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ORIGINAL PAPER

Specific Patterns of Emotion Recognition from Faces in Children with ASD: Results of a Cross-Modal Matching Paradigm

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Abstract
Children with ASD show emotion recognition difficulties, as part of their social communication deficits. We examined facial emotion recognition (FER) in intellectually disabled children with ASD and in younger typically developing (TD) controls, matched on mental age. Our emotion-matching paradigm employed three different modalities: facial, vocal and verbal. Results confirmed overall FER deficits in ASD. Compared to the TD group, children with ASD had the poorest performance in recognizing *surprise* and *anger* in comparison to *happiness* and *sadness*, and struggled with face–face matching, compared to voice-face and word-face combinations. Performance in the voice-face cross-modal recognition task was related to adaptive communication. These findings highlight the specific face processing deficit, and the relative merit of cross-modal integration in children with ASD.

Keywords Autism spectrum disorder · Facial emotion recognition · Cross-modal integration

Introduction

An ability to detect and accurately recognize a displayed emotion is considered a basic building block of social development (Ekman 1992; Feldman-Barrett 2006; Izard 2007). Emotion recognition involves the processing of several types of stimuli, such as facial expression, vocal intonation, body language, content of verbalization, as well as the complex integration of all of the above in dynamic contexts (Herba and Phillips 2004; Walker-Andrews 1997). In typical development, emotion recognition emerges gradually throughout childhood and becomes more accurate and efficient with time. The first emotion recognized accurately and consistently is usually happiness followed by sadness and anger and then by fear and surprise (Camras and Allison 1985; Herba et al. 2006). It has been shown that by 3–5 years of age, children already rely heavily on faces as cues for emotion recognition (Hoffner and Badzinski 1989). This developmental track is significantly hampered in children with Autism spectrum disorder (ASD).

ASD is a pervasive neurodevelopmental condition, characterized by core deficits in social communication and restricted and repetitive behavior patterns (American Psychiatric Association 2013). Deficits in understanding others' emotional and mental states are considered a core characteristic of ASD (Hobson 1993; Karmiloff-Smith et al. 1995). Since the ability to recognize and understand emotion is a basic building block of theory-of-mind and social functioning, many research studies have been dedicated to exploring emotion recognition in individuals with ASD (for a review, see Uljarevic and Hamilton 2013).

Although the clinical definitions and experimental evidence point to a global emotion recognition deficit in ASD (Feldman et al. 1993; Gross 2008), several studies also argue for emotion-specific deficits (Ashwin et al. 2006; Boraston et al. 2007). For instance, Bal et al. (2010) found that children with ASD were slower in recognizing emotions and selectively made more errors in detecting anger. Other studies have shown specific dysfunction in ASD in recognizing sadness (Boraston et al. 2007), disgust (Ashwin et al. 2006; Wright et al. 2008) and fear (Humphreys et al. 2007). Finally, studies have shown specific difficulties to detect and recognize surprise in children with ASD (Baron-Cohen et al. 1993; Jones et al. 2011), which were interpreted in

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the context of surprise involving mentalizing or theory-of-mind abilities that are compromised in individuals with ASD (Baron-Cohen et al. 2013). These conflicting findings raise the question of the specificity of emotion recognition deficits in ASD and point to the need for further comparisons of distinct emotions.

Most of the emotion recognition studies in ASD have focused on recognizing emotion from faces (facial emotion recognition: FER) (Harms et al. 2010). Unlike their typically developing (TD) peers, who have an inherent interest in faces from birth (Carver et al. 2003; Johnson et al. 2005), individuals with ASD display inattention to key aspects of social information and consequently fail to develop expertise in experience-expectant behavior and brain systems, such as FER (Dawson et al. 2005; Schultz 2005). Eye-tracking studies have found that individuals with ASD tend to focus less on the informative eye-region of a face (Corden et al. 2008; Pelphrey et al. 2002) or to process the information from the eye-region less effectively than their TD peers when attempting to recognize emotions (Baron-Cohen et al. 1997a; Gross 2008). Individuals with ASD tend to look more at the mouth region of the face and this focus can hinder their ability to accurately recognize emotional expressions (Klin et al. 2002; Neumann et al. 2006; Spezio et al. 2007).

