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ORIGINAL CONTRIBUTION

Emotional valence detection in adolescents with oppositional defiant disorder/conduct disorder or autism spectrum disorder

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Abstract

Oppositional defiant disorder, conduct disorder (ODD/CD), and autism spectrum disorder (ASD) share poor empathic functioning and have been associated with impaired emotional processing. However, no previous studies directly compared similarities and differences in these processes for the two disorders. A two-choice emotional valence detection task requiring differentiation between positive, negative, and neutral IAPS pictures was administered to 52 adolescents (12–19 years) with ODD/CD, 52 with ASD and 24 typically developing individuals (TDI). Callous–unemotional (CU) traits were assessed by self- and parent reports using the Inventory of callous–unemotional traits. Main findings were that adolescents with ODD/CD or ASD both performed poorer than TDI in terms of accuracy, yet only the TDI—not both clinical groups—had relatively most difficulty in discriminating between positive versus neutral pictures compared to neutral–negative or positive–negative contrasts. Poorer performance was related to a higher level of CU traits. The results of the current study suggest youth with ODD/CD or ASD have a diminished ability to detect emotional valence which is not limited to facial expressions and is related to a higher level of CU traits. More specifically, youth with ODD/CD or ASD seem to have a reduced processing of positive stimuli and/or lack a 'positive perception bias' present in TDI that could either contribute to the symptoms and/or be a result of having the disorder and may contribute to the comorbidity of both disorders.

Keywords Emotional valence detection task · Conduct disorder · Oppositional defiant disorder · Autism spectrum disorder · Callous–unemotional traits

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Introduction

The detection of emotional valence—the intrinsic attractiveness/'goodness' (positive valence) or averseness/'badness' (negative valence) of a person, object, or situation provides crucial information for decision making [1]. Emotions with the same valence (e.g., anger and fear or pride and surprise) produce a similar influence on judgments and choices. The detection of negative valence activates the behavioural inhibition system (BIS), leading to a withdrawal from the person, object, or situation [2]. Similarly, the detection of positive valence activates the behavioural activation system (BAS), leading to an approach toward the person, object, or situation [3]. In daily life, emotional valence detection is frequently active during the recognition of facial expressions [4], providing crucial information on whether the other person is willing to positively interact with you or not. However, it is similarly crucial to correctly identify the emotional valence of non-facial stimuli and situations, since a reduced ability to detect the negative emotional valence of situations will inappropriately activate a tendency to approach the object or situation, causing potentially dangerous situations such as getting into fights or other self-harming situations [5]. Similarly, a reduced ability to detect the positive emotional valence of objects or situations will falsely activate a tendency to withdraw from the object or situation, leading for instance to social shyness and self-isolation [6]. As such, the correct processing of emotional content is essential to fully understand functional and dysfunctional behaviour.

Emotional valence is processed in similar (i.e., limbic and prefrontal) brain areas across disorders [7]. In nearly all psychiatric disorders, an increased likelihood has been found for an altered and/or reduced detection of emotional valence [8]. Of specific interest in this domain are disruptive behaviour disorders—oppositional defiant disorder and conduct disorder (ODD/CD)—and autism spectrum disorder (ASD), since both disorders can be hypothesized to be characterized by a disbalance in the BIS/BAS [9, 10] as well as a pronounced reduction in empathy. This is in contrast with other disorders also characterized by a disbalance in the BIS/BAS system such as anxiety [11] or mood disorders [12]. Individuals with ODD/CD tend to approach people, objects, and/or situations that have a (clear) negative valence to people without ODD/CD more than controls (i.e., typically developing individuals and individuals with ADHD) [10]. A decreased emotional arousal has been found in individuals with CD when looking at emotionally evocative pictures, potentially explaining this phenomenon [13, 14]. In contrast, individuals with ASD tend to avoid people, (social) situations, and sometimes objects that have a (clear) positive valence to individuals without ASD more than typically developing controls [15].

Notwithstanding the differences between both diagnostic categories, differentiation between both is sometimes difficult in everyday clinical practice. About a quarter of children with ASD show comorbid ODD/CD [16], and the incidence of ASD symptoms in ODD/CD is also clearly raised [17, 18]. Furthermore, both disorders frequently show comorbidity with ADHD [19, 20]. This overlap shows that psychopathology does not exist in dichotomous entities (i.e., presence of absence of a disorder) and that liability for having one disorder may increase liability for having another [21, 22]. Therefore, it may be important to focus on a research classification system for mental disorders based upon dimensions of functional systems, neurobiology and observable behaviour, such as the Research Domain Criteria (RDoC) project. RDoC supports research to explicate fundamental biobehavioural dimensions (such as emotional valence detection) that cut across current heterogeneous disorder categories [23]. Studying emotional valence detection may give more insight into the (non-) overlapping cognitive features of categorical disorders.

