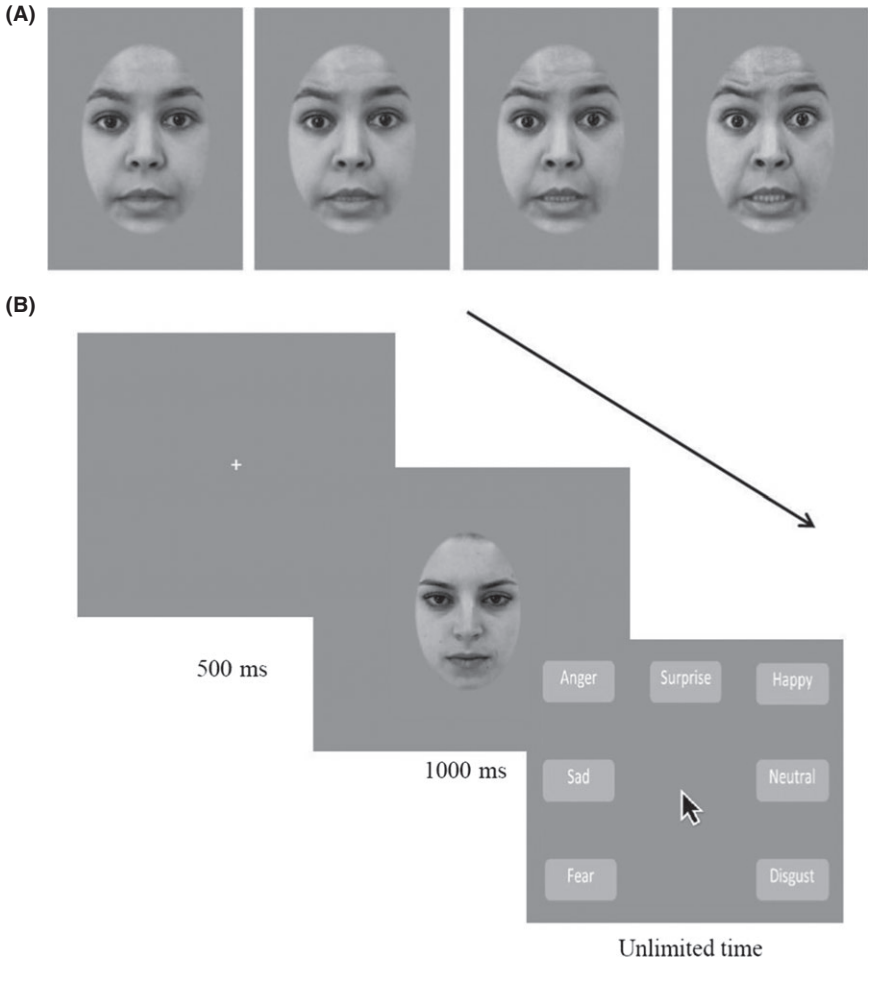

Figure 1 Task design and examples of facial expression stimuli used in the study. Panel A shows examples of static fearful stimuli, with intensities of 30%, 50%, 70% and 100%, respectively. Panel B depicts a trial sequence. Participants viewed facial expressions for 1,000 ms and were then asked to label the emotion

two-way interactions between these variables, on (a) overall categorisation accuracy, and (b) categorisation accuracy for each emotion. Initial models also included subject, psychiatric comorbidity,[2] and age as random factors.

When assessing categorisation accuracy across all emotions, emotional expression (anger, sadness, fear, happiness, surprise, disgust and neutral) was also included as a random factor. This provided the maximum power to explore the effects of our fixed variables, while accounting for variance introduced by subject and emotional expression. This was followed by separate analyses of categorisation performance for each individual emotion. The significance of each predictor (and hence its inclusion in the final model) was defined by likelihood ratio tests comparing the models with and without each predictor (see Appendix S1: Data Analytic Strategy in Supplementary Materials, available online, for further details). Simple effect sizes are quantified in the main text using Cohen's *d* (small ≥.20, medium ≥.50, large ≥.80; Cohen, 1988). In the context of a multipredictor model, Cohen's f^2 can be used to quantify the degree of variance explained by a single predictor, when accounting for all other variables. This additional effect size measure (which compliments the likelihood ratio tests described above) is reported in Table S3.

Eye tracking data. In line with Dadds et al. (2008), we performed a region of interest (ROI) analysis on the eye position data. Bespoke software was used to manually select three ROIs for each of our face stimuli: two around the eyes and one around the mouth (see Figure S1), regions that have been shown to be important in conveying emotional expressions (Adolphs, Baron-Cohen, & Tranel, 2002). At each 1 ms timepoint, the participant's eye position was evaluated against these ROIs.

We used these data to create two preference scores: (a) *initial eye preference*: the percentage of trials in which the participant moved from the first fixation point (a cross in the centre of the face) to fixate on the eye region first, minus the percentage of trials in which they moved to fixate on the mouth first, and (b) *total eye preference*: the percentage of overall trial time spent fixating the eye region, minus that spent fixating the mouth. In both cases, the first fixation was disregarded, as fixation on the central cross was necessary in order to initiate the trial. LMM analyses were used to assess whether: (a) initial eye preference, or (b) total eye preference were predicted by CD status, gender, CU traits, IQ, SES, stimulus type, emotional intensity, or their interactions.