Unlike the above studies that reported FER deficits in ASD, other studies report conflicting results or no differences between individuals with ASD and TD on FER tasks (e.g. Castelli 2005; Jones et al. 2011; Ozonoff et al. 1990; Tracy et al. 2011). These inconsistent findings regarding FER in ASD may be due to varying methodological aspects of FER paradigms. Whereas some studies examined FER using face-matching paradigms (e.g. Castelli 2005; Davies et al. 1994) others used vocal cues (e.g. Hobson 1986a, b; Loveland et al. 2008) or verbal labeling of facial expressions (e.g. Baron-Cohen et al. 1997b; Capps et al. 1992). Each of these paradigms calls for a somewhat different set of skills required for FER, which may be compromised in ASD.

Face matching paradigms require an attribution of different facial percepts (e.g. gender, age, or facial features) to a single specific emotion (Adolphs 2002; Haxby et al. 2002). This attribution is at the basis of a generalizing ability, which is particularly important when individuals are asked to match two faces that are portraying the same emotion in a different way. The detail oriented approach, characteristic of individuals with ASD (Happe and Frith 2006) may hinder their ability to acknowledge the similarities between two different faces that portray a similar emotion, as these differ in their micro-features.

The recognition of facial expression using vocal cues requires cross-modal integration, which was shown to be particularly challenging for individuals with ASD (Grossman et al. 2015; Hall et al. 2003). Indeed, studies that have examined how individuals with ASD recognize emotions in the auditory domain reported difficulties in matching emotional voices to emotional faces in both children and adults (Hobson 1986a, b; Loveland et al. 1995). Hall et al. (2003) reported that using vocal primes for FER tasks actually hampered performance in individuals with ASD, suggesting that simultaneously presenting cross-modal stimuli challenges, rather than fosters, emotion recognition. Others, however, found no difficulty in cross-modal emotion processing in individuals with ASD (Ben-Yosef et al. 2016).

Perhaps the most common FER paradigm is the one requiring verbal labeling of emotional faces. This paradigm assumes that participants' verbal ability is well established and may be the most direct way to address ER abilities. However, this may not be the case in children, or in individuals with delayed or compromised verbal ability. Some FER studies suggest that verbal ability may at times explain the ER deficit more than the ASD diagnosis (Loveland et al. 1997). When verbal ability is intact, however, it may also serve as a compensatory mechanism in individuals with ASD. Grossman and colleagues (2000) showed that children with ASD were able to accurately recognize emotions when these were presented alongside a matching verbal label, but not when they were paired with non-relevant words. Children with ASD may use semantic processing as a compensatory mechanism so that words become cues for emotion recognition and thus mask characteristic emotion recognition deficits (Katsyri et al. 2008; Piggot et al. 2004; Rutherford and Towns 2008).

The inconsistent findings regarding FER in ASD could be related to sample heterogeneity, such as different age groups or varying levels of functioning (Harms et al. 2010). Studies that assess younger participants with ASD tend to report on more significant dysfunctions in face processing compared to older participants. It is possible that older individuals with ASD have already developed compensatory mechanisms that allow them to overcome difficulties in basic ER (Jones et al. 2011). Similarly, higher-functioning individuals with ASD my better succeed in basic emotion recognition tasks, as this ability in ASD is linked with better cognitive functioning, specifically higher verbal mental age (Castelli 2005; Dyck et al. 2006; Hobson 1986a, b). Hence, it is highly important to examine children of younger age, where compensatory mechanisms have not yet developed to mask dysfunctions in emotion recognition abilities, and, in addition, to control for verbal mental age.

The current study aimed to assess the relative contribution of cues from several perceptual modalities to FER in children with ASD, compared to TD children, by utilizing a matching paradigm in which cues from three different modalities (verbal, vocal or visual) were presented alongside a face displaying one of four emotions: happy, angry, sad and surprised. For all task conditions [face–face (FF), word-face (WF), and voice-face (VF)] we asked children to match the emotion portrayed in the verbal/vocal/facial cue with one of three emotional faces. In line with previous research, we hypothesized that overall, children with ASD would perform more poorly in this task compared to TD children across all emotion conditions and cue modalities. We further hypothesized that over and above group, performance would be best in the most basic emotions—happy and sad, and poorest in the most complex emotion—surprise (Camras and Allison 1985). We expected to find an interaction effect for group and modality. Specifically we predicted that in the ASD group, children would perform better in the WF matching condition (due to the existence of a semantic compensatory mechanism), with poorer performance in the VF condition (requiring cross-modal integration) and in the FF condition, (requiring holistic face perception abilities). We also expected to find an interaction effect for group and type of emotion presented, with recognition of surprise being more significantly hampered in the ASD group, compared to the other, more basic emotions, which do not require mentalization. Finally, we hypothesized that ER performance of children with ASD would predict their adaptive functioning in the areas of communication and socialization, and examined if these areas could be explained by ER in specific modalities or by ER of specific emotions.