It may be further hypothesized that an altered/reduced ability to detect emotional valence in ODD/CD and ASD may be related to a reduced ability to understand, feel, and show empathy found in both disorders [24]. Empathy is the capacity to recognize, understand, and share the emotional states of others [25]. Empathy may be dissected into three domains, that is, emotional empathy, cognitive empathy, and motor empathy [26]. Emotional empathy refers to experiencing emotions consistent with and in response to those of others [27]. Cognitive empathy refers to reduced abilities to identify and describe how others may perceive situations [28] and to automatically track others' mental states [29]. Motor empathy refers to automatically and unconsciously mirroring the facial expressions of another person, known as facial mimicry [27]. In CD, deficits in emotional empathy have been related to callous–unemotional (CU) traits [30]. CU traits ('limited prosocial emotions') have been adopted as a specifier to CD in the *Diagnostic and Statistical Manual of Mental Disorders, fifth edition* (DSM-5), and are defined as a set of personality traits comprising lack of empathy, lack of remorse or guilt, shallow affect, and being unconcerned about performance. Indeed, conduct problems and high CU traits have been found to be related to deficits in emotional empathy, whereas ASD was found to be related to cognitive empathy deficits [31, 32]. However, recent studies have shown that CU traits might be best seen as cross-disorder construct with increased prevalence not only in CD, but in ODD and ASD as well [33, 34]. As such, an altered emotional valence detection may underlie the increased prevalence of CU traits across disorders and may help understand the comorbidity rates between both disorders.

Therefore, the current study set out to examine the overlapping and specific features of altered emotional valence detection in individuals with ODD, CD, or ASD and whether this is related to the severity of CU traits in both clinical groups. A two-choice emotional valence detection task was administered in adolescents with ODD/CD, or ASD, and in typically developing individuals (TDI). In each trial, two pictures with emotional valences were contrasted (neutral–positive, neutral–negative, and negative–positive). As the literature on this topic is sparse, we did not formulate a hypothesis how the different diagnostic groups would perform, and whether a moderating role of CU traits could be detected.

Method

Participants

Initially, 166 male subjects were approached to participate, of whom 38 dropped out because of: refusal to participate ($n=28$), not meeting inclusion criteria ($n=8$), or not able to obtain consent of legally appointed guardian ($n=2$). This resulted in a total sample of 128 male participants [$n=52$ patients with ODD or CD (ODD/CD), $n=52$ patients with ASD, and $n=24$ TDI group]. Participants with ODD or CD were grouped together, since both disorders are closely linked neurodevelopmental disorders of which ODD is either prodromal to CD [35, 36] or a subsyndromal form of CD (Biederman et al. 1996). All participants aged between 12 and 19 years ($M=15.3$ years, $SD=1.9$), and 81% were of Caucasian origin. They were recruited between April 2011 and September 2014 as part of a larger study on empathy (CU2-study). Participants were recruited through clinical institutes in The Netherlands, specialized in severe disruptive behaviour problems (De Hoenderloo Group, Ottho Gerhard Heldring Foundation, and Woodbrookers) or severe psychiatric problems (Karakter Child and Adolescent Psychiatry) and through information leaflets that were sent to families via the Dutch federation of Autism (NVA). Adolescents were excluded if they fulfilled one or more of the exclusion criteria (a) a combined diagnosis of ODD/CD and ASD, (b) an estimated total IQ < 80, and/or (c) suffering from a condition which may affect neurological or cognitive functioning, such as schizophrenia, bipolar disorder, alcohol and/or drugs dependency, presence of tics, language disorders (e.g., dyslexia), and epilepsy. The TDI group was recruited from a general community sample via city councils in the same geographical regions as the clinical groups. In- and exclusion criteria for the TDI group were similar to the ODD/CD and the ASD groups, except for having a clinical psychiatric diagnosis.

Diagnoses in the ODD/CD and the ASD groups were established according to DSM-IV-TR [37] criteria by a multidisciplinary team based on information gathered by a child psychiatrist, a child psychologist, and a review of clinical and prior records (if available), including information available from school or other professional institutions involved with the child. Thus, a consensus diagnosis was assigned, which is seen as more reliable compared to structured interviews for assessing diagnostic categories [38]. In the TDI group, the absence of a clinical psychiatric diagnosis was assessed based on parent report. For all three groups, legal guardians were asked to fill out a digital version [39] of the National Institute of Mental Health Diagnostic Interview Schedule for Children (DISC-IV; [40]). Legal guardians were asked to fill out the following sections: Attention-Deficit/Hyperactivity Disorder, ODD, CD, Tic Disorder, Alcohol, Marihuana, and Other Drugs, to control for possible psychiatric comorbidities. Because DSM-IV-TR diagnoses were automatically generated, an experienced child and adolescent psychiatrist (PH) and psychologist (MB) evaluated diagnostic findings of the computerized DISC. The use of non-psychotropic (5.5%) and antidepressant medication (2.3%) was allowed. If possible, psychotropic medication (i.e., stimulants, 21.8%, antipsychotics, 9.3%, and atomoxetine, 2.3%) was stopped prior to testing. Stimulants were discontinued for at least 24 h. Antipsychotics were discontinued for at least 72 h. However, when discontinuation was thought to have severe deteriorating effects, medication was continued (ODD/CD: $n=12$, ASD: $n=10$).