Relating eye tracking to behavioural data. Finally, we examined whether differences in fixation behaviour could explain (i.e., mediate) the relationship between participant characteristics (e.g., CD status, gender, CU traits) and emotion categorisation performance. Here, we investigated whether adding initial and/or total eye preference to the best-fitting models of emotion categorisation resulted in significant improvements in the predictive power of the models that would imply that the associations were explained by fixation behaviour.

Results

Demographic and clinical characteristics

Table 1 presents information about the characteristics of each of the four groups, with statistical comparisons. The groups did not differ significantly in age or ethnicity. However, the CD groups had significantly lower IQ scores than the TD groups. In addition, CD males were more likely to come from low SES backgrounds than the TD groups. Finally, both CD groups had higher levels of CU traits than their sex-matched control groups.

Overall categorisation accuracy

Figure 2 shows emotion categorisation as a function of CD status, gender, emotional intensity (morph strength) and stimulus type (static vs. dynamic), with the results of the LMM analyses presented in Table 2.[3]

Having CD and being male were both independently associated with significantly lower emotion categorisation accuracy across all emotions (CD status: $d = .72$, gender: $d = .97$). As expected, categorisation accuracy for static expressions increased with emotional intensity ($r^2 = .52$), but this effect was independent of CD status and gender.

Categorisation accuracy for individual emotions

Next, we investigated categorisation accuracy for each emotion separately (see Table 2). Participants with CD showed significantly poorer fear recognition relative to TD participants ($d = .75$). In addition, higher levels of CU traits were associated with poorer fear recognition across the whole sample ($r^2 = .30$). However, there was also a significant interaction between CD status and CU traits such that within the CD group, those with higher levels of CU traits showed *better* fear recognition (see Figure S2). Having CD ($d = .78$) and being male ($d = .45$) were both independently associated with poorer recognition of angry faces. Being male was also associated with poorer recognition of disgust, sadness, surprise and neutral expressions ($ds = .41$–$.58$).

For all emotions, categorisation accuracy increased with stimulus intensity, and for all emotions except fear and disgust, categorisation was better for dynamic than static stimuli (see Table 2). These effects were independent of CD group status or gender, with one exception: for disgust recognition, CD status significantly interacted with emotional intensity, such that the TD group showed greater improvements in performance than the CD group as emotional intensity increased (see Table 2).

Eye movements: initial and total eye preference

Figure 3 shows eye movement behaviour as a function of CD status and gender when viewing both static and dynamic facial expressions.

On average, participants made 3.44 fixations per 1,000 ms trial (across all conditions), with an average fixation duration of 303.8 ms; previous research suggests that the first two fixations are most predictive of facial emotion recognition (Schurgin et al., 2014) and facial emotion recognition typically occurs within 1,000 ms (De Sonneville et al., 2002). Importantly, the CD and TD groups did not differ in: (a) the percentage of trials in which the first fixations were

Table 1 Demographic and clinical characteristics of the sample

	TD Males[1] (n = 26)	CD Males[2] (n = 26)	TD Females[3] (n = 25)	CD Females[4] (n = 24)		Post hocs
M (*SD*)					*F*	
Age (years)	16.22 (1.45)	15.94 (1.98)	16.40 (1.53)	16.21 (1.69)	.33	–
IQ	104.65 (11.39)	87.12 (7.33)	100.40 (12.64)	91.42 (16.70)	10.87***	1, 3 > 2, 4
CU traits	22.88 (6.08)	30.38 (7.56)	17.96 (6.45)	26.83 (8.95)	12.78***	1, 3 < 2; 3 < 4
n (%)					χ^2	
High SES	17 (65)	5 (19)	14 (56)	10 (42)	10.77*	1, 3 > 2
Low SES	4 (15)	12 (46)	8 (32)	9 (38)		
Caucasian	21 (81)	24 (92)	24 (96)	23 (96)	4.87	–
ADHD	–	11 (42)	–	6 (25)	1.67	–
MDD	–	5 (19)	–	4 (17)	.06	–
Anxiety	–	1 (4)	–	4 (17)	2.28	–
Substance abuse	–	0 (0)	–	1 (4)	–	
Alcohol abuse	–	0 (0)	–	1 (4)	–	
PTSD	–	0 (0)	–	1 (4)	–	

The presence of a current psychiatric disorder was an exclusion criterion for the TD group. ADHD, attention-deficit/hyperactivity disorder; CD, Conduct Disorder; CU, callous-unemotional; IQ, intelligence quotient; MDD, major depressive disorder; PTSD, Post-Traumatic Stress Disorder; *SD*, standard deviation; SES, socioeconomic status; TD, typically developing.
The groups are annotated using superscript values to enable presentation of the results of post hoc group comparisons following up significant main effects of group shown in the F values column.
*p < .05; ***p < .001.

outside the ROIs, or (b) the total time spent fixating outside the ROIs, and neither CD status nor gender interacted with emotion, or intensity for these measures (as assessed via separate ANOVAs for static and dynamic stimuli). Thus, the analyses below focus on the relative preference for eyes and mouth regions, which capture the critical group differences in eye movement behaviour.