Methods

Participants

The ASD group comprised 29 children (5 girls), aged 8–12 years, who were recruited through a special education school for children with ASD in central Israel. ASD diagnosis for participants was confirmed using the Autism Diagnostic Observation Schedule (ADOS-G, Lord et al. 2000). All children met ADOS criteria for ASD. The TD group comprised 34 children (7 girls) aged 2.1–6, who were recruited through ads in the community. Since all children in the ASD group had cognitive deficits, children in the TD group were chronologically younger ($t_{(61)} = 17.67$, $p < .001$), and groups were matched on verbal mental age ($t_{(61)} = .14$, $p > .1$), using the 4th edition of the Peabody Picture Vocabulary Test (PPVT-IV: Dunn and Dunn 2007). The two groups were also matched on gender ($\chi^2(1) = 0.11$, n.s) and parent rated SES ($Z = -.567$, n.s). Table 1 presents averages and standard deviations of participants' demographics. The study was ethically approved by the chief scientist of the Israeli Ministry of Education, and by the ethics committee of the psychology department, Bar-Ilan University. All parents provided informed consent prior to their child's participation.

Table 1 Averages (and standard deviations) of participants' demographics

	ASD group	TD group
Gender (m:f)	24:5	27:7
Age (years)	9.13 (1.18)	4.01 (1.11)
PPVT-IV mental age (years)	4.18 (1.48)	4.13 (1.50)
ADOS-G communication	6.50 (1.99)	–
ADOS-G social interaction	8.93 (2.92)	–
VABS-2 communication	64.82 (7.60)	–
VABS-2 socialization	59.64 (8.51)	–

PPVT Peabody picture Vocabulary Test, 4th Edition, *ADOS-G* Autism Diagnostic Observation Schedule—Generic, *VABS-2* Vineland Adaptive Behavior Scales, 2nd Edition

Instruments

Cross-Modal FER Matching Task

This task comprised facial expressions of four emotions taken from the NimStim database (Tottenham et al. 2009). Selected stimuli were gender-balanced. Voices used in the study were non-verbal emotional utterances taken from Montreal Affective Voices (Belin et al. 2008). The task comprised three conditions (FF, VF, WF) × four emotions (happy, sad, angry, surprised) × four items per emotion in each condition, with a total of 48 items. Within each condition, item order presentation was counterbalanced. In each condition, children were presented with three faces, the target emotion and two foils, each representing a different emotion. Each of the four emotions had the same chance of appearance as a foil. In the WF condition, a verbal label appeared above the emotional faces in a question form (e.g., children were asked to indicate by pointing "who feels angry?"). The experimenter read the question aloud. In the VF condition the experimenter clicked on the icon appearing above the emotional faces and children heard an emotional vocalization (gender matched to faces). The experimenter then pointed to the speaker and asked the children to indicate "who feels like that?". In the FF condition a picture of an emotional face (gender matched) appeared above the three emotional faces. The experimenter then pointed to the top face and asked the children to indicate "who feels like that?". If the child did not respond, the experimenter pointed to the top face and said: "This is Dan/Annie". Who of these feels like Dan/Annie?. Figure 1 illustrates the task conditions.

Task scores were calculated as the number of items correctly recognized for each emotion in each condition. Scores ranged between 0 and 4. Scores were also summed for each condition (range 0–16) and for each emotion type (range 0–12).

