J Autism Dev Disord (2014) 44:2363–2368
DOI 10.1007/s10803-014-2084-z

BRIEF REPORT

Brief Report: Accuracy and Response Time for the Recognition of Facial Emotions in a Large Sample of Children with Autism Spectrum Disorders

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Published online: 15 March 2014

Abstract The empirical literature has presented inconsistent evidence for deficits in the recognition of basic emotion expressions in children with autism spectrum disorders (ASD), which may be due to the focus on research with relatively small sample sizes. Additionally, it is proposed that although children with ASD may correctly identify emotion expression they rely on more deliberate, more time-consuming strategies in order to accurately recognize emotion expressions when compared to typically developing children. In the current study, we examine both emotion recognition accuracy and response time in a large sample of children, and explore the moderating influence of verbal ability on these findings. The sample consisted of 86 children with ASD ($M_{age} = 10.65$) and 114 typically developing children ($M_{age} = 10.32$) between 7 and 13 years of age. All children completed a pre-test (emotion word–word matching), and test phase consisting of basic emotion recognition, whereby they were required to match a target emotion expression to the correct emotion word; accuracy and response time were recorded. Verbal IQ was controlled for in the analyses. We found no evidence of a systematic deficit in emotion recognition accuracy or response time for children with ASD, controlling for verbal ability. However, when controlling for children's accuracy in word–word matching, children with ASD had significantly lower emotion recognition accuracy when compared to typically developing children. The findings suggest that the social impairments observed in children with ASD are not the result of marked deficits in basic emotion recognition accuracy or longer response times. However, children with ASD may be relying on other perceptual skills (such as advanced word–word matching) to complete emotion recognition tasks at a similar level as typically developing children.

Keywords Autism spectrum disorder · Emotion recognition · Emotion processing · Social communication

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Introduction

A defining feature of autism spectrum disorder (ASD) is impaired emotional competence, which is commonly studied by examining children's capacities for emotion recognition (Begeer et al. 2008). However, evidence for deficits in the ability to label and recognize basic emotion expressions in children with ASD are somewhat inconsistent. This may be due to a number of different factors. First, there are very few large studies comparing facial emotion recognition between children with ASD and typically developing (TD) children. In a recent meta-analysis, Uljarevic and Hamilton (2013) reported that only 15 studies (from a total of 48) included more than 20 participants; importantly, significant differences between children with ASD and TD children were far less likely to emerge in studies with larger sample sizes. Furthermore, when correcting for the bias in the literature to report on small samples, there was a marked reduction in effect size (from −.80 to −.40). The current study presents data from a relatively large sample of children with ASD to examine the possibility that the basic facial emotion recognition deficits reported for this group are a function of the literature's predominant focus on studies with small samples.

Researchers have postulated that although children with ASD may be able to recognize basic emotion expressions, they do so using strategies that are more deliberate than strategies used by TD children, such as focusing on specific perceptual features (Rump et al. 2009; Tracy et al. 2011). However, most studies have failed to find a substantive difference in response times for facial emotion recognition when comparing children with ASD and TD children (e.g., Grossman et al. 2000; Law Smith et al. 2010; Piggot et al. 2004; Tracy et al. 2011; Wang et al. 2004), although there are some exceptions (e.g., Bal et al. 2010; Homer and Rutherford 2008).

To better understand the nature of purported emotion recognition deficits of children with ASD, which are typically most apparent in social contexts, it is possible that a closer focus on the role played by verbal abilities will be instructive. It is now well established within typical samples that IQ, and in particular verbal IQ (VIQ), covaries with children's emotion recognition abilities (e.g., Schultz et al. 2001). Indeed, Jones et al. (2011) demonstrated a similar result for children with ASD; they found that children with lower IQ, regardless of ASD status, had significantly poorer emotion recognition compared to those with higher IQ (see also Loveland et al. 2008). Such findings highlight the importance of taking into account differences in VIQ when comparing emotion recognition performance of children with ASD and TD children.