We first considered whether eye movement behaviour was related to CD status, gender, CU traits, IQ, SES, stimulus type and emotional intensity across all emotional expressions (Table 2). Females showed increased initial eye preferences relative to males (d = .51). However, neither CD status nor CU traits were significantly associated with initial or total eye preferences across all emotional expressions.

Next, we performed separate eye movement analyses for each emotional expression. Participants with CD showed a reduced tendency to fixate the eyes first when viewing sad expressions (d = .76). In addition, this initial eye preference was lower in males, relative to females, and lower for dynamic, relative to static, stimuli (see Table 2). Having CD (d = .41) and being male (d = .49) were both associated with a lower total eye preference when viewing fearful expressions. Higher levels of CU traits were associated with a reduced tendency to fixate the eyes first when viewing surprised faces (r^2 = .20). On the other hand, CU traits and emotional intensity interacted to predict initial eye preference for surprise: this increased with emotional intensity, and this effect was larger in individuals with higher levels of CU traits (see Table 2).

Finally, relative to males, females displayed a stronger tendency to fixate the eyes first for angry, fearful, surprised and neutral expressions (ds = .48–.57). With the exception of disgust, females also showed greater total eye preferences than males for all emotions (ds = .43–.66).

Eye movement behaviour as a predictor of categorisation accuracy

The preceding analyses revealed: (a) that CD status, gender, and CU traits (for fear alone) predicted emotion categorisation performance, and (b) that CD status, gender and CU traits (for surprise alone) were related to eye fixation patterns. This raises an important question – does a reduced tendency to fixate the eyes *explain* the emotion recognition deficits observed in participants with CD?

If eye fixation patterns influence the categorisation of emotional faces, then we would expect our models of categorisation to *improve* when measures of eye movement behaviour are added as predictors. However, if these fixation patterns *mediate* the emotion recognition deficits associated with CD and/or CU traits, then we would expect an additional effect to emerge when eye movement behaviours are added to our categorisation models: the magnitude of effects related to CD status or CU traits will be diminished (i.e., coefficients will become smaller), because the CD- or CU traits-related effects on categorisation performance are explained by abnormal fixation patterns.

Indeed, including initial and total eye preference measures significantly improved the best-fitting model of overall emotion categorisation (see Table S2). However, these improvements were very small in the context of the overall effect sizes (see Table S3 for model improvements, as quantified via Cohen's f^2). Increased total eye preference was associated with improvements in overall emotion categorisation across all participants, irrespective of CD status or gender. This was partially counteracted