The Vineland Adaptive Behavior Scale, 2nd edition—Teacher form (Sparrow et al. 2005). This measure provides

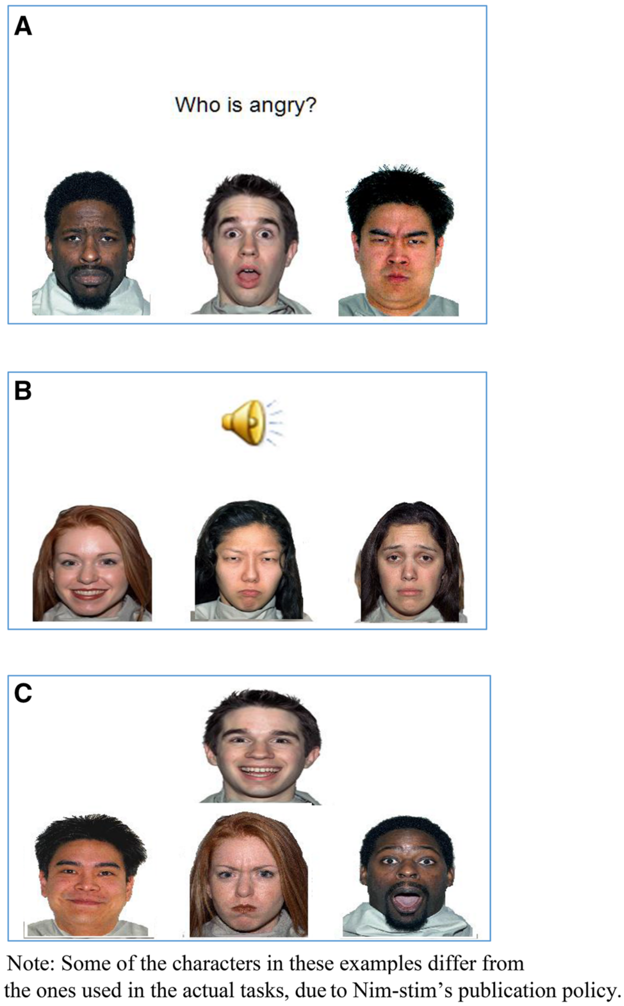


Fig. 1 Examples of the three emotion recognition conditions: **a** word-face, **b** voice-face, and **c** face–face

a list of age appropriate adaptive behaviors in three major domains: communication, daily living, and socialization. Scales have an average of $M=100$ and SD of 15, with higher scores indicating more adaptive functioning. The VABS-2 is a well-established measure of adaptive functioning in ASD studies (Klin et al. 2007). In the present study, we used the communication and socialization scales, the two aspects of social-communication relevant for ER. The VABS-2 was filled out by teachers of children in the ASD group only.

Procedure

TD children were seen in their homes and children with ASD were seen at their school. The study took place in a separate quiet room either at home or at the school. Initially, children with ASD underwent the ADOS-G assessment. All participants took the PPVT which was followed by a 15-min break. Participants were then seated about 50 cm from a 15 inch screen Dell laptop computer, with external speakers, and the experimenter played the three FER matching tasks, using Microsoft PowerPoint, in a counter-balanced order. Participants responded by pointing to their preferred answer. All tasks started with two practice items so that children fully understood the task at hand and got used to it. If a child did not succeed in one of the practice trials, the experimenter explained the task again and the child underwent the practice trials again. Only after the child succeeded in both practice trials, the test phase was initiated. Teachers of children in the ASD group completed the VABS-2 separately at school.

Analysis

In order to test for main effects of group, modality, emotion and all possible interactions between these variables, a repeated measures MANOVA was conducted, with modality of stimuli (VF, FF, WF), and emotion (happy, sad, angry, surprised) as within subject variables, and group (ASD or TD) as the between-subject variable.

In order to examine the contribution of ER in the different modalities, and of the recognition of distinct emotions to the adaptive communication and socialization skills of children with ASD, four hierarchical regression analyses were performed, with two outcome variables (VABS-2 communication and socialization scores) and two predictor models (ER modality, and emotion type), controlling for children's ADOS scores and PPVT verbal mental age.