In sum, the current study employs a large sample size to compare basic facial emotion recognition accuracy and response time in children with ASD ($n = 86$) and TD children ($n = 114$), aged 7–13 years. This emotion modality and age group was specifically chosen as they are most commonly examined in the extant literature, however, it should be noted that other modality of emotion recognition have been examined (e.g., gestured, verbal and non-verbal) with similarly mixed results (e.g., Boucher et al. 2000; Jones et al. 2011; Hobson 1991).

Based on Uljarevic and Hamilton's (2013) meta-analysis, we do not expect children with ASD to show marked deficits in basic facial emotion recognition accuracy compared to TD children, and if significant differences between these groups do emerge we expect them to be small. In addition to emotion recognition accuracy, we include response time as a more sensitive index of performance. While several small studies have failed to find a significant difference in response time between children with ASD and TD children (e.g., Grossman et al. 2000; Law Smith et al. 2010; Piggot et al. 2004; Wang et al. 2004), the current study represents the first that is sufficiently powered to detect a small effect. Finally, we further explore the influence of children's VIQ as a potential source of difference between children with ASD and TD children emotion recognition performance.

Table 1 Participant details

	HFASD *M* (*SD*)	TD *M* (*SD*)
Boy/girl	76/10	94/20
Age in years	10.65 (1.23)	10.32 (1.32)
VIQ[a]*	103.58 (14.44)	110.56 (15.78)
SRS[b]*	98.87 (19.95)	27.25 (10.86)

M mean score, *SD* standard deviation

* Groups differ significantly, $p < 0.01$

[a] Peabody Picture Vocabulary Test

[b] Social Responsiveness Scale

Method

Participants

After obtaining written parental consent, we included an initial sample of 259 children (7–13 years) diagnosed with high-functioning ASD (HFASD; $n = 114$) and a typically developing comparison group ($n = 145$). As is typical in this research there was a gender imbalance in the HFASD group (see Table 1). The HFASD diagnoses were based on assessments by independent psychiatrists or certified psychologists in accordance with DSM-IV criteria (American Psychiatric Association 2000), who were working independently from the current research group, and were blind to the outcomes of this study. Children from the typically developing group were matched on gender, chronological age, and VIQ and recruited from primary and high schools near Amsterdam, The Netherlands. They had no known history of developmental lag or disorders.

Parents of both children with HFASD and TD children completed the Social Responsiveness Scale (SRS, a parental observation scale, Constantino and Gruber 2007; Roeyers and Thys 2010). We included only children with a raw score above the threshold for ASD on the Dutch version of the SRS (Constantino and Gruber 2007; Roeyers and Thys 2010). Any TD child who scored above these thresholds was excluded from the study. Participants completed the Dutch version of the Peabody Picture Vocabulary Test-NL (PPVT; Dunn and Dunn 2007; Schlichting 2005) as a measure of VIQ (Hodapp and Gerken 1999). Children from both groups scoring below 70 on the PPVT were also excluded.

The final sample comprised in 86 children with HFASD and 114 TD children (see Table 1 for participant details). For children in the HFASD group, 41 % of mothers and 40 % of fathers had a high school education, while 46 % of mothers and 46 % of fathers had vocational or university education. Similarly, for typical children, 26 % of mothers and 28 % of fathers had a high school education, and 66 %

of mothers and 62 % of fathers had university or vocational training. There was no significant difference between children with HFASD and typical children's mother's highest level of education, while there was a significant difference for father's education. However, when results were re-analysed controlling for father's highest level of education the pattern of findings remained unchanged.

There was no significant age difference between children with HFASD and their TD counterparts, $t(198) = -1.77$, $p = 0.079$, Cohen's $d = -.25$. As expected, there was a significant difference in SRS scores; children with HFASD scored considerably higher when compared to TD children, $t(198) = -32.50$, $p < 0.001$, Cohen's $d = -4.62$. There was also a significant difference in VIQ; children with HFASD had lower VIQ compared to TD children (see Table 1 for means), $t(197) = 3.20$, $p = 0.002$, Cohen's $d = .46$.