Participants were required to have a minimum average estimated total full-scale intelligence quotient (FSIQ) of ≥ 80. FSIQ was estimated using four subtests of the Dutch version Wechsler Intelligence Scale for Children (WISC-III): Similarities, Vocabulary, Block Design, and Picture Completion [41]. These selected WISC-III subtests are known to correlate between 0.90 and 0.95 with the full-scale IQ [42]. For children older than 16 years, the Wechsler Adult Intelligence Scale (WAIS-III) was administered [43]. When intelligence was assessed within a year prior to the inclusion, and either the WISC or WAIS was applied, we used the scores of that assessment.

This study was approved by the Dutch *Central Committee on Research involving Human Subjects,* protocol number NL26773.000.09 (Centrale Commissie Mensgebonden Onderzoek; CCMO). Both parents and the adolescents (if 12 years and older) signed the informed consent.

Measures

A two-choice emotional valence detection task was used with a high load on set-shifting abilities. This task has previously shown to be associated with differential reaction times in adults, being grouped as forensic psychiatric patients, psychopaths, and normal controls [44], indicating differentiating properties across different diagnostic groups of this task. The task required participants to pay attention to stimuli with a predefined affective load presented in the centre of the screen and to respond as rapidly as possible by pressing the space bar for target stimuli (hits) while withholding the response to non-target stimuli. Stimuli consisted of pictures from the International Affective Picture System (IAPS) database which were validated for their valence [45], and grouped into three categories (positive and negative valence, and neutral; for example, see Fig. 1). In each block, two valences were contrasted (neutral–positive, neutral–negative, and negative–positive), to investigate whether changes in false-positive reactions and in reaction time are related to specific (combinations of) emotions. Only two emotional valences were presented per block. Each valence combination was presented twice in two different blocks varying the valence of target stimuli (50%) versus non-target stimuli (50%) to investigate whether changes in false-positive reactions and in reaction time are related to stimulus order (i.e., the order in which specific combinations of emotions are presented. Thus, valence contrast was manipulated (with three emotional valences) and stimulus order (e.g., neutral stimuli as target stimuli and positive as non-target stimuli in block 1 and the reverse in block 2). This resulted in six experimental blocks (neutral–positive, positive–neutral; neutral–negative, negative–neutral; negative–positive, and positive–negative), each with 32 trials. Each single block lasted approximately 45 s in duration, with a fixed 500 ms stimulus presentation and response window, followed by a 900 ms inter-stimulus interval. A short practice session of ten trials with the same presentation rate preceded each block to learn the distinction between the two affective categories being used in each block. The practice block was automatically repeated once if the participant did not reach the 80% accuracy cutoff the first time. Thereafter, the experimental block was started. Outcome variables were the percentage of hits, the mean reaction time per block, and the signal-to-noise ratio d' (percentage hits—percentage false positives).

The test battery was shown on a Dell Latitude D530 laptop with a Windows Vista operating system. The task was presented using the MINDS-software program (version 1.2.7) [46], which is a digital test manager used to present a test battery. Participants were positioned in front of a laptop about 60 cm from a 15-inch screen with a resolution of 1024 × 768 pixels and a refresh rate of 60 Hz. Images were presented in the centre of the display with neutral grey background. Images were 15.5 × 20.5 cm in size, covering a visual angle of 15° vertically and 20° horizontally. Finishing the total task took about 15 min.

CU traits were assessed by self- and parent report on the Inventory of Callous–unemotional traits (ICU), Dutch translation [47]. The ICU contains 24 items, which are rated on a four-point Likert scale ranging from 0 = *does not apply at all* to 3 = *applies very well*. Internal consistency of the Dutch ICU was shown to be good [48, 47]. In the current study, Cronbach's alpha was high (0.80 for ICU-SR, 0.90 for ICU-PR). Concurrent validity between the ICU and psychopathy scales is acceptable ($r = 0.45–0.68$ between ICU and Antisocial Process Screening Device [49], and Childhood Psychopathy Scale [47].

ASD symptoms were assessed by administering the Social Communication Questionnaire (SCQ) [50]. This is a 40-item parent-report questionnaire that asks about characteristic autistic symptoms. Each item is rated as either *Yes* or *No*. Nineteen items rate current behaviour and 20 items rate behaviour when the child was 4–5 years. Cut-off score is ≥ 15. Sensitivity was found to range between 0.85 and 0.88, Specificity was found to range between 0.72 and 0.78 in English-language versions [51–53]. In this study, Cronbach's alpha for the total SCQ was 0.75. For analyses, the current behaviour items were used.

Fig. 1 Examples from the emotional valence detection task. On the left a positive stimulus, in the middle a neutral stimulus, on the right a negative stimulus

Procedures

A short telephone screening and, subsequently, screening questionnaires were used to verify if families could participate. Those families were invited to visit one of the participating clinics. Testing of the participants took place in a quiet room at their clinical institute. The task described here was part of a broader neuropsychological assessment battery used in the 'psychopathology and the lack of empathy' (CU2) project. Youths completed the battery in approximately 2 h and the order of the task administration was counterbalanced. Participants were motivated with small breaks and received a financial compensation (vouchers of € 20.00) after test administration.

