Behaviour Research and Therapy 113 (2019) 32–38

Contents lists available at ScienceDirect

Behaviour Research and Therapy

journal homepage: www.elsevier.com/locate/brat

Emotional processing deficits in Italian children with Disruptive Behavior Disorder: The role of callous unemotional traits☆

Lucia Billeci[a], Pietro Muratori[b,*], Sara Calderoni[c,d], Natasha Chericoni[b], Valentina Levantini[b], Annarita Milone[b], Annalaura Nocentini[e], Marina Papini[b], Laura Ruglioni[b], Mark Dadds[f]

[a] Institute of Clinical Physiology, National Research Council of Italy, (CNR), Pisa, Italy
[b] IRCCS Stella Maris, Scientific Institute of Child Neurology and Psychiatry, Pisa, Italy
[c] Department of Developmental Neuroscience, IRCCS Stella Maris, Pisa, Italy
[d] Department of Clinical and Experimental Medicine, University of Pisa, Pisa, Italy
[e] Department of Sciences of Education and Psychology, University of Florence, Italy
[f] School of Psychology, University of Sydney, Australia

ARTICLE INFO

Keywords:
Disruptive behavior disorder
Callous traits
Eye gaze
Emotional processing

ABSTRACT

Research suggests that callous unemotional (CU) traits are associated with poor emotion recognition due to impairments in attention to relevant emotional cues. To further investigate the mechanisms that underlie CU traits, this study focused on the relationship between levels of CU and children's attention to, and recognition of, facial emotions. Participants were 7- to 10-year-old Italian boys, 35 with a diagnosis of Disruptive Behavior Disorder (age: M = 8.93, SD = 1.35), and 23 healthy male controls (age: M = 8.86, SD = 1.35). Children viewed standardized emotional faces (happiness, sadness, fear, disgust, anger, and neutral) while eye-tracking technology was used to evaluate scan paths for each area of interest (eyes, face, mouth), and for each emotion. CU traits were assessed using parent and teacher ratings on the Antisocial Process Screening Device. In the whole sample, elevated levels of CU traits were associated with a lower ability to recognize sadness, a lower number of fixations, and a lower average length of each fixation, specifically to the eye area of sad faces. In children with Disruptive Behavior Disorder diagnoses, high levels of CU traits were associated with lower duration of fixations to the eye-region on the eye area of sad faces, which in turns predicted lower levels of sadness recognition. The findings confirm that poor emotion recognition is associated with impairments in attention to critical information about other people's emotions. The clinical implications are discussed.

1. Introduction

Disruptive Behavior Disorders (DBDs), including Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD), are common child mental health problems that are characterized by antisocial, hostile and aggressive behaviors and deficits in emotional regulation. In their most severe form, conduct problems involve the violation of the rights of others or the violation of major societal norms (American Psychiatric Association, 2013). The presence of Callous Unemotional (CU) traits in children with DBDs defines a subclass of children with higher etiological risk and poorer responses to interventions (for a review see Frick, Ray, Thornton, & Kahn, 2014). The main features of CU traits are a lack of empathy and guilt, shallow or deficient emotions, and a lack of care or concern about performance on tasks and other people's feelings (Frick & Ray, 2015). Recent research has suggested that while DBD children with elevated CU traits do less well in current interventions, they are not "untreatable" and can improve with intensive interventions when they are carefully tailored to their unique psychopathological characteristics (Hawes, Price, & Dadds, 2014). As such, research is needed to identify mechanisms for intervention that underlie the development of CU traits and can be targeted in early intervention. A better understanding of the mechanisms that promote and protect against high CU traits in youths, such as emotion processing, could inform treatments that directly target these mechanisms in DBD children.

☆ Lucia Billeci and Pietro Muratori contributed equally to the present work.

* Corresponding author. IRCCS Stella Maris, Viale del Tirreno 331, 56018, Pisa, Italy.
E-mail address: pietro.muratori@fsm.unipi.it (P. Muratori).

https://doi.org/10.1016/j.brat.2018.12.011
Received 19 October 2017; Received in revised form 6 November 2018; Accepted 19 December 2018
Available online 20 December 2018

1.1. Emotional processing and callous unemotional traits

There is substantial evidence that individuals with disruptive behaviors have difficulties in facial emotion recognition (Fairchild, Van Goozen, Calder, Stollery, & Goodyer, 2009; Short, Sonuga-Barke, Adams, & Fairchild, 2016; Sully, Sonuga-Barke, & Fairchild, 2015). Recently, impaired facial emotion recognition has been associated with elevated levels of CU traits in youths with disruptive behaviors (Blair, Leibenluft, & Pine, 2014). In brief, studies that investigated whether a child's ability to identify facial expressions accurately is related to CU traits show that the latter are associated with impairments in identifying expressions of emotion, especially distress emotions of sadness and fear (Blair & Coles, 2000; Blair, Colledge, Murray, & Mitchell, 2001; Dadds, El Masry, Wimalaweera, & Guastella, 2008). However, in a meta-analysis, Dawel, O'Kearney, McKone, and Palermo (2012) indicated that the direct or moderated effect of CU traits on emotion recognition is not limited to fear or sadness, and is evident to some extent for most types of emotions. Furthermore, not all studies have found an association between CU traits and emotion recognition impairments in clinical populations (Martin-Key, Graf, Adams, & Fairchild, 2018; Sully et al., 2015). It is important to note that CU traits appear to be associated with impairment in emotion recognition even in the absence of conduct problems. For example, Woodworth and Waschbusch (2008) found that children with higher levels of CU traits, regardless of whether they exhibit conduct problems, were less accurate in identifying sad facial expressions. Interestingly, in this study children with higher CU scores were more accurate in labeling fear than were children with lower CU scores. These contradictory findings are in line with the approach proposed by Dadds, Jambrak, Pasalich, Hawes and Brennan (2011); they suggested that children with CU traits are characterized by a more general impairment in attention to emotional stimuli, in this case, eye gaze to key features of the emotional face that may underlie a deficit in recognition across all emotions.