Materials

The Recognition of Facial Expressions

The recognition of facial expressions task was presented on a Microsoft Surface Touch table, which is similar to a large tablet or iPad,[1] and follows the procedure reported by Grossman et al. (2000). In the pre-test phase, children were presented with a target emotion word (happy, sad, angry or scared) in the middle of the screen, and asked to touch the matching word as quickly as possible choosing from four emotion words listed at the bottom of the screen (word–word matching). Once the child had selected his/her option the next target emotion would appear. Each emotion word was presented four times, resulting in 16 trials, administered in the same randomized order for all children.

In the test phase, children were required to match a static target facial emotion expression to the correct emotion word presented at the bottom of the screen (face-word matching). Emotion expressions (happy, sad, angry and scared) were derived from Karolinska Directed Emotional Faces set (Lundqvist et al. 1998). All expressions were modeled by a female and children were presented with 4 different faces for each emotion, resulting in 16 trials administered in a fixed randomized order. Prior to the 16 word-face trials, children were given a single practice item to familiarize them with the procedure. Children's emotion recognition accuracy was calculated as the number of correct face-word matches (a score of 1 for a correct response, and a score of 0 for an incorrect response). Response time for each item was also assessed.

[1] The software for the current tasks was developed and programmed by Autitouch BV (Copyright Freena Eijffinger/Autitouch BV).

Verbal IQ: Peabody Picture Vocabulary Test-III-NL

Verbal IQ was assessed using the PPVT (Dunn and Dunn 2007), a measure of receptive vocabulary and is highly correlated with more general measures of IQ (Hodapp and Gerken 1999). Participants had to select one of four pictures representing a given word. The test consists of 16 sets of 12 words that increase in difficulty. Based on the PPVT participants received a VIQ score standardized for age.

Social Responsiveness Scale

The Social Responsiveness Scale (SRS, Constantino and Gruber 2007) is a parent questionnaire that examines autistic traits in children. The SRS consists of five scales: social awareness, social cognition, social communication, social motivation, and autistic mannerisms. A higher total score indicates more autistic traits. This measure has established reliability and validity (Constantino and Gruber 2007).

Procedure

Trained assistants tested children in a quiet room at the children's schools. Participants completed the PPVT first, and then learned how the touch screen table worked. In order to familiarise children with the touch table, children were invited to choose their own background pattern. Once children were comfortable with the touch table, the emotion recognition task was administered.

Results

First, to test for differences in emotion recognition accuracy and response time by group (children with HFASD versus TD children) in the pre-test phase (i.e., word–word matching), two ANOVAs were conducted controlling for verbal ability. There was an unexpected significant difference in accuracy by group, $F(1, 191) = 4.40$, $p = 0.037$, $\eta^2_\rho = .023$, such that children with HFASD ($M = 15.16$, $SD = 1.63$) had a higher number of words correctly identified compared to TD children ($M = 14.73$, $SD = 2.31$) when controlling for verbal ability. Response times did not differ by group, $F(1, 191) = .10$, $p = 0.756$, $\eta^2_\rho = .001$.

Descriptive statistics for emotion recognition accuracy (word-face matching) and response time during the test phase are presented in Table 2. There was no significant correlation between ASD symptom severity, as measure by the Social Responsiveness Scale, and emotion recognition accuracy or response time (either as a total score or by specific emotion) for children with HFASD.

Table 2 Means (standard deviation) of emotion recognition accuracy and response time (in seconds) for emotion faces

	HFASD	TD		
	M (*SD*)	*M* (*SD*)	*t*(193)	Cohen's *d*
Accuracy				
Happy	3.71 (.78)	3.76 (.52)	.58	.08
Sad	2.40 (1.04)	2.69 (1.00)	1.95†	.28
Scared	2.79 (.91)	2.94 (.68)	1.35	.19
Angry	3.43 (.86)	3.52 (.78)	.81	.12
Total	12.33 (2.32)	12.92 (1.86)	1.97†	.28
Response time				
Happy	7.26 (2.49)	7.20 (2.11)	−.18	.03
Sad	12.54 (7.61)	12.53 (6.74)	.01	.00
Scared	19.96 (11.28)	18.31 (8.10)	−1.19	.17
Angry	10.07 (4.40)	10.51 (4.62)	.67	.10
Total	49.83 (20.11)	48.55 (15.44)	−.50	.07