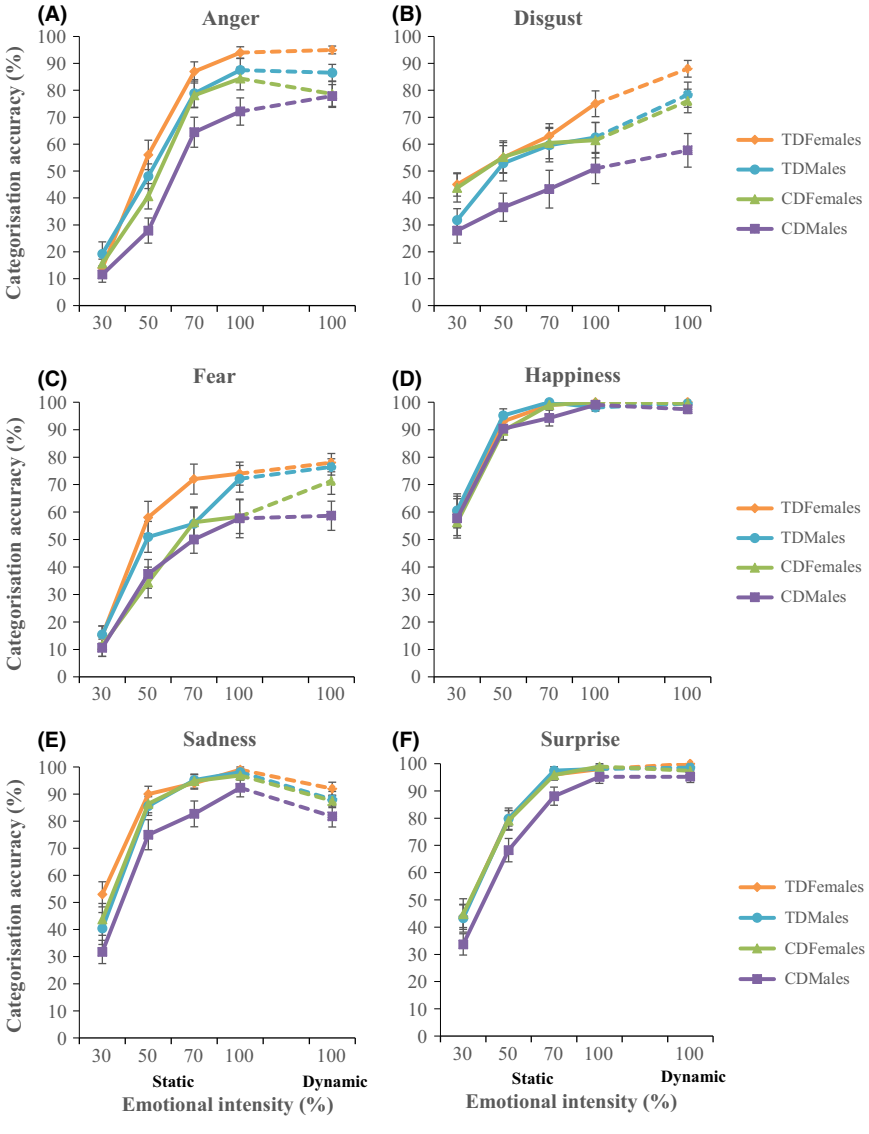

Figure 2 Emotion categorisation accuracy data for each group, as a function of emotion, intensity and stimulus type. Categorisation accuracy scores for static stimuli, split by emotion intensity (30%, 50%, 70%, 100%), and dynamic stimuli (full intensity; 100%) per emotion are shown in panels A-F. Error bars show ±standard error. CD, conduct disorder; TD, typically developing [Colour figure can be viewed at wileyonlinelibrary.com]

by a negative relationship between initial eye preference and categorisation performance, in the context of the full, multipredictor model.

In addition, eye movement behaviour added predictive power to the individual models of categorisation for anger, fear, happiness and sadness (see Table S2). However, the model improvements were again very small, in terms of effect size (see Table S3). Participants' categorisation of anger improved with increasing total eye preference, irrespective of CD status or gender. This effect was weaker for dynamic and lower intensity static stimuli. Increased initial eye preference was associated with better fear categorisation, but only for high intensity expressions (the reverse was found for low intensity expressions). Higher total eye preference scores were associated with enhanced happiness recognition, but only for lower intensity expressions. Finally, initial eye preference scores were negatively associated with recognition of lower intensity sad expressions, across all participants.

The addition of eye movement measures led to very small, but significant, improvements in the models of categorisation across emotional expressions, and for fear, happiness, and sadness recognition considered separately. Importantly, however, the addition of these predictors had little effect on the importance of CD, gender or CU traits as independent predictors in the model – the average change in these predictors was −2%. In addition, we note that the effects of eye movement behaviour on emotion recognition did not vary as a function of CD status, CU traits or gender. In addition, irrespective of CD status, eye movement behaviour was only associated with modest effects on categorisation performance. In summary, there were only small differences between the CD and TD groups in fixation patterns, and these differences did not explain the much larger group differences in emotion categorisation. These analyses provide strong evidence that CD-related deficits in emotion categorisation are not mediated by atypical fixation

Table 2 Simplified models for emotion categorisation and eye movement behaviour, across all emotions and for individual emotions

	Predictors (*B*)							
	CD	Gender	CU	Stimulus type	Emotional intensity	CD*CU	CD* Emotional intensity	CU* Emotional intensity
Categorisation Accuracy								
All	−5.51***	5.67***	–	–	.68***	–	–	–
Anger	−7.18*	6.83*	–	8.40**	1.01***	–	–	–
Fear	−29.08**	–	−1.02**	–	.70***	1.00*	–	–
Disgust	–	13.22***	–	−10.31***	.42***	–	−.14**	–
Happiness	–	–	–	7.52***	.52***	–	–	–
Sadness	–	6.46**	–	17.80***	.71***	–	–	–
Surprise	–	3.47*	–	8.61***	.77***	–	–	–
Neutral	–	7.00*	–	–	–	–	–	–
Initial Eye Preference								
All	–	21.96*	–	–	–	–	–	–
Anger	–	29.56**	–	13.57**	–	–	–	–
Fear	–	34.41**	–	–	–	–	–	–
Disgust	–	–	–	−11.77*	−.18**	–	–	–
Happiness	–	–	–	–	–	–	–	–
Sadness	−11.97**	45.00**	–	33.48***	−.33***	–	–	–
Surprise	–	63.57***	−1.32**	58.65***	–	–	–	.01*
Neutral	–	31.38**	–	–	–	–	–	–
Total Eye Preference								
All	–	–	–	4.78***	–	–	–	–
Anger	–	8.91*	–	4.88***	–	–	–	–
Fear	−8.84*	9.39*	–	6.55***	.05**	–	–	–
Disgust	–	–	–	4.68***	–	–	–	–
Happiness	–	8.60*	–	4.32***	–	–	–	–
Sadness	–	12.31**	–	3.92**	−.05*	–	–	–
Surprise	–	9.13*	–	6.84***	.15***	–	–	–
Neutral	–	9.41*	–	–	–	–	–	–

B, unstandardised beta; CD, Conduct Disorder; CU, callous-unemotional traits; Initial eye preference, the percentage of trials in which the participant fixated on the eye region first, minus the percentage of trials in which they fixated the mouth region first; Total eye preference, the percentage of overall trial time spent fixating the eye region, minus that spent fixating the mouth.
*$p < .05$; **$p < .01$; ***$p < .001$.

patterns. Thus, difficulties interpreting emotional cues, rather than attentional issues, are likely to underlie the emotion recognition deficits observed in the CD group.