Data analyses

To examine the group differences regarding emotional valence detection and set-shifting capacities, repeated measure ANOVAs were conducted with group as between subjects factor (three levels: TDI, ODD/CD, and ASD), valence contrast as within subjects factor (three levels: neutral–positive, neutral–negative, and positive–negative) and response set as within subjects factor (two levels: original set versus reversed set). Analyses were separately run for percentage hits, reaction time of hits, and d' (signal-to-noise ratio, calculated as percentage hits—percentage false positives). Analyses were run with and without IQ as covariate, and medication and comorbidity (i.e., ADHD present or not present) as between subjects factor. Covariates were entered separately to examine the unique effects on the results. Discrepancies in results were reported. Across and within groups, Pearson's correlations between CU and ASD symptoms (SCQ current items), and task performance were examined. Correlational analyses between CU traits and task performance were run within groups. All analyses were carried out in SPSS version 24. Power analysis indicated a sample size of $N = 102$ was needed to achieve 95% power to detect main and interaction effects of $d \geq 0.25$ using the proposed repeated measure ANOVA with three groups. Missing data were 0% for the emotional valence detection task performance ($N = 128$) and ICU self-report questionnaire ($N = 128$), and 7.8% for the parent-rated SCQ and ICU ($N = 118$). Missing data were not replaced.

Results

Descriptives

See Table 1 for sample characteristics. The majority (84.6%) of the ODD/CD group was diagnosed with having ODD, 15.4% with CD. Comorbid ADHD was found in 59.6% of the ODD/CD group and in 42.3% of the ASD group. In the clinical groups, 34.4% used psychotropic medication. Stimulants were the mostly prescribed medication type (21.8%), followed by antipsychotics (9.3%) and non-psychotropic medication (5.5%), with stimulants being significantly more prescribed in the ASD group, compared to the ODD/CD group ($p < .05$). For 12 youths with ODD/CD and 10 youths with ASD, discontinuation of medication was not possible.

The three groups did not differ in age, but did significantly differ in IQ [F (2, 120) = 19.65, $p < .001$], whereby TDI ($M = 106.1$, SD = 8.1) and ASD ($M = 102.7$, SD = 11.1) had a higher mean IQ compared to ODD/CD ($M = 92.7$, SD = 8.9). The ODD/CD group showed significantly higher self-reported CU scores than both the TDI and the ASD groups, whereas the TDI and the ASD groups did not differ from each other [F (2, 125) = 9.04, $p < .01$]. The ODD/CD group scored significantly higher on parent-reported CU traits than the ASD group, and the ASD group scored significantly higher than the TDI group [F (2, 115) = 57.06, $p < .001$]. For SCQ scores, the ASD group scored significantly higher than the ODD/CD group, and the ODD/CD group scored significantly higher than the TDI group [F (2, 110) = 44.46, $p < .001$].

Task manipulation effects

Main effects of response set were found for percentage hits, reaction time hits and d', in which performance on the second (i.e., reversed set) was made with slightly slower RTs, percentage hits and lower d', suggesting the reversed response-set taxed set-shifting abilities. However, since there were no two-way (diagnosis by response set) or three-way (diagnosis by response set by valence contrast) effects on any of the outcome variables, for simplification, further analyses were carried out with data collapsed for blocks contrasting the same valences. Main effects of *valence contrast* were found on all parameters, in which discriminating between positive and neutral pictures appeared more difficult compared to negative versus positive or negative versus neural pictures, as reflected by fewer hits, longer RTs for hits, and a lower d'. No differences were found for the ability to discriminate between negative versus positive and negative versus neutral, see Table 2 for results of the repeated measure ANOVAs.

Diagnostic effects

A main effect of diagnosis was found for percentage of hits (Table 2), with adolescents with ODD/CD or ASD performing poorer than TDI (both $p = .01$), with no difference between adolescents with ODD/CD or ASD ($p = .95$) (Fig. 2). In addition, a trend main effect of diagnosis on d' was present, with overall a poorer signal-to-noise ratio in

Table 1 Characteristics of the study population ($N = 128$)

	Total group		TDI		ODD/CD		ASD		Contrasts
	M	±SD	*M*	±SD	*M*	±SD	*M*	±SD	
Age (years)	15.3	1.9	15.9	1.8	15.5	1.7	14.9	2.0	ns
FSIQ***	99.4	11.1	106.1	8.1	92.7	8.9	102.7	11.1	ODD/CD < ASD = TDI
VIQ***	100.1	14.0	108.3	9.7	90.5	12.5	103.8	12.7	ODD/CD < ASD = TDI
PIQ	99.6	14.1	103.7	14.1	95.1	12.6	101.3	14.5	ns
ICU-SR total score**	26.9	9.0	23.2	6.3	30.7	10.0	24.8	7.5	ODD/CD > ASD = TDI
ICU-PR total score***	29.4	11.9	16.0	7.0	38.9	9.4	28.0	8.4	ODD/CD > ASD > TDI
SCQ total score***	11.7	7.1	3.1	2.4	11.9	6.1	15.5	5.7	ASD > ODD/CD > TDI
	N	%	*N*	%	*n*	%	*n*	%	Contrasts
	128	100.0	24	18.8	52	40.6	52	40.6	
Institute									
Child and Adolescent Psychiatry	51	39.8	0	0	9	17.0	42	80.8	
Youth Welfare	45	35.2	0	0	44	83.0	2	3.8	
Municipalities	24	18.8	24	100	0	0	0	0	
Dutch Association for Autism	8	6.3	0	0	0	0	8	15.4	
Comorbidity**									
ADHD	53	41.4	0	0	31	59.6	22	42.3	ODD/CD > ASD > TDI
None	64	50.0	24	100	12	23.1	29	55.8	
Missing	11	8.6	0	0	9	17.3	1	1.9	
Medication[a,]*									
Yes	51	39.7	0	0	18	34.6	33	63.5	ASD > ODD/CD > TDI
No	70	54.7	23	95.8	27	51.9	19	36.5	
Missing	7	5.5	1	4.2	7	13.5	0	0	
Ethnicity parents ($n = 258$)***									
Caucasian	207	80.9	46	95.8	60	57.7	101	97.1	ODD/CD < ASD = TDI
African	19	7.4	0	0	19	18.3	0	0	
Unknown	25	9.4	2	4.2	21	20.2	1	1.0	
Missing	6	2.3	0	0	4	3.8	2	1.9	
Highest level of education parents[b,]*									
Lower	8	6.3	0	0	5	9.6	3	5.8	
Middle	36	28.1	3	12.5	14	26.9	19	36.5	
Higher	60	46.9	21	87.5	10	19.2	29	55.8	ODD/CD < ASD < TDI
Missing	24	18.8	0	0	23	44.2	1	1.9	