However, only two studies have investigated the relationship between levels of CU traits and attention to emotional stimuli, using eye-tracking systems to detect eye gaze impairment. Dadds et al. (2008) tested whether high levels of CU traits are associated with reduced attention to the eye region of other people's faces, in a sample of typically developing youths. Findings from Dadds' study (2008) showed that high levels of CU traits predicted poor fear recognition, a lower number and duration of eye fixations, and fewer first foci to the eye region. There were no differences in gaze indices to the mouth region. Dadds et al. (2008) also showed that the simple manipulation of asking youth to look at the eyes results in increased emotion recognition. These evidences suggest that the attention to eye region of others might mediate the relation between CU traits and emotion recognition. Recently, Martin-Key et al. (2018) found that CU traits predicted reduced fixations to the eyes, but this was verified only for surprised expressions.

At the neural processing level, a wealth of studies that suggested involvement of the amygdala in both attending to and interpreting facial emotion expressions and monitoring of the eye-gaze of other people (Haxby, Hoffman, & Gobbini, 2000). Thus it is instructive to note that fMRI investigations have revealed an association between CU traits and selective impairment in empathic responses characterized by reduced amygdala responses to fearful expressions (Jones, Laurens, Herba, Barker, & Viding, 2009; Marsh et al., 2008; White et al., 2012a). In particular, White et al. (2012b) demonstrated that the amygdala hypoactivity observed in response to fearful faces in young patients with DBD and high CU traits is not secondary to an attentional deficit, but is specifically related to the CU component of psychopathic traits.

No study has yet investigated the relationship between the levels of CU traits and impairment in emotion recognition and/or in eye movement behavior using eye-tracking in children with a DBD diagnosis. In the present study, we investigated the role of CU traits in determining emotional processing in children with a DBD diagnosis, using a remote eye-tracking system. We argue that investigating the association between levels of CU traits and emotional processing in a clinical sample is important for the development of new intervention models for DBD children. If a specific association between CU traits and emotional processing deficits is confirmed in a clinical sample, further development of interventions which focuses on improving children's abilities to process emotions might reduce children's CU traits (e.g. Dadds, Cauchi, Wimalaweera, Hawes, & Brennan, 2012; Hubble, Bowen, Moore, & Van Goozen, 2015).

We measured levels of CU traits and externalizing problems continuously across a sample of DBD and typically developing children, and tested in the whole sample whether the level of CU traits, externalizing behavioral problems, age, intelligence quotient, income and group membership are associated with emotion recognition deficits and impairment in eye gaze to key features of emotional faces. Starting from the evidence found in Dadds et al. (2008), we also explored a mediation model linking CU traits to emotion recognition deficits through attention to the eye-regions. Unlike Dadds et al. (2008) and Martin-Key et al. (2018) who focused their studies on adolescents, we chose to analyze the relationship between CU traits and the processing of emotionally salient stimuli in younger children. This may enable us to see whether the difficulties that were found in the aforementioned studies emerge in the developmental phases preceding adolescence at a time when early intervention may be more successful.

2. Method

2.1. Participants and procedures

Participants were a clinical group of children with an ODD/CD diagnosis and a non-clinic group of children with no current or past diagnosis of psychiatric disorders. The clinical group was composed of 35 boys undergoing assessment at a specialized service for children with DBDs in the Department of Developmental Neuroscience at the Stella Maris Scientific Institute in Pisa, Italy. Primary diagnoses in the clinical sample were as follows: 19 ODD; 16 CD (American Psychiatric Association, 1994). They were aged 7–10 years (M = 8.93, SD = 1.35). Inclusion criteria were: a Full Scale IQ (WISC-III, Wechsler, 1991) of 85 or above; a main diagnosis of ODD or CD according to K-SADS-PL (Kaufman et al., 1997); no ongoing medication treatment. Although comorbidity with attention-deficit/hyperactivity disorder (ADHD) occurs in many children with ODD or CD (Loeber, Burke, & Pardini, 2009), we excluded ADHD children from the study in order to standardize the sample. Twelve ODD or CD children were being recruited at our hospital at the time of the current study, but they were not included as they were on medication. Subjects under medication were excluded as previous studies have reported that different kinds of drugs can affect emotion recognition abilities (Hempel, Dekker, van Beveren, Tulen, & Hengeveld, 2010; Bilderbeck, Atkinson, Geddes, Goodwin, & Harmer, 2017). No significant differences in diagnosis ratio (ODD/CD) and level of CU traits between those who were included and those who were not included in the study emerged from attrition analysis. We also recruited a sample of 23 healthy male controls with no current or past diagnosis of any psychiatric disorder, with a mean age of 8.86 years (SD = 1.35) and an IQ of 85 or above. Within this group, no participant had a current diagnosis of DBD, assessed using the K-SADS-PL (Kaufman et al., 1997). The levels of CU traits were assessed using the combined version (comprising both parent and teacher ratings) of the Antisocial Process Screening Device (APSD; Frick & Hare, 2001) were 4.79 (SD .89). The final sample consisted of 35 DBD patients and 23 healthy controls. See Table 1 for the characteristics of the two samples. Table 1 includes the mean of the family income for each group. A post-hoc power analysis using the *Power 3.1.9 (Faul, Erdfelder, Lang, & Buchner, 2007) was performed to estimate the power of our sample size. For a effect size settled at .35, similar to that found by Dadds et al. (2008), and a level of significance for a *p*-value fixed at $< .05$, our