Discussion

The present study explored male and female typically developing (TD) and Conduct Disorder (CD) adolescents' ability to categorise dynamic and morphed static facial expressions. We also assessed the effects of callous-unemotional (CU) traits on emotion recognition performance. Overall, having CD and being male had independent and detrimental effects on the recognition of facial expressions across multiple emotions. This pattern of findings held regardless of whether the stimuli were static or dynamic and also across different emotional intensities, and the associated effect sizes were in the medium-to-large range.

When considering each emotion separately, having CD and being male were independently related to poorer anger recognition. CD was also associated with impaired fear recognition. These findings support previous research demonstrating impaired recognition of anger and fear in adolescents with CD (Bowen et al., 2013; Fairchild et al., 2009, 2010; Short et al., 2016; Sully et al., 2015). Critically, our work extends these previous findings by demonstrating that anger and fear recognition deficits are still present when the stimuli are dynamic or presented at lower intensity. Furthermore, CU traits were associated with impaired fear recognition when considering the *entire* sample. Contrary to expectations, however, elevated CU traits were related to *enhanced* recognition of fearful expressions in the CD group.

Although the former finding for the overall sample is consistent with past research demonstrating an association between psychopathic traits and difficulties identifying fearful expressions (Blair, Colledge, Murray, & Mitchell, 2001; Fairchild et al., 2009), we note that the latter finding may be considered surprising given previous findings that impaired fear recognition is more pronounced in those with CD and elevated CU traits relative to those with lower levels of CU traits (Fairchild et al., 2009; Marsh & Blair, 2008), and theories proposing that psychopathy is linked to selective deficits in processing distress cues (Blair, 1995, 2003). However, not all studies have found an association between CU traits and fear recognition impairments in CD populations. In fact, some researchers found no differences between individuals with CD and high versus low CU traits in emotion recognition performance (Sully et al., 2015) and others have shown