Results

MANOVA Analysis

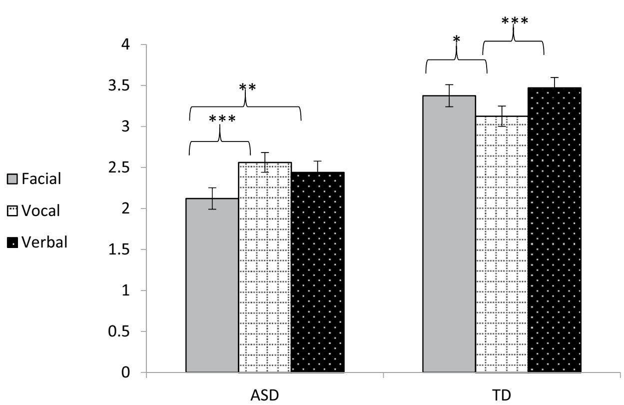
The MANOVA yielded a significant main effect for group: $F_{(1,61)}=37.25$, $p<.001$, $\eta^2=.38$. Performance scores in the ASD group ($M=2.36$, $SD=.12$) were overall significantly lower compared to the performance scores in the TD group ($M=3.32$, $SD=.11$). We also found a significant effect for modality: $F_{(2,60)}=3.96$, $p<.05$. $\eta^2=.12$. In order to explore this effect we compared all pairs of modalities (correcting for multiple comparisons with Bonferroni) and found that only the mean difference between modality FF and WF was significant (*mean difference* $i-j=.207$, $p<.05$), $F_{(2,60)}=3.96$, $p<.05$, $\eta^2=.12$. Performance in modality FF ($M=2.75$, $SE=.09$) was significantly lower than modality WF ($M=2.965$, $SE=.09$).

We also found a significant main effect for emotion $F_{(3,59)}=26.42$, $p<.001$. $\eta^2=.30$. In order to explore this effect we compared all pairs of emotions (correcting for multiple comparisons with Bonferroni) and found that the recognition of *surprised* was significantly lower compared to all other emotions displayed: the mean difference between *happy* and *surprised* was significant (*mean difference* $i-j=.68$, $p<.001$), as were the mean differences between *sad* and *surprise*d (*mean difference* $i-j=.78$, $p<.001$) and *angry* and *surprised* (*mean difference* $i-j=.52$, $p<.001$).

The interaction between group and modality was also significant: $F_{(2,122)}=8.77$, $p<.001$, $\eta^2=.13$. In order to explore this interaction, we compared simple effects of modality (adjusting for multiple comparisons using Bonferroni) in each group, and found that in TD children, performance was poorer in VF compared to FF and WF (*mean difference* $i-j=.25$, $p<.05$; *mean difference* $i-j=.34$, $p<.005$, respectively), which did not differ from each other. In the ASD group, performance was poorer in FF compared to VF and WF (*mean difference* $i-j=.40$, $p<.005$; *mean difference* $i-j=.32$, $p<.01$, respectively), which did not differ from each other. These differences are illustrated in Fig. 2.

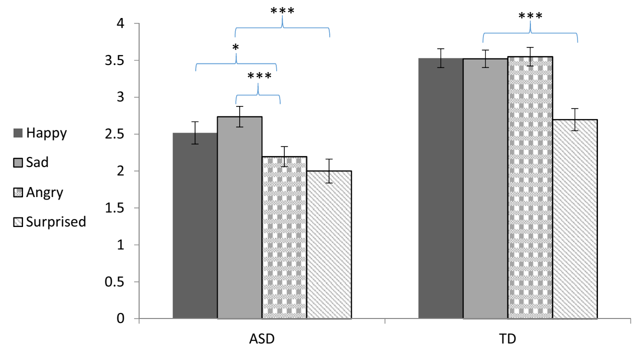
The interaction between group and emotion was also significant: $F_{(3,59)}=4.63$, $p<.005$, $\eta^2=.15$. We then explored the simple effects of emotion in each group separately. In the TD group, recognition of *surprised* was significantly poorer than recognition of all other emotions (*mean difference* $i-j=.83$, $p<.001$; *mean difference* $i-j=.82$, $p<.001$; *mean difference* $i-j=.85$, $p<.001$ for differences between surprised versus happy, sad, and angry, respectively) that did not differ from each other. In the ASD group, recognition was significantly poorer for *angry* and *surprised* (which did not differ from each other), in comparison to *sad* and *happy* (which did not differ from each other) (happy versus angry: *mean difference* $i-j=.32$, $p<.05$; happy versus surprised: *mean difference* $i-j=.51$, $p<.001$; sad versus angry: *mean difference* $i-j=.54$, $p<.001$; sad versus surprised: *mean difference* $i-j=.74$, $p<.001$). Figure 3 illustrates this interaction.