Table 1
Characteristics of the samples.

	Disruptive Behavior Disorder (*N* = 35)	Healthy Controls (*N* = 23)	*F*	*p*
Age, y	8.93 (1.35)	8.86 (1.35)	.08	NS
EXT CBCL	67.07 (3.15)	56.20 (2.71)	57.22	.000
CU APSD	8.77 (2.36)	4.79 (.89)	34.44	.000
IQ WISC III	101.81 (6.15)	101.90 (6.28)	.01	NS
Family income, euros	18.720 (1.23)	32.080 (3.43)	16.32	.020

Notes. EXT CBCL = Child Behavior Checklist Externalizing Problems. CU APSD = Antisocial Process Screening Device combined version Callous Unemotional subscale. IQ WISC III = Wechsler Intelligence Scale for Children Third Edition full scale Intelligence Quotient.

sample size has a power > .90 to test our hypothesis. Ethical approval was obtained by the Stella Maris Scientific Institute, and informed consent was obtained from all subjects.

2.2. Measures

Children's diagnosis: The Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL, Kaufman, 1997) was used to assess the children for current and past DSM-IV disorders. Clinicians conducting the K-SADS interviews underwent training and satisfied reliability criteria (*k* Cohen ≥ .80). Both parents and children participating in the study completed the K-SADS interview independently. The rate of child-parent K-SADS diagnosis agreement was .87 (*k* Cohen).

Children's Intelligence Quotient: The Wechsler Intelligence Scale for Children, 3rd Ed. (Wechsler, 1991), was used to assess the Intelligence Quotient (criterion for the inclusion in the study was a Full Scale IQ ≥ 85).

Externalizing Problems: The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) is a 118-item standardized behavioral checklist, completed by parents for recording behavioral problems and skills in children from 6 to 18 years of age. Parents rate each behavior or symptom on a 3-point scale: not true (0), somewhat or sometimes true (1), or very true or often true (2). The 118 items are aggregated in eight different subscales related to both Internalizing and Externalizing domains, including Withdrawn, Somatic Complaints, Anxious/Depressed, Social Problems, Thought Problems, Attention Problems, Delinquent Behavior, and Aggressive Behavior. A number of studies have demonstrated convergence between the statistically derived syndromes of the CBCL and DSM-IV disorders (American Psychiatric Association, 1994; Edelbrock & Costello, 1988; Kazdin & Heidish, 1984), indeed, CBCL syndromes display good diagnostic efficiency for assessing common externalizing disorders in children (Hudziak, Copeland, Stanger, & Wadsworth, 2004).

Levels of CU traits: CU traits were assessed using the combined version (comprising both parent and teacher ratings) of the Antisocial Process Screening Device (APSD; Frick & Hare, 2001). We combined parent and teacher scores into one score. The APSD comprises seven items to evaluate narcissism, six items to evaluate callous-unemotional traits and five items to evaluate impulsivity. Each item was rated following a 3-point Likert scale: Not At All True (0), Sometimes True (1) or Definitely True (2). The APSD has been shown to be reliable and valid (Frick & Hare, 2001). In the current sample the Cronbach α coefficients were .83 for the parent version and .84 for the teacher version of the APSD. There is substantial support for the validity of the APSD in distinguishing sub-groups of antisocial youth with more severe and aggressive behavior and characteristics similar to adult psychopathy (Frick, Kimonis, Dandreaux, & Farell, 2003; Muratori et al., 2016).

Stimuli set: The stimuli we used were images from the NimStim Set of Facial Expressions (Tottenham et al., 2009), which consisted of naturally posed photographs of professional actors. Actors were instructed to make different facial expressions. We selected the same set of emotions used by Dadds et al. (2008): happy, sad, angry, fearful, disgusted and neutral. We used photographs of 4 actors, 2 males and 2 females. The authors of this set of images tested the percentage of emotion recognition for each expression (Tottenham et al., 2009). The faces were presented on a black background. Subjects were presented with 24 images (4 actors, each displaying 6 emotional expressions). During the eye-tracking task, each stimulus was presented individually for 4 s. The order of stimuli was randomized across actors and emotions. The stimuli were interspersed with grey fixation crosses on a black background lasting 20 s.

Participants were presented with six emotion labels (anger, sadness, happiness, fear, disgust, and neutral) and asked to select the emotion that best described the displayed expression. Participants were given an unlimited time to respond, but were instructed to be as quick and accurate as possible. A correct response was scored 1 and an incorrect response was scored 0.