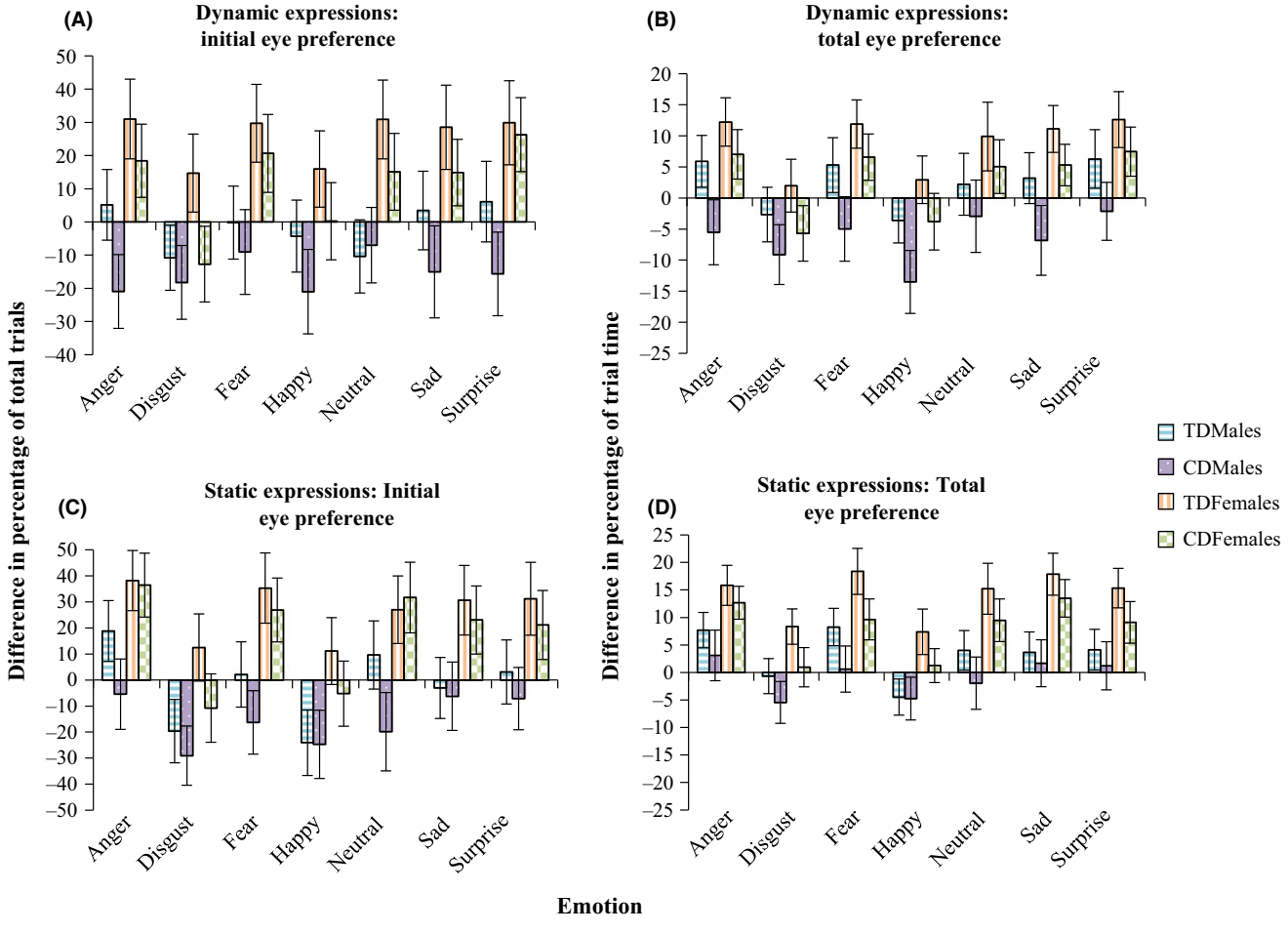

Figure 3 Eye movement data for each group, split by emotion and stimulus type. Initial and total eye preference scores for dynamic stimuli are shown in panels A–B, whereas eye preference scores for static stimuli (collapsed across emotional intensity, for ease of plotting) are presented in panels C–D. Error bars show ±standard error. CD, conduct disorder; TD, typically developing [Colour figure can be viewed at wileyonlinelibrary.com]

superior fear recognition in children with conduct problems and elevated CU traits (Woodworth & Waschbusch, 2008).

Considering the eye tracking data, males were less likely to fixate the eye region first, relative to females, across all emotions. This confirms previous findings in adults showing sex differences in orienting towards the eyes (Hall et al., 2010). When considering each emotion separately, having CD and being male were both independently related to a reduced tendency to fixate the eyes for sad and fearful expressions. CU traits predicted reduced attention to the eyes, but this was only true for *surprised* expressions. This finding is partly in line with Dadds et al.'s (2008) finding of reduced attention to the eyes in children high in CU traits. Critically, having CD and being male appear to be stronger predictors of reduced overt attention to the eyes than having elevated CU traits.

However, while eye movement behaviours differed according to both group status and gender, these differences were comparatively small and did not explain the larger group differences in emotion recognition performance. In fact, although individual differences in eye movement behaviour were associated with variation in emotion recognition accuracy, the addition of the eye movement variables to the models of categorisation accuracy provided only marginal benefits in their predictive power to explain categorisation performance. Importantly, including these variables did not reduce the importance of CD status, CU traits or gender in explaining emotion recognition. Therefore, our findings suggest that although individuals with CD, and particularly males with CD, exhibit abnormal eye fixation patterns, these differences do not explain the association between CD status and emotion recognition performance. Taken together, our findings suggest that problems interpreting emotional cues, rather than attentional issues, are likely to underlie the emotion recognition deficits observed in adolescents with CD.

To our knowledge, this is the first study to examine recognition of and attention to static and dynamic emotional faces in both male and female subjects with and without CD. Using both dynamic and lower intensity static stimuli increased the study's ecological validity, and the fact that adolescents with CD showed impaired recognition of facial expressions across stimulus types suggests that previously reported deficits were not merely artefacts of using simplified, static stimuli. In addition, the CD and TD

groups were well-characterised from a clinical perspective, using reliable diagnostic measures.

The study also had several limitations. First, the sample size was only moderate, reflecting the difficulties in recruiting adolescents, and particularly females, with CD. Furthermore, relative to the TD group, the CD group had lower IQs and came from lower socioeconomic status (SES) backgrounds. It is important to note, however, that CD has been repeatedly linked to lower IQ and SES (Piotrowska, Stride, Croft, & Rowe, 2015). For this reason, matching groups on these variables has the potential to reduce the representativeness of the groups, and therefore the generalisability of our findings. Additionally, we included both IQ and SES as fixed variables in all models, meaning that we accounted for the variance introduced by group differences in these variables. Critically, because our design is cross-sectional, we cannot infer that the presence of CD is causally related to deficits in emotion recognition. When analysing the behavioural data for individual emotional expressions, we did not apply a correction for multiple outcome measures: these data arose from separate subsets of trials. More generally, there is no consensus regarding the appropriateness or necessity of adjusting *p* values to account for multiple outcome measures; here, we provide effect sizes as a less contentious measure of statistical importance (see Feise, 2002). Finally, it is worth noting that CU traits were assessed using the self-report version of the Inventory of Callous-Unemotional traits, which may be influenced by social desirability effects.

Conclusion

Adolescents with CD showed impairments in emotion recognition, and a reduced tendency to fixate the eye region of the face when viewing fearful and sad expressions. Interestingly, we found that having CD and being male had additive, detrimental effects on emotion recognition and attention to the eyes. As such, interventions seeking to improve emotion recognition in adolescents with CD may need to be tailored according to gender, with males being likely to require more comprehensive training programmes than females. Critically, our analyses suggest that CD-related deficits in facial emotion recognition might be better conceptualised as resulting from problems in the appraisal of emotional cues, rather than abnormal eye fixation patterns.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Data Analytic Strategy.
Figure S1. An example static stimulus showing the regions of interest for the eye tracking analyses.
Figure S2. Fear categorisation accuracy as a function of Inventory of Callous-Unemotional traits (ICU) score, averaged across stimulus type (static and dynamic).
Table S1. Full models for facial emotion categorisation and eye movement behaviour, across all emotions and for individual emotions.
Table S2. Improved models of categorisation accuracy when including measures of eye movement behaviour as predictors.
Table S3. Effect sizes (expressed as Cohen's f-squared) associated with key predictor variables, in the context of multipredictor models.

