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ORIGINAL PAPER

Emotion Perception or Social Cognitive Complexity: What Drives Face Processing Deficits in Autism Spectrum Disorder?

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Abstract Some, but not all, relevant studies have revealed face processing deficits among those with autism spectrum disorder (ASD). In particular, deficits are revealed in face processing tasks that involve emotion perception. The current study examined whether either deficits in processing emotional expression or deficits in processing social cognitive complexity drive face processing deficits in ASD. We tested adults with and without ASD on a battery of face processing tasks that varied with respect to emotional expression processing and social cognitive complexity. Results revealed significant group differences on tasks involving emotional expression processing, but typical performance on a non-emotional but socially complex task. These results support an emotion processing rather than a social complexity explanation for face processing deficits in ASD.

Keywords Autism spectrum disorder · Face processing · Facial expression perception · Trustworthiness perception

Introduction

Autism Spectrum Disorder (ASD) is defined by deficits in two areas: (1) Social communication and interactions, and (2) restricted patterns of behaviours and interests (American Psychiatric Association 2013). Deficits in social communication comprise a wide range of difficulties such as initiating and maintaining conversations, making appropriate eye contact, and understanding and interpreting social information. Faces provide a wealth of social information and typical adults are experts at processing facial information [see Maurer et al. (2002) for review].

Face Processing in ASD

There is a large literature that has focused on deficits in individuals with ASD in processing facial identity [see Weigelt et al. (2012) for review] and in processing emotional facial expressions [see Harms et al. (2010) for review]. With respect to processing facial identity, although deficits in face recognition have been reported using computer-generated stimuli (Wolf et al. 2008), many studies have demonstrated that children and adults with ASD show several of the behavioural phenomena that are considered hallmarks of expert face processing in typical individuals [see Maurer et al. (2002) for review of behavioural markers of typical face processing expertise]. For example, those with ASD have been shown to display typical face inversion effects (Lahaie et al. 2006; Rutherford et al. 2007; Scherf et al. 2008), whole-part effects (Joseph and Tanaka 2003; Wolf et al. 2008; Faja et al. 2009), and composite face effects (Nishimura et al. 2008). In addition, Weigelt et al. (2013) demonstrated that individuals with ASD have a specific deficit in remembering face identities, however when memory demands are relieved, ASD participants perform similar to typical individuals. Together, these studies do not support the idea that individuals with ASD process facial identity in a qualitatively atypical way, although they may be less efficient at processing facial identity.

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In contrast to facial identity processing, studies examining emotional facial expression processing have reported atypical performance in individuals with ASD. Rutherford et al. (2012) reported that adults with ASD show atypical emotional expression aftereffects, suggesting that the psychological organization of emotional expressions is atypical in adults with ASD. Several studies have demonstrated that adults with ASD perform more poorly at labeling emotional expressions in comparison to typical adults (Howard et al. 2000; Dziobek et al. 2006; Corden et al. 2008; Bal et al. 2010).

Walsh et al. (2014; see also Rutherford and McIntosh 2007) examined cognitive strategies employed by adults with and without ASD while processing emotional expressions and reported that adults with ASD rely on an atypical rule-based strategy whereas typical individuals use the expected implicit template-matching strategy. These authors report experiments in which those with and without ASD choose which of two images show realistic depictions of various emotions. Those with ASD were more likely to choose the more exaggerated image, consistent with the prediction of a rule-based model. Control participants were more likely to choose the image closer to the average expression, consistent with a template-matching strategy. Together the results of these studies, which examined emotional expression processing in adults with ASD, suggest atypical and poorer performance on behavioural tasks that involve emotional expression processing.

What Drives Deficits in Emotional Expression Perception in ASD?