TDI typically developing individual, *ODD/CD* oppositional defiant disorder/conduct disorder, *ASD* autism spectrum disorder, *ICU-SR* inventory of callous unemotional traits—self-report, *ICU-PR* inventory of callous unemotional traits—parent report, *SCQ* social communication questionnaire, *M* mean, *SD* standard deviation, *ns* not statistically significant ($p > .05$)

p value after Bonferroni correction: *$p < .05$, **$p < .01$, ***$p < .001$

[a]If possible, psychotropic medication was stopped prior to testing. For 12 youths with ODD/CD and 10 youths with ASD discontinuation of medication was not possible

[b]Highest level of education parents: Lower—primary education/preparatory lower level vocational education, Middle—preparatory middle-level vocational education, Higher—higher level vocational education/preparatory university education

adolescents with ODD/CD or ASD compared to TDI ($p = .02$ and .05, respectively), with no difference between adolescents with ODD/CD or ASD ($p = .63$). However, a trend-significant diagnosis*block order effect was found, with post-hoc tests showing that performance decreased linearly in the TDI group [F (1, 23) = 6.57, $p = .017$], but remained more stable in both clinical groups [ODD/CD: F (1, 51) = 2.95, $p = .09$; ASD: F (1, 51) = 0.51, $p = .48$]. Furthermore, a diagnosis by valence contrast was found for hit RT. Post-hoc tests showed that valence contrast had no significant effect on RT in the ASD group [F (2,50) = 2.00, $p = .15$], whereas it did in the TDI group [F (2,22) = 5.25, $p = .01$] and the ODD/CD group [F (2,50) = 4.58, $p = .02$]. The TDI group was slower in discriminating between positive versus neutral

Table 2 Descriptives of average scores per valence contrast, response set, and diagnosis; results of the repeated measures ANOVAs

	TDI *M* (SD)	ODD/CD *M* (SD)	ASD *M* (SD)	Repeated measures ANOVA[2]	F; p; η^2
Percentage hits				Diagnosis	4.04; .02; .06
POS–NEU[1]	91.7 (9.0)	85.5 (14.5)	82.1 (23.2)	Valence contrast	18.0; < . 001; .13
NEU–POS	91.9 (9.1)	84.3 (16.2)	88.3 (12.4)	Diagnosis × valence contrast	ns
POS–NEG	95.6 (7.5)	91.6 (12.6)	89.0 (14.8)		
NEG–POS	96.9 (4.5)	96.2 (5.8)	93.7 (17.3)		
NEU–NEG	95.1 (9.4)	87.0 (16.0)	90.0 (11.6)		
NEG–NEU	96.4 (6.4)	91.5 (15.0)	93.4 (13.8)		
Reaction time hits				Diagnosis	ns
POS–NEU	521.5 (130.7)	488.6 (76.8)	512.0 (105.3)	Valence contrast	13.03; < .001; .17
NEU–POS	519.8 (82.7)	504.8 (100.5)	527.4 (95.5)	Diagnosis × valence contrast	3.67; .006; .06
POS–NEG	469.3 (42.2)	488.6 (90.7)	505.1 (74.1)		
NEG–POS	465.0 (47.7)	470.0 (57.4)	497.8 (63.8)		
NEU–NEG	481.8 (59.6)	514.4 (89.6)	522.3 (90.6)		
NEG–NEU	448.3 (53.3)	470.6 (79.0)	492.4 (57.0)		
d' (percentage hits—percentage false positives)				Diagnosis	2.89; .06; .04
POS–NEU	61.0 (31.3)	51.1 (30.3)	48.1 (37.9)	Valence contrast	49.2; < .001; .28
NEU–POS	68.0 (21.6)	53.0 (28.4)	53.8 (25.3)	Diagnosis × valence contrast	ns
POS–NEG	81.0 (12.2)	72.2 (21.0)	67.2 (23.1)		
NEG–POS	74.5 (21.8)	78.7 (20.1)	72.6 (27.1)		
NEU–NEG	76.1 (25.0)	63.2 (30.1)	67.6 (24.1)		
NEG–NEU	81.8 (17.7)	71.0 (28.6)	69.8 (28.0)		