Acknowledgements

N.M-K. was supported by Kids Company and a Vice-Chancellor's Scholarship from the University of Southampton. The authors would like to thank the participants and their parents for taking part in the study. They also thank the schools, pupil referral units, and the Southampton and Hampshire Youth Offending Services for helping with participant recruitment. The authors have declared that they have no competing or potential conflicts of interest.

Correspondence

Graeme Fairchild, Department of Psychology, University of Bath, Bath, BA2 7AH, UK; Email: g.fairchild@bath.ac.uk

Key points

- Adolescents with Conduct Disorder (CD) are reported to show deficits in facial emotion recognition, but it is unclear whether these impairments reflect difficulties with attention and/or appraisal of emotional content.
- We investigated recognition of, and attention to, static and dynamic facial expressions in male and female adolescents with CD and typically developing controls using eye tracking methods.
- Participants with CD, and males in particular, exhibited emotion recognition deficits and fixated less on the eyes when viewing facial expressions than controls.
- Across the whole sample, higher callous-unemotional traits were related to poorer fear recognition, but within the CD group, higher callous-unemotional traits were associated with *better* fear recognition.
- Although fixation on the eyes was positively associated with recognition performance, abnormal fixation patterns did not explain the emotion recognition deficits associated with CD.

Notes

1. This approach was chosen over the traditional ANOVA approach as it provides a principled way to include both continuous and categorical variables, whilst modelling individual subject- and stimulus-related sources of variation. By more precisely modelling random variation, power to detect effects of interest is increased, without inflating the probability of Type II errors (see Baayen, Davidson, & Bates, 2008; Bates, Kliegl, Vasishth, & Baayen, 2015).
2. PTSD, alcohol and substance abuse were not included as random factors as they were present in only one subject, and therefore were subsumed by the subject factor.
3. For simplicity, Table 2 only includes predictors of interest; i.e., those relating to our a priori hypotheses (see Table S1, for full model summaries).

References

Adams, W.J., Gray, K.L.H., Garner, M., & Graf, E.W. (2010). High-level face adaptation without awareness. *Psychological Science*, *21*, 205–210.

Adolphs, R., Baron-Cohen, S., & Tranel, D. (2002). Impaired recognition of social emotions following amygdala damage. *Journal of Cognitive Neuroscience*, *14*, 1264–1274.

Adolphs, R., Gosselin, F., Buchanan, T.W., Tranel, D., Schyns, P., & Damasio, A.R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature*, *433*, 68–72.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th edn). Washington, DC: Author.

Baayen, R., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(Special Issue: Emerging Data Analysis), 390–412.

Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious Mixed Models. ArXiv e-prints.

Blair, R.J.R. (1995). A cognitive developmental approach to morality: Investigating the psychopath. *Cognition*, *57*, 1–29.

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

Blair, R.J.R., Colledge, E., Murray, L., & Mitchell, D.G.V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *Journal of Abnormal Child Psychology*, *29*, 491–498.

Bowen, K.L., Morgan, J.E., Moore, S.C., & van Goozen, S.H.M. (2013). Young offenders' emotion recognition dysfunction across emotion intensities: Explaining variation using psychopathic traits, conduct disorder and offense severity. *Journal of Psychopathology and Behavioral Assessment*, *36*, 60–73.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: L. Erlbaum.

Dadds, M.R., El Masry, Y., Wimalaweera, S., & Guastella, A.J. (2008). Reduced eye gaze explains "fear blindness" in childhood psychopathic traits. *Journal of the American Academy of Child and Adolescent Psychiatry*, *47*, 455–463.

Dadds, M.R., Perry, Y., Hawes, D.J., Merz, S., Riddell, A.C., Haines, D.J., … & Abeygunawardane, A.I. (2006). Attention to the eyes and fear-recognition deficits in child psychopathy. *British Journal of Psychiatry*, *189*, 280–281.

De Sonneville, L.M.J., Verschoor, C.A., Njiokiktjien, C., Op het Veld, V., Toorenaar, N., & Vranken, M. (2002). Facial identity and facial emotions: Speed, accuracy, and processing strategies in children and adults. *Journal of Clinical and Experimental Neuropsychology*, *24*, 200–213.

Fairchild, G., Stobbe, Y., van Goozen, S.H.M., Calder, A.J., & Goodyer, I.M. (2010). Facial expression recognition, fear conditioning, and startle modulation in female subjects with conduct disorder. *Biological Psychiatry*, *68*, 272–279.

Fairchild, G., Van Goozen, S.H.M., Calder, A.J., Stollery, S.J., & Goodyer, I.M. (2009). Deficits in facial expression recognition in male adolescents with early-onset or adolescence-onset conduct disorder. *Journal of Child Psychology and Psychiatry*, *50*, 627–636.