Data acquisition: The eye-tracking measures were administered individually over the course of 4 weeks following the baseline evaluation in a quiet hospital room, especially set up for the experiment. Eye gaze was recorded using the SMI RED 500 binocular eye tracker provided by SensoMotoric Instruments (Teltow, Germany), with a sample rate of 120 Hz. The eye-tracker was positioned in front of the subject, below a 22-inch flat screen monitor where the stimuli were presented using the SMI Experiment Center Software. The distance between the screen and the subject was approximately 65 cm. Before starting the experimental task, a five-point calibration procedure was carried out, in which the children were asked to follow with their gaze a little toy that moved around on the screen. This task was repeated until the deviation from the known calibration target for both the x and y components was below 1°.

Children were then administered a set of stimuli, in which they passively viewed a set of faces depicting either happy, sad, angry, fearful, disgusted, or neutral expressions. Each trial was preceded by a colorful ‘attention-getter’ that was displayed at the center of the screen until the child looked at it for at least 500 ms. This phase was necessary to re-center the eyes before beginning the trial. Once attention was secured, the pre-recorded stimuli replaced the attention-getter. Trials with excessive blinking (more than 50% of the trial duration) were excluded from the analysis. Trials were excluded due to blinking in 15 out of 47 subjects (9 patients and 6 controls). There were no statistically significant differences in terms of number of excluded trials between patients and controls (patients: M = 0.68, SD = 0.88, controls: M = 0.47, SD = 0.74, p = .44). In addition, there were no statistically significant differences in the eye-tracking measures between subjects whose trials had been excluded and subjects whose trials had been retained (F = 0.48; p = .84; η2 = 0.94). Using SMI BeGaze Software (SensoMotoric Instruments) the following areas of interest (AOIs) were selected: face, eyes, and mouth. The outcome measures produced were: number of fixations (FC), average length of each fixation (FD) and length of first fixation (FFD). To avoid unconscious looking, a fixation threshold of 100 ms was applied to the raw data. The outcome measures for each AOI were calculated separately for each image and collapsed across emotions. To adjust for individual differences due to blinking or momentary distraction from the screen, the FD (or FC) on each AOI was calculated as a percentage of the overall FD (or FC) on the whole face (Kirk, Hocking, Riby, & Cornish, 2013; Perlman et al., 2009). The FD (or FC) on the face, on the other hand, was computed as a percentage of the overall time spent looking at the screen (Kirk et al., 2013).

2.3. Statistical analyses

The statistical analyses included three steps. Firstly, we used linear regression models in the whole sample to test if the levels of CU traits, externalizing behaviors, and group membership (DBD versus healthy) were associated with emotion recognition deficits and impaired eye gaze while controlling for IQ level, age, and family income. The dependent variables from the emotion recognition task were number of fixations (FC), average length of each fixation (FD) and length of first fixation (FFD) on the AOI for each of the six facial expressions (happy, sad, angry, scared, disgusted, or neutral). Secondly, we tested mediational models linking CU traits to emotion recognition deficits through attention to the eye-regions (controlling for IQ, age, family income, group membership and externalizing behavioral problems), with direct and indirect effects. Given that we hypothesized that mechanisms would be different in the clinical vs control group, we first tested a mediational model where the fixations interacted with the group membership to demonstrate that the conditional effects of FD and FC on recognition is moderated by group. Lastly, the source of significant interactions between group and fixations was examined through a Multiple-Group approach where the mediational models were freely estimated in the two groups. All the analyses were performed using Mplus 7 (Muthen & Muthen, 2012). Because the variables did not show consistent values of skewness and kurtosis, the ML estimator was used. To avoid bias due to the limited attrition in the sample, we estimated all models using the direct maximum likelihood procedure available in Mplus. Indirect effects were estimated using the Mplus model indirect command. Finally, given the small sample size, the bootstrap technique was used (1000 bootstrap samples).

3. Results

Findings from the regression analyses (see Table 2) indicated that in the whole sample, elevated levels of CU traits were associated with a lower ability to recognize sadness, even when the levels of externalizing behavioral problems, group membership, IQ, age and family income were statistically controlled for. Furthermore, elevated levels of CU traits were associated with a lower number of fixations (FC), and a lower average length of each fixation (FD) on the eye area of sad faces, even when the levels of externalizing behavioral problems, group membership, IQ, age and income were statistically controlled for. All regression models with other emotions/AOI as dependent variables were not significant. Tables of other regression models are available on request.

In order to test eye gaze mechanisms linking CU traits, number and length of fixation on the eye area of sad faces, and sadness recognition, we performed two mediational models where CU traits predicted sadness recognition via number of fixations (FC), and via average length of each fixation (FD) on the eye area of sad faces, controlling for the levels of externalizing behavioral problems, group membership, IQ, age and family income. Findings are reported in Table 3. There was a significant interaction between group and average length of each fixation (FD) on the eye area of sad faces, indicating that the relationship between fixations and emotion recognition (the mediational path) differs by group. No other significant effects were found for number of fixation on the eye area of sad faces.

Table 3
Mediational models predicting sadness recognition via FD eye sadness and via FC eye sadness in the full sample.