This two-choice emotional valence detection task required participants to pay attention to stimuli with a predefined affective load presented in the centre of the screen, and to respond as rapidly as possible by pressing the space bar for target stimuli, while withholding the response to non-target stimuli. The task consists of six blocks presented in random order, each with 32 trials. Stimuli consisted of pictures from the IAPS database, and grouped into three categories: positive, neutral and negative valence

TDI typically developing individual, *ODD/CD* oppositional defiant disorder/conduct disorder, *ASD* autism spectrum disorder, *M* mean, *SD* standard deviation, *ns* not statistically significant ($p > .05$)

[a]Because of randomization, type of valence contrast did not relate to block order

[b]Repeated measure ANOVAs were conducted withgroup as between subjects factor (three levels: TDI, ODD/CD, ASD), valence contrast as within subjects factor (three levels: neutral–positive; neutral–negative, and positive–negative) and response set as within subjects factor (two levels: original set versus reversed set)

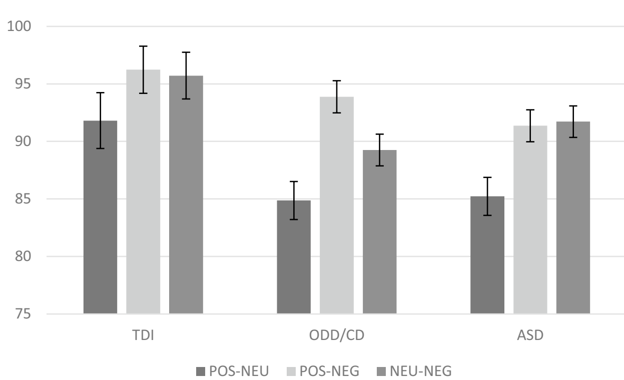

Fig. 2 Percentage hits (mean and standard error) by diagnosis

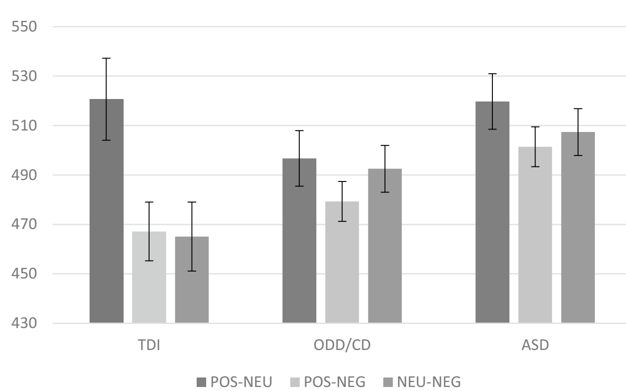

Fig. 3 Reaction time (mean and standard error) for hits in milliseconds to discriminate two pictures with distinct valence by diagnosis

pictures than in the other two conditions (both $p < .01$) that did not differ from each other. In contrast, the ODD/CD group was faster in discriminating between positive versus negative pictures than in the other two conditions ($p < .03$) that did not differ from each other (Fig. 3). Covarying for ASD symptoms did change the p values but not the overall pattern of findings.

Moderating role of CU traits

Parent-rated CU traits and ASD symptoms (SCQ current items) correlated significantly ($r = .31$, $p < .001$). Self-rated CU traits did not correlate with parent-rated ASD symptoms ($r = .04$, $p = .69$). Self- and parent-rated CU traits correlated significantly ($r = .50$, $p < .001$). Significant small correlations were found between ASD symptoms and slower reaction times in three out of six blocks (NEG–POS: $r = .21$, $p = .025$; NEU–NEG: $r = .22$, $p = .016$; NEG–NEU: $r = .25$, $p = .006$), but not for measures of accuracy. Parent-rated CU traits correlated with reduced accuracy on two out of six blocks (fewer hits: NEU–POS: $r = -.21$, $p = .024$; NEU–NEG: $r = -.25$, $p = .006$) and lower d' scores (NEU–POS: $r = -.25$, $p = .008$; NEU–NEG: $r = -.18$, $p = .048$). Parent-rated CU traits did not correlate with measures of speed. Similarly, self-rated CU traits did not correlate with measures of speed, but did correlate with poorer performance in terms of accuracy on 1 out of 6 blocks (NEU–POS: fewer hits $r = -.30$, $p = .001$; lower d' $r = -.30$, $p < .001$). To examine the moderating role of CU traits, CU traits (parent and self-rated separately) were added to the main model as main effect as well as in a two-way interaction with diagnosis. No (trend) significant two-way interaction effect was found between diagnosis and CU traits on task performance, suggesting no support for a moderating role of CU traits in explaining the group differences in task performance. Running correlational analyses within groups, within the control group and ASD, no significant correlations were found between task performance measures and ASD or CU symptoms. Within the ODD/CD group, significant correlations were found between ASD symptoms and percentage false positives for discriminating between positive and neutral and between positive and negative pictures, with higher ASD symptom levels relating to a lower percentage of hits (r = −.33, −.31, respectively).