† $p < 0.1$

To test for group and emotion differences in emotion recognition accuracy two 2 (group: HFASD, Typical) × 4 (emotion: Happy, Sad, Angry, Scared) repeated measures ANOVAs were conducted. First, given the significant difference in verbal ability between children with HFASD and TD children, and the fact that verbal ability was significantly correlated to children's performance on both overall emotion recognition accuracy, $r(194) = .289$, $p < 0.001$, and response time, $r(194) = .142$, $p = 0.048$, verbal ability was included as a covariate. In this model, there was no main effect of group on children's emotion recognition accuracy, $F(1, 191) = 1.06$, $p = 0.304$, $\eta_\rho^2 = .006$. There was, however, a significant emotion effect, $F(3, 573) = 10.65$, $p < 0.001$, $\eta_\rho^2 = .053$, with Happy and Angry expressions more frequently reported correctly compared to Sad and Scared regardless of group membership. The emotion by group interaction was not significant $F(3, 573) = .29$, $p = 0.836$, $\eta_\rho^2 = .001$.

Second, given the unexpected increased accuracy in word–word matching of children with HFASD compared to TD children in the pre-test phase, overall accuracy score during the pre-test phase was included as a covariate. In this model, there was a significant difference in emotion recognition accuracy by group, $F(1, 192) = 7.27$, $p = 0.008$, $\eta_\rho^2 = .036$, such that, once controlling for accuracy in the pre-test phase, children with HFASD were significantly *less accurate* at labelling emotion expressions compared to TD children. There was also a significant emotion effect, $F(3, 576) = 5.83$, $p < 0.001$, $\eta_\rho^2 = .029$, with Happy and Angry expressions more frequently reported correctly compared to Sad and Scared regardless of group membership. The emotion by group interaction effect was not significant $F(3, 576) = .98$, $p = 0.403$, $\eta_\rho^2 = .005$.

Examining children's response time for emotion recognition controlling for verbal ability revealed no significant effect of group, $F(1, 191) = 1.03$, $p = 0.312$, $\eta_\rho^2 = .005$, or emotion, $F(3, 573) = .30$, $p = 0.824$, $\eta_\rho^2 = .002$, nor was there a significant emotion by group interaction, $F(3, 573) = 2.47$, $p = 0.061$, $\eta_\rho^2 = .013$.

Finally, although a similar gender imbalance was present in both the HFASD and TD group, all results were re-analyzed excluding girls. The pattern of results remained equivalent with one exception; when only boys were included a significant group by emotion interaction effect for emotion face-word reaction time was observed, although the effect size was relatively small, $\eta_\rho^2 = .018$.

Discussion

This study examined facial emotion recognition in children with HFASD. In contrast to previous research, the current study employed a large sample to compare both emotion recognition accuracy and response time in children with HFASD and TD children. When controlling for verbal ability, there was no substantive difference in facial emotion recognition accuracy or response time between children with HFASD and TD children, a finding that is consistent with most of the previous research when large sample sizes have been utilized (e.g., Jones et al. 2011; Loveland et al. 2008). However, when controlling for children's accuracy in emotion word–word matching during the pre-test—a linguistic task that is relevant to the task demands of the emotion recognition assessment—differences in facial emotion recognition between children with HFASD and TD children did emerge.

Children with HFASD performed *more* accurately at emotion word–word matching during the pre-test phase when compared with TD children, however, once accuracy in emotion word–word matching was controlled, children with HFASD performed significantly *less* accurately at emotion word-face matching during the test phase. This finding suggests that specific abilities, such as an elevated general perceptual skill (Happé and Frith 2006), may influence a task's outcome despite not being directly assessed. That is, the highly accurate word–word matching of children with HFASD is relied upon to help in the more challenging task of matching a word to its corresponding facial emotion expressions. Thus, effects of an increased perceptual skill at word–word matching, or indeed any non-social or non-emotional skill, may obscure limitations of children with HFASD on other emotion-specific tasks.