A third interaction effect that came out significant was between modality and emotion: $F_{(6,56)}=8.00$, $p<.001$, $\eta^2=.46$



* $p<.05$, ** $p<.01$, *** $p<.005$

Fig. 2 Average recognition scores (and S.E.) for each modality in the ASD and TD groups



* $p<.05$, *** $p<.001$

Fig. 3 Average recognition scores (and S.E.) for each emotion in the ASD and TD group

However, since this interaction includes both children with ASD and TD, two groups that significantly differed on emotion recognition, we did not continue to explore this interaction. The three-way interaction between group, modality and emotion was not significant ($F_{(6,56)}=1.50$, n.s.).

Regression Analyses

In the first regression analysis, predicting VABS-2 communication scores, PPVT mental age and total ADOS-G scores were entered in the first step, to control for verbal mental age and autism severity. The second step included the three modality ER scores (FF, VF, WF), entered in stepwise method. The regression yielded a significant effect of verbal mental age ($\beta=.42$, $p<.05$), explaining 30.7% of the criterion's variance ($F_{[2,20]}=4.44$, $p<.05$). Next, the ER modality analysis yielded a significant effect for VF scores ($\beta=.49$, $p<.05$), explaining an additional 17.2% of the criterion's variance ($F_{[1,19]}=6.28$, $p<.05$). Overall, this model explained 47.9% of the variance in adaptive communication.

In the second regression analysis, predicting VABS-2 communication scores, PPVT mental age and total ADOS-G scores were entered in the first step. The second step included the four emotion type scores (happy, sad, angry, surprised). Results of the first step were identical to those stated in the regression above. The second step yielded no significant effects of the emotion type scores.

Similar regression analyses, predicting the VABS-2 Socialization score, yielded no significant results, beyond that of PPVT verbal mental age ($\beta=.54$, $p<.01$).

Discussion

The current study examined FER in children with ASD and cognitive deficits and in TD controls, matched on mental age. We used an emotion matching paradigm employing three different modalities: facial, vocal and verbal. Our findings confirmed overall FER deficits in ASD and shed new light on the ability of children with ASD to conduct cross-modal integration of emotional stimuli, and on the nature of their developmental delay in terms of emotion recognition skills.

Our results are consistent with existing evidence pointing to difficulties in emotion recognition from faces in children with ASD (see Harms et al. 2010, for a review). Overall, children with ASD performed relatively poorly on the emotion recognition tasks and were less accurate compared to the mental-age matched TD children. This finding was evident even though, on average, TD children were chronologically 5 years younger than children with ASD.

As hypothesized, children with ASD had the poorest performance in the FF combination which had significantly hindered performance compared to VF and WF. Beyond the overall FER deficit shown in the ASD group, the distinct pattern of results in the different matching modalities indicate that children with ASD show a more severe FER deficit, when asked to match an emotional facial expression with the same expression on another person. These within-modality performance difficulties have been described as a specific face processing deficit in ASD (Hoffner and Badzinski 1989). This deficit hinders the ability to generalize beyond the unique features of a face to recognize an underlying emotion, thus proving difficult to match faces which do not have identical features. It is important to note that these deficits did not occur because of gender differences of the different protagonists, as items maintained the same gender between targets and foils. Developmentally, a face processing deficit in individuals with ASD may be the result of attenuated social motivation, yielding reduced expertise for faces (Dawson et al. 2005). The compromised face processing expertise in ASD is evident not only on the behavioral-level but also in the development of the neural circuitry specialized for face processing (Gordon et al. 2013, 2016; McPartland et al. 2004).