Fairchild, G., Van Goozen, S.H., Stollery, S.J., & Goodyer, I.M. (2008). Fear conditioning and affective modulation of the startle reflex in male adolescents with early-onset or adolescence-onset conduct disorder and healthy control subjects. *Biological Psychiatry*, *63*, 279–285.

Feise, R.J. (2002). Do multiple outcome measures require p-value adjustment? *BioMed Central Medical Research Methodology*, *2*, 8.

Frick, P.J. (2003). *The Inventory of Callous-Unemotional Traits. Unpublished rating scale*. The University of New Orleans.

Hall, J.K., Hutton, S.B., & Morgan, M.J. (2010). Sex differences in scanning faces: Does attention to the eyes explain female superiority in facial expression recognition? *Cognition and Emotion*, *24*, 629.

Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., … & Ryan, N.D. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*, 980–988.

Lynam, D., Moffitt, T., & Stouthamer-Loeber, M. (1993). Explaining the relation between IQ and delinquency: Class, race, test motivation, school failure, or self-control? *Journal of Abnormal Psychology*, *102*, 187–196.

Marsh, A.A., & Blair, R.J.R. (2008). Deficits in facial affect recognition among antisocial populations: A meta-analysis. *Neuroscience and Biobehavioral Reviews*, *32*, 454–465.

Moffitt, T.E., Caspi, A., Rutter, M., & Silva, P.A. (2001). *Sex differences in antisocial behaviour: Conduct disorder, delinquency, and violence in the Dunedin longitudinal study*. Cambridge: Cambridge University Press.

Moffitt, T.E., & Silva, P.A. (1988). IQ and delinquency: A direct test of the differential detection hypothesis. *Journal of Abnormal Psychology*, *97*, 330–333.

Office for National Statistics (2010). *Standard occupational classification 2010*. Basingstoke, UK: Palgrave Macmillan.

Pajer, K., Leininger, L., & Gardner, W. (2010). Recognition of facial affect in girls with conduct disorder. *Psychiatry Research*, *175*, 244–251.

Pajer, K.A., Stein, S., Tritt, K., Chang, C.-N., Wang, W., & Gardner, W. (2008). Conduct disorder in girls: Neighborhoods, family characteristics, and parenting behaviors. *Child and Adolescent Psychiatry and Mental Health*, *2*, 1–28.

Pardini, D., & Frick, P.J. (2013). Multiple developmental pathways to conduct disorder: Current conceptualizations and clinical implications. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *22*, 20–25.

Piotrowska, P.J., Stride, C.B., Croft, S.E., & Rowe, R. (2015). Socioeconomic status and antisocial behaviour among children and adolescents: A systematic review and meta-analysis. *Clinical Psychology Review*, *35*, 47–55.

Schurgin, M.W., Nelson, J., Iida, S., Ohira, H., Chiao, J.Y., & Franconeri, S.L. (2014). Eye movements during emotion recognition in faces. *Journal of Vision*, *14*, 14. https://doi.org/10.1167/14.13.14.

Schwenck, C., Gensthaler, A., Romanos, M., Freitag, C.M., Schneider, W., & Taurines, R. (2014). Emotion recognition in girls with conduct problems. *European Child and Adolescent Psychiatry*, *23*, 13–22.

Schwenck, C., Mergenthaler, J., Keller, K., Zech, J., Salehi, S., Taurines, R., … & Freitag, C.M. (2012). Empathy in children with autism and conduct disorder: Group-specific profiles

and developmental aspects. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *53*, 651–659.

Short, R.M.L., Sonuga-Barke, E.J.S., Adams, W.J., & Fairchild, G. (2016). Does comorbid anxiety counteract emotion recognition deficits in conduct disorder? *Journal of Child Psychology and Psychiatry*, *57*, 917–926.

Spezio, M.L., Adolphs, R., Hurley, R.S.E., & Piven, J. (2007). Abnormal use of facial information in high-functioning autism. *Journal of Autism and Developmental Disorders*, *37*, 929–939.

Sully, K., Sonuga-Barke, E.J.S., & Fairchild, G. (2015). The familial basis of facial emotion recognition deficits in adolescents with conduct disorder and their unaffected relatives. *Psychological Medicine*, *45*, 1965–1975.

van der Schalk, J., Hawk, S.T., Fischer, A.H., & Doosje, B. (2011). Moving faces, looking places: Validation of the Amsterdam Dynamic Facial Expression Set (ADFES). *Emotion*, *11*, 907–920.

Wechsler, D. (1999). *Wechsler abbreviated scale of intelligence*. New York: The Psychological Corporation: Harcourt Brace & Company.

Woodworth, M., & Waschbusch, D. (2008). Emotional processing in children with conduct problems and callous/unemotional traits. *Child: Care Health and Development*, *34*, 234–244.

Yoshikawa, S., & Sato, W. (2008). Dynamic facial expressions of emotion induce representational momentum. *Cognitive, Affective and Behavioral Neuroscience*, *8*, 25–31.

Accepted for publication: 3 July 2017
First published online: 7 September 2017