	Via FD		
	B	*SE*	*P*
Sadness recognition on			
IQ	-.118	.116	.309
AGE	.054	.113	.631
INCOME	.207	.129	.110
CU	-.519	.318	.103
GROUP	-.210	.233	.368
EXT	.057	.145	.693
FD eye sadness	-.177	.218	.418
FD*GROUP	.539	.244	.027
FD eye sadness on			
IQ	.040	.141	.775
AGE	-.109	.134	.416
INCOME	.136	.157	.387
CU	-.639	.234	.006
GROUP	.322	.211	.126
EXT	.001	.284	.997
	Via FC		
	B	*SE*	*P*
Sadness recognition on			
IQ	-.094	.121	.438
AGE	.099	.120	.407
INCOME	.227	.136	.095
CU	-.227	.340	.504
GROUP	-.213	.251	.396
EXT	.077	.158	.624
FC eye sadness	-.259	.230	.261
FC*GROUP	.280	.252	.268
FC eye sadness on			
IQ	-.017	.134	.902
AGE	-.199	.127	.116
INCOME	.125	.150	.404
CU	-.652	.222	.003
GROUP	.296	.201	.141
EXT	-.024	.269	.929

Notes. FD = Fixation Duration. FC = Fixation Counts. IQ = Intelligence Quotient. CU = Callous-Unemotional traits. EXT = Externalizing Problems. B = Regression Coefficient. SE = Standard Error. *p* = Significance probability.

In order to interpret the interaction term, a Multiple-Group approach was used to evaluate the mediational paths freely in the two groups, clinical and healthy group. As shown in Table 4, the indirect path from CU to sadness recognition via FD on the eye area of sad faces was significant in the clinical sample, meaning that higher levels of CU traits are associated with lower FD on the eye area of sad faces which in turns predicts lower levels of sadness recognition. The same indirect

Table 2
Multivariate regression models predicting emotion recognition and eye-tracking measures.

	FC eye sadness (R2 = .235)			FD eye sadness (R2 = .273)			Sadness recognition (R2 = .438)		
	B	*SE*	*P*	*B*	*SE*	*p*	*B*	*SE*	*P*
INCOME	.125	.150	.404	.136	.157	.387	.248	.138	.072
AGE	-.199	.127	.116	-.109	.134	-.813	.076	.119	.520
IQ	-.017	.134	.902	.040	.141	.775	-.096	.125	.440
CU	-.652	.222	.003	-.639	.234	.006	-.491	.214	.040
EXT	-.024	.269	.929	.001	.284	.997	-.283	.248	.255
GROUP	.296	.201	.141	.322	.211	.126	.132	.188	.482

Notes. B = Standardized estimates. FD = Fixation Duration. FC = Fixation Counts. IQ = Intelligence Quotient. CU = Callous Unemotional traits. EXT = Externalizing Problems. R^2 = Coefficient of Determination. B = Regression Coefficient. SE = Standard Error. *p* = Significance probability.

Table 4
Multiple-Group Models by group condition: Mediational models predicting sadness recognition via FD eye sadness.

	Clinical sample		
	B	*SE*	*p*
Sadness recognition on			
IQ	-.135	.136	.321
AGE	.145	.128	.256
INCOME	.107	.140	.448
EXT	-.231	.200	.246
FD eye sadness	.470	.168	.005
CU	-.200	.222	.368
FD eye sadness on			
IQ	.081	.174	.643
AGE	.007	.164	.964
INCOME	.270	.169	.111
CU	-.660	.227	.004
EXT	.072	.258	.782
Indirect effect: CU → FD eye sadness → sadness recognition = −.310*			
	Control sample		
	B	*SE*	*p*
Sadness recognition on			
IQ	-.164	.228	.471
AGE	-.201	.242	.406
INCOME	.391	.214	.067
EXT	-.096	.246	.696
FD eye sadness	.240	.259	.353
CU	.085	.224	.706
FD eye sadness on			
IQ	-.006	.223	.980
AGE	-.219	.229	.340
INCOME	.057	.219	.793
CU	-.327	.220	.136
EXT	.006	.255	.981
Indirect effect: CU→ FD eye sadness→ sadness recognition = −.028; ns			

Notes. FD = Fixation Duration. FC = Fixation Counts. IQ = Intelligence Quotient. CU = Callous-Unemotional traits. EXT = Externalizing Problems. B = Regression Coefficient. SE = Standard Error. *p* = Significance probability.

effect was not significant in the healthy sample.

4. Discussion

Our study investigated the role of CU traits in determining emotional processing deficits in children. The current findings show that the levels of CU traits are associated with a lower ability to recognize sadness both in children with DBD and in healthy control. These effects persist after accounting for age, IQ, externalizing behavioral problems and family income, indicating a peculiar association between the levels of CU traits and children's ability to recognize sadness. Importantly, in our sample, CU traits (nor externalizing behavioral problems) were not associated with impaired eye gaze to the eye region of faces or deficits in recognizing emotions, except for faces expressing sadness. In this regard, or findings are very similar to those of Woodworth and Waschbusch (2008), however previous studies have found that children with high CU traits exhibit a specific impairment in recognizing fear (Dadds et al., 2008; Martin-Key et al., 2018). Our results do not confirm these findings, as we did not find associations between levels of CU traits and impairment in recognizing and processing fearful facial expressions. Our results are also in contrast with the meta-analysis by Dawel et al. (2012), which revealed that children with high CU might show impairments across all emotion types. Finally, the current findings are in contrast with Rehder, Mills-Koonce, Willoughby, Garrett-Peters, Wagner, and Family Life Project Key Investigators (2017) who suggested that family income may be associated with emotion recognition in children. It is important to consider that the majority of previous studies investigating emotional processing in children with CU traits used community samples, whereas we used a sample with 35 children with a DBD diagnosis. It is possible that the difference between our results and previous studies on fear processing is due to the composition of the sample.