Contrary to our original hypothesis, performance in the VF task was not poorer than that of the WF task in children with ASD. In view of their poor performance on the within-modality task (FF), it is possible that the cross modality tasks (VF and WF) provided children with ASD with valuable cues which supported their FER. Although their performance on these tasks was still significantly poorer than children with TD, an examination of these findings within the ASD group, offers an intriguing insight into the benefit of cross-modal integration in children with ASD. Previous studies suggested cross-modal integration is a challenge for individuals with ASD (e.g., Boucher et al. 2000; Hall et al. 2003; Loveland and Tunali-Kotoski 2005; O'Connor 2007). Our findings replicate these reports, and extend them by revealing that within modality matching, and specifically FF matching, may be more challenging for children with ASD. Thus, it appears that when it comes to emotion recognition, cross modal integration is preferable to intra-modal processing. Future studies should explore how intra-modal integration in the auditory channel (i.e. voice–voice) compares to that of the FF matching paradigm. It is important to note that our vocal stimuli were at high emotional salience, which may have made them easy to attend to. Previous studies have shown that individuals with ASD find high intensity vocal emotional cues easier to address, compared to subtle vocal cues (Globerson et al. 2015; Grossman and Tager-Flusberg 2012).

Another area in which children with ASD showed superior performance, compared to the FF condition was the WF condition, suggesting they rely on verbal cues as a compensatory mechanism (Belmonte and Yurgelun-Todd 2003). It has been argued that such compensatory mechanisms are less automatic, and yet they may allow some individuals with ASD to perform relatively well in ER tasks (Harms et al. 2010). Whereas such a mechanism was previously demonstrated in children with Asperger Syndrome (Grossman et al. 2000), we demonstrate how lower functioning children with ASD may still find verbal labeling an effective compensatory mechanism, despite their cognitive deficits.

The pattern of results regarding emotion type recognition accuracy further reveals the altered development of ER in children with ASD, compared to their mental-age matched controls (Durand et al. 2007). In the TD sample, with an average age of 4 years, the expected intact recognition of *happiness, sadness* and *anger* was found, whereas the recognition of *surprise* was still a challenge. In the ASD group, however, the recognition of *anger*, in addition to that of *surprise*, was compromised. Specific deficits in the recognition of anger in children with ASD have been previously reported (Bal et al. 2010). These deficits were related to the severity of ASD and may correspond with the cognitive deficits characteristic of our ASD group. It has been suggested that anger identification deficits in ASD may stem from difficulties collecting contextual cues or social experience, which are required for intact anger recognition (Bal et al. 2010; Thomas et al. 2007). Taken together, our findings suggest that the pattern of ER in ASD comprises both a general deficit and emotion-specific alterations.

An interesting association was found in the current study between the ability to integrate facial and vocal cues in ER and the adaptive communication skills of children with ASD. In addition to verbal ability, performance on the VF task was the only significant ER predictor of adaptive communication. These findings suggest that, in addition to verbal intelligence, difficulties in the integration of facial and vocal cues in children with ASD may hamper their effective communication in real-life settings. The importance of face-voice integration for speech comprehension in individuals with ASD has been previously demonstrated (Grossman et al. 2015). Future studies should explore its role in affective communication.

A few limitations should be noted: In the current study, we included four emotions; three are considered basic (*happy, sad*, and *angry*) and one that requires theory-of-mind capacities: *surprise*. In order to reach a better grasp of the unique nature of FER in children with ASD, future studies should include other basic emotions, such as *fear* and *disgust*, as well as more complex emotions that require mentalization, such as *shame, pride* or *jealousy*. By including more emotions, we can assess developmental delays as well as unique patterns of ER and also examine the influence of valance and emotion complexity better. Such an examination, that has been conducted for children with high-functioning ASD (Fridenson-Hayo et al. 2016), could include a wider range of ages, to allow for a more comprehensive understanding of FER in children with ASD and cognitive deficits. In addition, in this study performance IQ was not assessed, and therefore the groups were not matched on it. Since visual compensatory mechanisms partly rely on visual spatial analysis, if the ASD group had performance IQ deficits, this may explain why the FF condition came out the lowest. Future studies should match TD and ASD groups on performance as well as verbal mental age. Finally, our study is limited by its relatively modest sample size. Since ASD is a heterogeneous condition, future studies, employing a larger sample, should explore ER differences between subgroups within the autism spectrum, such as sex differences.

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Author Contributions All authors made substantial contributions to the study. OG. GK, and KP designed the study, KP collected the data, OG and IG analyzed the data and wrote the manuscript.

Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval This study was approved by the Chief Scientist of the Israeli Ministry of Education (#10.32), and by the ethics committee of the Department of Psychology, Bar-Ilan University.

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