When controlling for VIQ, no substantive differences in either accuracy or response time between children with

HFASD and TD children was evident. Nevertheless, children who had higher verbal ability were more accurate and responded more quickly, a finding that does suggest VIQ plays a role, at least to some extent, in children's emotion recognition, comparable to the results of Jones et al. (2011).

No differences between children with ASD and TD children in facial emotion recognition response time was found in the current study, supporting previous findings with smaller samples (Grossman et al. 2000; Law Smith et al. 2010; Piggot et al. 2004; Tracy et al. 2011; Wang et al. 2004) that show children with HFASD do not use more time-consuming processes to recognize emotion expressions. While it is often argued that children with HFASD rely on more deliberate strategies (Klin et al. 1999), the results of the current study suggest that the recognition of basic facial emotions presented in a static modality may not require time-costly compensating skills. Indeed, Rump et al. (2009) found that children with autism performed more poorly at emotion recognition when expressions were subtle and presented for a limited amount of time—conditions that are more closely aligned to features of real life social interaction. Furthermore, response time differences between children with HFASD and TD children have also been demonstrated when the emotion recognition task requires matching emotion expressions rather than attaching verbal labels to a single emotion expression, presumably because of the additional processing load incurred by multiple emotional facial stimuli (Piggot et al. 2004).

An important limitation of the current study was the use of a basic facial emotion recognition task, with a relatively limited number of trials. First, the ability to respond adequately to the presentation of static images may not reflect fully intact emotion recognition abilities required in processing emotions in other modalities (e.g., gestured, verbal or non-verbal expressions of emotion) or when facial emotion recognition is made more subtle (e.g., presenting conflicting information, under time pressure; Harms et al. 2010). Indeed, research has reported deficits in emotion processing in individuals with HFASD when these facial expressions of emotions are more subtly presented (Philip et al. 2010; Wallace et al. 2011). It is likely that these more difficult facial emotion recognition tasks are more closely aligned with the emotion skills required to process emotions as they are expressed in daily life situations.

Second, differences between children with HFASD and TD children's ability to recognize complex social emotions were not examined. Expressions of surprise, and other more complex social emotions such as embarrassment and guilt, are expected to be particularly difficult for children with HFASD to accurately recognize because understanding this expression necessitates an understanding of the person's belief or social context (Baron-cohen et al. 1993). Some studies have presented evidence for a specific deficit in surprise, embarrassment and guilt when compared to basic emotions such as sadness, anger and joy (e.g., Baron-Cohen et al. 1993; Heerey et al. 2003; Jones et al. 2011). However, it should be noted that in their recent meta-analysis Uljarevic and Hamilton (2013) found no systematic accuracy difference in surprise expression between children with HFASD and TD children, although other social emotions were not examined.

In sum, the results of the current study suggest that children with HFASD, at least by 10 years of age, do not have marked deficits in basic facial emotion recognition, with little evidence of a systematic difference between children with HFASD and TD children in accuracy or response time for emotion recognition when controlling for verbal ability. This finding highlights the limitations of using static images of basic facial emotions during diagnostic or treatment procedures for children with autism in this age and ability range. However, a difference in accuracy of emotion expressions between children with HFASD and TD children did emerge when basic word–word accuracy was controlled, suggesting that difference between children with HFASD and their TD peers in basic emotion recognition at 10 years of age may better be understood as a difference in processing rather than outcome. Children with HFASD may be relying on their advanced perceptual recognition skills to perform at an equivalent level of their TD peers. This may result in similar outcomes, but likely requires more efforts. As such, emotion recognition difficulties experienced by children with HFASD may be obscured by their high verbal and cognitive abilities. Clearly, continued focus on more subtle emotion recognition deficits in larger samples of children with HFASD is needed to further clarify this finding.

Acknowledgments This research was initiated and financially supported by Autitouch BV. Children, parents and schools are thankfully acknowledged for their help. Tessa Glasbergen and Halima Azdad asssisted with the data collection.

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