Our findings also indicate that CU traits are associated with lower number of fixations, and a lower average length of each fixation, on the eye area of sad faces both in children with DBD and in healthy control. In accordance with Dadds' findings (Dadds et al., 2008), our study showed that CU traits are associated with a fundamental problem that prevents children from directing attention to emotionally salient aspects (people's eyes). High levels of CU traits in children have also been associated with amygdala hypo-responsivity (Moul, Killcross, & Dadds, 2012), so we can speculate that in our sample higher levels of CU traits are associated with lower attention to the eye region due to deficits in amygdala responsivity. However, ad-hoc functional MRI tasks should be planned to confirm this hypothesis. From a developmental point of view we can postulate that this poor orientation to emotional stimuli and, in particular, to the eyes of caregivers could prejudice the child's responsiveness to parental discipline and affection, as well as the development of higher order empathic processing. However, the association we found seemed to be influenced by the type of emotion the children were presented with: higher levels of CU traits were associated with lower FC and FD, specifically for the eye region of sad faces.

We modeled CU traits continuously across a sample of DBD and typically developing children. However, the mediation process that link CU traits to emotion recognition deficits through attention to the eye-regions, seems to be suitable only for our clinical sample of DBD children. Importantly, these effects seem to be driven by CU traits and not by the levels of behavioral problems, IQ and family income. In children with DBD diagnosis high levels of CU traits are associated with lower FD on the eye area of sad faces, which in turns predicts lower levels of sadness recognition. CU traits can be also identified in children without behavioral problems (for a review see Frick et al., 2014); we can postulate that the impairment in processing sad faces could be considered a specific risk factor for the association between CU traits and conduct problems, because it prevents children from developing a normal sense of guilt and remorse for behavioral misconduct; and these deficits could have wide cascading consequences for the child and for the parent-child relationship.

This study exhibits a number of strengths including the focus on children with a current DBD diagnosis as well as the use of eye-tracking technology to assess eye movement behavior over relatively long trials. However, there are also several limitations, which provide scope for future research. One potential limitation is that our DBD group included children with either a CD or ODD diagnosis. Secondly, we used a parent reported evaluation of externalizing behavioral problems. Thirdly, we used static facial expressions. These kinds of stimuli are not very realistic: future studies should use different types of stimuli, such as videos, which are more similar to real-life interactions that children experience daily. Critically, because our design is cross-sectional, we cannot infer that the presence of elevated levels of CU traits is causally related to deficits in emotion recognition and eye movement behavior in children with a DBD diagnosis. Finally, this study was insufficiently powered, given the small sample, to investigate the influence of potential moderators on our findings. Future studies with larger samples are needed to determine whether the results obtained are influenced by other child characteristics. For instance, Dadds, Kimonis, Schollar-Root, Moul, and Hawes (2017) proposed that anxiety levels could identify different emotional impairments associated with high CU traits.

Although our results could induce researchers to make causal hypotheses regarding the relation between abnormal eye gaze patterns and callous traits, it is not clear whether abnormal eye gaze patterns drive the development of CU traits, or represent a by-product of CU traits. Some theorists argue that abnormal eye gaze patterns begin early and play an important role in the development of CU traits and subsequent psychopathy. Research shows that CU traits are associated with a deficit in attention to critical emotional stimuli. This can be seen across a range of stimuli presented using computerized paradigms, but according to Dadds et al. (2014), it is particularly important when it is expressed early in development as a failure to attend to the eye region of attachment figures. The empirical evidence that deficits in eye gaze emerge early and drive or at least precede the development of CU traits is mixed. Bedford, Pickles, Sharp, Wright, and Hill (2015) showed that reduced face preference in newborns predicted CU traits at 2.5 years. Bedford et al. (2017) showed that this reduced face preference only predicted later CU traits when it was associated with low maternal sensitivity. Thus, the causal relationship between abnormal eye gaze and CU traits through childhood is still unclear, and longitudinal studies will be needed to tease out their developmental sequence.

We feel it is important to point out that this paper shows for the first time that deficits in eye gaze to the eye region of emotional faces mediate the poor recognition of distress faces in children referred for disruptive behavior. This finding has important implications for the DBD clinical approaches. High levels of CU traits are clear risk signs for poor response to treatment in children with a DBD diagnosis (Masi et al., 2013). There are several evidence based models for reducing aggressive behavioral problems in children (for a review see Battagliese et al., 2015), however it is not clear how to reduce the level of CU traits in children with a DBD diagnosis, even though there have been some promising pilot studies (Muratori et al., 2017). The results of this study enable us to suggest creating multimodal intervention models for children with DBD and high levels of CU traits, as well as for their parents. These treatments should focus on training children to look at the eye region and to recognize sadness. Simultaneously, parents should be instructed to talk about their feelings with their children and to seek eye contact with them. Currently, there are some promising treatments for children and adolescents with CD and high levels of CU traits, which are focused on the improvement of emotion recognition and prosocial and empathic behavior in the child, as well as on parenting skills (Dadds et al., 2012; Datyner, Kimonis, Hunt, & Armstrong, 2015). We hope that the current study on the association between levels of CU traits and emotional processing in a clinical sample, may encourage clinicians to develop interventions, which aspire to train children to pay attention to the eye region when watching others' faces, in order to implement their ability to recognize emotions.