Sensitivity analyses

Adding IQ, age, or comorbid ADHD did not alter the results. Taking into account medication use, the main effect of diagnosis and the diagnosis*block interaction on d' in the analyses on performance across time independent of valence contrast became non-significant. Post-hoc analyses indicated no significant differences between the group with ODD ($n = 44$) and the group with CD ($n = 8$). On all parameters, estimated marginal means were quite similar for both groups, although slightly better in the CD group (percentage hits: ODD $M = 89.1$, CD $M = 91.0$; reaction time hits: ODD $M = 491.6$, CD $M = 478.0$).

Discussion

This study aimed to investigate the overlapping and specific features of altered emotional valence detection in individuals with either ODD/CD or ASD and whether this is related to the severity of CU traits in both clinical groups. A two-choice emotional valence detection task was administered in 128 adolescents using validated pictures from the IAPS database [45]. Main findings were that adolescents with ODD/CD or ASD both performed poorer than TDI in terms of accuracy, yet only the TDI group—not both clinical groups—had relatively most difficulty in discriminating between positive versus neutral pictures compared to neutral–negative or positive–negative contrasts. Poorer performance was related to a higher level of CU traits. The results of the current study suggest youth with ODD/CD or ASD have a diminished ability to detect emotional valence which is not limited to facial expressions and is related to a higher level of CU traits. More specifically, youth with ODD/CD or ASD seems to have a reduced processing of positive stimuli and/or lack a 'positive perception bias' present in TDI that could either contribute to the symptoms and/or be a result of having the disorder, and may contribute to the comorbidity of both disorders. The continuous switching of response set affected the performance of TDI more so than that of both clinical groups, albeit TDI had more room for deterioration in performance compared to both clinical groups.

To the best of our knowledge, this is the first study to investigate and directly compare emotional valence detection capacities in youths with ODD/CD and those with ASD. Overlapping results for both groups were found for accuracy: both groups had more difficulty in detecting the emotional valence of the stimuli presented compared to the TDI group. This is in line with the previous studies showing that emotion recognition deficits are found in both disorders [27, 15, 13]. Furthermore, in neither group, the valence contrast (i.e., discriminating between positive, negative, and neutral valences) strongly affected performance, which was in striking contrast with the TDI. The TDI group showed clear difficulty in discriminating between positive and neutral valences in comparison with discriminating between negative and neutral or positive valences. It seems that the TDI group spent more time processing the stimuli given that positive versus neutral was the most difficult differentiation based on the accuracy data. This may reflect a reduced processing of positive stimuli in those with ODD/CD or ASD compared to

TDI. However, it may also tentatively be argued that TDI have a 'positive perception bias' in which they have more difficulty in differentiating between neutral and positive valences, compared to both clinical groups. This seems in line with the previous studies [54–56] and our data suggest that this positive perception bias is absent in both clinical groups. The absence of a positive perception bias in both clinical groups may also suggest a more negative perception bias in both clinical groups, but it would then be expected that both clinical groups had relatively more difficulty in discriminating between neutral and negative pictures, which was not the case. The current results, therefore, support the idea that the absence of a positive perception bias may either increase the risk of developing the social interaction problems as present in ASD and ODD/CD and/or may be the result of having social interaction problems.

In this study, we expected differential impairment in emotional valence detection between the clinical groups. However, differences between the ODD/CD group and the ASD group were small and non-significant. There are several possible explanations for this negative finding. It may be that both groups had difficulty in distinguishing emotional valence, because we used pictures without differentiating emotions specifically. Research regarding emotional face recognition has shown that emotion recognition in ODD/CD seems to be impaired for negative emotions only [27]. For youths with ODD/CD this impairment may be related to fearful, and to a lesser extent, sad emotion only [57], while emotion recognition in ASD seems to be impaired across all emotions [27]. Another explanation may be that we used static pictures and not dynamic. Similar research in ODD/CD has focused on the use of dynamic pictures [27]. However, as youths with CP show other responses other responses to real-life situations than to hypothetical situations [57], one could infer that recognizing the emotional valence of static pictures may be more difficult to youths with ODD/CD than dynamic pictures. Youths with ASD seem to be less sensitive to static pictures than to dynamic pictures, whereas whether there is such a correlation for youths with CD is unknown [27]. A further explanation could be that the duration of stimulus presentation was too short, as ASD youths seem to need more time for a correct reaction [58, 32]. Yet, stimulus duration of 500 ms (i.e., > 160 ms), as presented in our study, should suffice for correct identification of emotional valence [58]. A last possible explanation to mention here is that research shows that youth with conduct problems may experience emotional valence differently from other youth. Negative emotion, especially aggression, may be related to approach, whereas anxiety may be related to withdrawal (see also Van Honk and Schutter [59], and Blair [5]). Furthermore, negative emotion may be amusing, especially to youth with conduct problems and high CU traits [60]. However, these possible explanations need further investigation.