Financial support

Grant RC 2014–2016 funded by the Italian Ministry of Health.

Conflicts of interest

None of the authors has any conflict of interest related to this manuscript.

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

References

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA school-age forms and profiles.* Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

American Psychiatric Association (1994). *DSM-IV: Diagnostic and statistical manual.* Washington (DC): Author.

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

Battagliese, G., Caccetta, M., Luppino, O. I., Baglioni, C., Cardi, V., Mancini, F., et al. (2015). Cognitive-behavioral therapy for externalizing disorders: A meta-analysis of treatment effectiveness. *Behavior Research Therapy, 75*, 60–71.

Bedford, R., Pickles, A., Sharp, H., Wright, N., & Hill, J. (2015). Reduced face preference in infancy: A developmental precursor to callous-unemotional traits? *Biological Psychiatry, 78*, 144–150.

Bedford, R., Wagner, N. J., Rehder, P. D., Propper, C., Willoughby, M. T., & Mills-Koonce, R. W. (2017). The role of infants' mother-directed gaze, maternal sensitivity, and emotion recognition in childhood callous unemotional behaviours. *European Child & Adolescent Psychiatry,* 1–10.

Bilderbeck, A. C., Atkinson, L. Z., Geddes, J. R., Goodwin, G. M., & Harmer, C. J. (2017). The effects of medication and current mood upon facial emotion recognition: Findings from a large bipolar disorder cohort study. *Journal of Psychopharmacology, 31*, 320–326.

Blair, R. J. R., & Coles, M. (2000). Expression recognition and behavioural problems in early adolescence. *Cognitive Development, 15*, 421–434.

Blair, R. J. R., Colledge, E., Murray, L., & Mitchell, D. G. (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.

Blair, R. J. R., Leibenluft, E., & Pine, D. S. (2014). Conduct disorder and callous-unemotional traits in youth. *New England Journal of Medicine, 371*, 2207–2216.

Dadds, M. R., Allen, J. L., McGregor, K., Woolgar, M., Viding, E., & Scott, S. (2014). Callous-unemotional traits in children and mechanisms of impaired eye contact during expressions of love: A treatment target? *Journal of Child Psychology and Psychiatry, 55*, 771–780.

Dadds, M. R., Allen, J. L., Oliver, B. R., Faulkner, N., Legge, K., Moul, C., et al. (2012a). Love, eye contact and the developmental origins of empathy v. psychopathy. *The British Journal of Psychiatry, 200*, 191–196.

Dadds, M. R., Cauchi, A. J., Wimalaweera, S., Hawes, D. J., & Brennan, J. (2012b). Outcomes, moderators, and mediators of empathic-emotion recognition training for complex conduct problems in childhood. *Psychiatry Research, 199*, 201–207.

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 & Adolescent Psychiatry, 47*, 455–463.

Dadds, M. R., Jambrak, J., Pasalich, D., Hawes, D. J., & Brennan, J. (2011). Impaired attention to the eyes of attachment figures and the developmental origins of psychopathy. *Journal of Child Psychology and Psychiatry, 52*(3), 238–245.

Dadds, M. R., Kimonis, E. R., Schollar-Root, O., Moul, C., & Hawes, D. J. (2017). Are impairments in emotion recognition a core feature of callous–unemotional traits? Testing the primary versus secondary variants model in children. *Development and Psychopathology,* 1–11.

Datyner, A., Kimonis, E. R., Hunt, E., & Armstrong, K. H. (2015). Using a novel emotional skills module to enhance empathic responding for a child with conduct disorder with limited prosocial emotions. *Clinical Case Studies, 15*, 35–52 2016.

Dawel, A., O'Kearney, R., McKone, E., & Palermo, R. (2012). Not just fear and sadness: meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy. *Neuroscience & Biobehavioral Reviews, 36*, 2288–2304.

Edelbrock, C., & Costello, A. J. (1988). Convergence between statistically derived behavior problem syndromes and child psychiatric diagnoses. *Journal of Abnormal Child Psychology, 16*, 219–231.

Fairchild, G., Van Goozen, S. H., 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.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175–191.

Frick, P. J., & Hare, R. D. (2001). *Antisocial process screening device: APSD.* Toronto: Multi-Health Systems.

Frick, P. J., Kimonis, E. R., Dandreaux, D. M., & Farell, J. M. (2003). The 4 year stability of psychopathic traits in non-referred youth. *Behavioral Sciences & the Law, 21*, 713–736.

Frick, P. J., & Ray, J. V. (2015). Evaluating callous-unemotional traits as a personality construct. *Journal of Personality, 83*, 710–722.

Frick, P. J., Ray, J. V., Thornton, L. C., & Kahn, R. E. (2014). Can callous-unemotional traits enhance the understanding, diagnosis, and treatment of serious conduct problems in children and adolescents? A comprehensive review. *Psychological Bulletin, 140*, 1–57.

Hawes, D. J., Price, M. J., & Dadds, M. R. (2014). Callous-unemotional traits and the treatment of conduct problems in childhood and adolescence: A comprehensive review. *Clinical Child and Family Psychology Review, 17*, 248–267.

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Sciences, 4*, 223–233.

Hempel, R. J., Dekker, J. A., van Beveren, N. J., Tulen, J. H., & Hengeveld, M. W. (2010). The effect of antipsychotic medication on facial affect recognition in schizophrenia: A review. *Psychiatry Research, 178*, 1–9.

Hubble, K., Bowen, K. L., Moore, S. C., & Van Goozen, S. H. (2015). Improving negative emotion recognition in young offenders reduces subsequent crime. *PLoS One, 10*(6) e0132035.

Hudziak, J. J., Copeland, W., Stanger, C., & Wadsworth, M. (2004). Screening for DSM-IV externalizing disorders with the child behavior checklist: A receiver-operating characteristic analysis. *Journal of Child Psychology and Psychiatry, 45*(7), 1299–1307.

Jones, A. P., Laurens, K. R., Herba, C. M., Barker, G. J., & Viding, E. (2009). Amygdala hypoactivity to fearful faces in boys with conduct problems and callous–unemotional traits. *American Journal of Psychiatry, 166*, 95–102.

Kaufman, J., Birmaher, B., Brent, D., Rao, U. M. A., Flynn, C., Moreci, P., et al. (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 & Adolescent Psychiatry, 36*, 980–988.

Kazdin, A. E., & Heidish, I. E. (1984). Convergence of clinically derived diagnoses and

parent checklists among inpatient children. *Journal of Abnormal Child Psychology, 12*, 421–435.
Kirk, H. E., Hocking, D. R., Riby, D. M., & Cornish, K. M. (2013). Linking social behaviour and anxiety to attention to emotional faces in Williams syndrome. *Research in Developmental Disability, 34*, 4608–4616.
Loeber, R., Burke, J., & Pardini, D. A. (2009). Perspectives on oppositional defiant disorder, conduct disorder, and psychopathic features. *Journal of Child Psychology and Psychiatry, 50*, 133–142.
Marsh, A. A., Finger, E. C., Mitchell, D. G., Reid, M. E., Sims, C., Kosson, D. S., et al. (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.
Martin-Key, N. A., Graf, E. W., Adams, W. J., & Fairchild, G. (2018). Facial emotion recognition and eye movement behaviour in conduct disorder. *Journal of Child Psychology and Psychiatry, 59*, 247–257.
Masi, G., Muratori, P., Manfredi, A., Lenzi, F., Polidori, L., Ruglioni, L., et al. (2013). Response to treatments in youth with disruptive behavior disorders. *Comprehensive Psychiatry, 54*, 1009–1015.
Moul, C., Killcross, S., & Dadds, M. R. (2012). A model of differential amygdala activation in psychopathy. *Psychological Review, 119*, 789.
Muratori, P., Lochman, J. E., Manfredi, A., Milone, A., Nocentini, A., Pisano, S., et al. (2016). Callous unemotional traits in children with disruptive behavior disorder: Predictors of developmental trajectories and adolescent outcomes. *Psychiatry Research, 236*, 35–41.
Muratori, P., Milone, A., Manfredi, A., Polidori, L., Ruglioni, L., Lambruschi, F., et al. (2017). Evaluation of improvement in externalizing behaviors and callous-unemotional traits in children with disruptive behavior disorder: A 1-year follow up clinic-based study. *Administration and Policy in Mental Health and Mental Health Services Research, 44*, 452–462.
Muthen, L. K., & Muthen, B. O. (2012). *Mplus Version 7 user's guide.* Los Angeles, CA: Muthen & Muthen.
Perlman, S. B., Morris, J. P., Vander Wyk, B. C., Green, S. R., Doyle, J. L., & Pelphrey, K. A. (2009). Individual differences in personality predict how people look at faces. *PLoS One, 4* e5952.
Rehder, P. D., Mills-Koonce, W. R., Willoughby, M. T., Garrett-Peters, P., Wagner, N. J., & Family Life Project Key Investigators (2017). Emotion recognition deficits among children with conduct problems and callous-unemotional behaviors. *Early Childhood Research Quarterly, 41*, 174–183.
Short, R. M., Sonuga-Barke, E. J., 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.
Sully, K., Sonuga-Barke, E. J., & 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.
Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., et al. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168*, 242–249.
Wechsler, D. (1991). *WISC-III: Wechsler intelligence scale for children: Manual.* Psychological Corporation.
White, S. F., Marsh, A. A., Fowler, K. A., Schechter, J. C., Adalio, C., Pope, K., et al. (2012b). Reduced amygdala response in youths with disruptive behavior disorders and psychopathic traits: Decreased emotional response versus increased top-down attention to non emotional features. *American Journal of Psychiatry, 169*, 750–758.
White, S. F., Williams, W. C., Brislin, S. J., Sinclair, S., Blair, K. S., Fowler, K. A., et al. (2012a). Reduced activity within the dorsal endogenous orienting of attention network to fearful expressions in youth with disruptive behavior disorders and psychopathic traits. *Development and Psychopathology, 24*, 1105–1116.
Woodworth, M., & Waschbusch, D. (2008). Emotional processing in children with conduct problems and callous/unemotional traits. Child: care. *health and development, 34*(2), 234–244.