Diminished ability to detect emotional valence was related to a higher level of CU traits, although we found no support for a moderating role of CU traits in explaining the group differences in task performance. In youth with conduct problems, high CU traits have been found to be related to a subjective pleasant judgement to negative images, compared to neutral and positive pictures [61], but see Refs. [62, 63] possibly explaining more difficulty discriminating between negative, neutral and positive pictures in the current study. Furthermore, in comparison with youth with conduct problems and low CU traits and normal controls, youth with conduct problems and high CU traits was found to show decreased distraction from distressing pictures [64–66], pinpointing to a decreased activation of the BIS in youth with high CU traits. The latter appears particularly so for children with high CU traits that have no major environmental factor (i.e., maltreatment) explaining the presence of CU traits, showing a smaller acoustic startle response when viewing negative IAPS pictures [67]. Our data and that of the previous studies may suggest that a diminished ability to detect emotional valence is related to an increased level of CU traits. As such, our findings are in line with a recent study in which an emotional Go/No-go task was applied, reporting that the difficulties that children with combined CU traits and oppositional conduct problems have in processing emotions are more of an emotional rather than an attentional nature [68].

Self-reported CU traits were found to be related to poorer detection of positive pictures, while parent-reported CU traits were related to poorer detection of positive and negative pictures. As already mentioned, it may be that ODD/CD youth with high CU traits may experience negative pictures in a positive way [60] and, therefore, find difficulty in discriminating valence. However, poor detection of positive pictures is more difficult to explain. It may be that ODD/CD youth with high CU traits may experience negative pictures in a positive way [60], and thus find difficulty in discriminating valence. One could argue that either neutral or positive pictures are misinterpreted also, as youth with conduct problems and high CU traits have problems to correctly identify emotion when expressed facially, vocally, and through bodily postures (see also Herpers et al. 2014). As such, our finding could implicate that youth with conduct problems and high CU traits have difficulty in identifying emotional valence in a more general way. However, to clarify the underpinnings of this difficulty, further research would be needed.

Deviant performance on this emotional valence detection task could have been caused by executive functioning (EF) difficulties, since task performance not only required emotional valence recognition, but also behavioural inhibition, learning new rules and unlearning old rules and switching of response set. Surprisingly, when data were analysed with performance indices measured across blocks when continuous demands were placed on switching abilities between response rules, working memory, and inhibitory control, no major group differences emerged. If anything, the TDI group showed more difficulty with maintaining the high accuracy level over time than both clinical groups did (who had poorer performance already from the first block onwards). These findings suggest that previously reported weaknesses in executive functions in individuals with ASD [69, 70, 29, 71] and to a lesser extent in individuals with ODD/CD [72] did not explain the current results of diminished ability to detect emotional valence of objects, situations, or people by youth with ODD/CD or ASD.

Despite its strengths, such as the direct comparison of an ODD/CD group and an ASD group, and its focus on an emotional valence detection task, our study also showed limitations. The emotional valence detection task tapped into multiple processes (behavioural inhibition, attentional bias, recognition of emotional valence, working memory, and reversal learning), making it difficult to precisely pinpoint why subjects with ODD/CD or ASD had difficulty with the task. However, when analyses were repeated explicitly examining effects of continuous switching of response set on performance, both clinical groups did not perform worse than the TDI group, making it unlikely that these broader EF processes strongly influenced the overall poorer performance of both clinical groups in terms of valence detection. Both clinical groups contained a substantial number of participants using medication. However, antipsychotics were stopped 2 days before and stimulants on the test day, making it unlikely that medication strongly influenced results. However, correcting for medication use only influenced results for d', but not for the other measures. Furthermore, when studying disorders such as ODD, CD, or ASD, it is important to take comorbidity into account, as both disorders are known to be highly comorbid with attention-deficit/hyperactivity disorder (ADHD) [73, 74]. ADHD is known to be related to significant impairment on EF tasks [75] as well as emotional valence detection [76]. However, sensitivity analyses revealed that results were not influenced by the presence of a comorbid diagnosis of ADHD. Another limitation that should be noted is that we do not know whether the findings are unique to ODD/CD and ASD, or whether they reflect a deficit that cuts across those with psychopathology relative to TDI. An additional clinical group without core deficits in empathy could further add to the significance of our findings.

In conclusion, the results of the current study suggest that youth with ODD/CD or ASD has a diminished ability to detect emotional valence which is not limited to facial expressions and is related to a higher level of CU traits. More specifically, youth with ODD/CD or ASD showed marked difficulty in the distinction between neutral and positive pictures, compared to TDI. We hypothesized that this may be due to reduced processing of positive stimuli, or to a lack of 'positive perception bias' which seems to be present in TDI. Both tendencies could either contribute to the symptoms and/or be a result of having the disorder, but may contribute to the comorbidity of both disorders.

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Compliance with ethical standards

Conflict of interest In the past 3 years, Dr. Buitelaar has been a consultant to/member of advisory board of/and/or speaker for Janssen Cilag BV, Eli Lilly, Bristol-Myer Squibb, Shering Plough, UCB, Shire, Novartis, and Servier. He is not an employee of any of these companies, and not a stock shareholder of any of these companies. He has no other financial or material support, including expert testimony, patents, and royalties. Drs. Herpers, Bakker, Greven, Wiegers, Nijhof, Baanders, and Rommelse declare that they have no conflict of interest.

Ethical approval This study was approved by the Dutch *Central Committee on Research involving Human Subjects,* protocol number NL26773.000.09 (Centrale Commissie Mensgebonden Onderzoek; CCMO). As such, all procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants, and their parents, included in the study.

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