It may be that individuals with ASD have deficits that are specific to processing emotional expression information in faces. However, processing emotional expressions can be considered a more socially cognitive complex task compared to processing other aspects of facial information, such as identity. Here we refer to social cognitive complexity as the degree to which a face processing task recruits higher-order social cognitive skills, such as evaluating and interpreting the internal state of a person, or assessing a social trait such as trustworthiness based on a photograph of a person. Identity recognition is based on invariant facial information, while facial expression recognition requires one to recognize and interpret fluctuating facial information [for reviews see Haxby et al. (2000) and Haxby et al. (2002)]. These two categories of facial information appear to be processed at least somewhat independent of one another and involve different neural structures (Bruce and Young 1986; Haxby et al. 2000). Typical individuals are able to accurately recognize social cognitively complex facial expressions, or expressions that convey complex mental states, from both whole faces as well as from the eye region alone (Baron-Cohen et al. 1997). Typical individuals also make rapid judgments of socially complex psychological traits, such as trustworthiness, based on facial information [see Todorov (2008) for review]. Some face processing tasks are less socially cognitively complex compared to others. For example, identity recognition, while computationally complex (recognizing an identity from hundreds previously encountered), is not as socially cognitively complex as emotional expression discrimination or recognition, which requires one to analyze a given facial expression, compare it to previous representations of facial expressions, and critically to infer the underlying internal emotional state.

The current literature does not definitively identify the source of the face processing deficit in ASD; it could be driven by a deficit in processing emotional expression information, or a deficit in processing socially complex information. Adolphs et al. (2001) examined adults with ASD's discrimination and intensity rating of basic emotional facial expressions (happy, sad, fear, disgust, surprise, and anger) as well as their ratings of trustworthiness and approachability. The authors reported that while the participants with ASD were able to discriminate and rate the intensity of facial expressions as well as typical participants were, their judgments of trustworthiness were atypical, suggesting deficits in making certain social judgments of faces. The conclusions of this study are limited by the small sample size and the fact that the tasks for each type of face processing differed significantly from each other making it difficult to compare results across tasks. Also, there was no simple face identity task included, so one can not make conclusions about whether individuals with ASD have deficits in all tasks involving face processing, or deficits exclusively in tasks related to processing social information in faces. Thus, the current study used a relatively large sample of individuals with ASD to compare performance on several face processing tasks that varied with respect to emotion perception and social cognitive complexity.

The Current Study

The current study was designed to test whether the facial expression content of the task or the level of social cognitive complexity drives deficits in face processing abilities in adults with ASD. We designed a battery of face processing tasks that ranged in social cognitive complexity, and also could be categorized as either involving emotional expression processing or not. Participants completed four tasks in the same order: Identification Task, Basic Expression Recognition Task, Complex Expression Recognition Task, and Trustworthy Perception Task. The Identification and Basic Expression Recognition tasks were relatively simple in terms of social cognitive complexity compared to the Complex Expression Recognition and Trustworthy Perception tasks. If the deficit in face processing in ASD is driven by deficits in expression processing, then the ASD group would perform worse than the typical group on the Basic and Complex Expression Recognition tasks, but show typical performance on the Identification and Trustworthy perception tasks. If, in contrast, the deficits are driven by the social cognitive complexity of the task, the ASD group would show poorer performance on the Complex Expression Recognition and Trustworthy Perception tasks compared to the control group, but show typical performance on the Identification and Basic Expression Recognition tasks.

Methods

Materials

Identification Task

Thirty-two greyscale images of eight male and eight female faces (two images of each of eight models with different lighting (e.g., direct vs. peripheral), one used as the model image and the other displayed as an option in the response screen) were used in this task. These photographs were taken by the experimenters and were used in previous experiments. Half were used in the practice blocks and the other half were used in the experimental task. Each photo consisted of the model's face cropped with an oval mask to remove external features. Model images were displayed at a visual angle of 15.19° by 10.76° at a viewing distance on 60 cm. Response screen faces were displayed at a visual angle of 5.72° by 3.81° at a viewing distance of 60 cm.

Basic Expression Recognition Task

Thirty-two greyscale images of four male and four female models (different from above) each displaying four expressions (angry, fear, sad, happy) were used in this task. Images were taken from an established face database and had been validated in previous studies (Tottenham et al. 2009). The mean percent agreement across models for each expression was .93 for angry, .62 for fearful, 1 for happy and .82 for sad (Palermo and Coltheart 2004). Each image was displayed at a visual angle of 15.19° by 11.42° at a viewing distance of 60 cm.

Complex Expression Recognition Task

Thirty-two greyscale images of four male and four female models (different from those used in the other tasks) each displaying four expressions (arrogant, bored, flirtatious, and thoughtful) were used in this task (See Fig. 1 for examples). These photographs were taken by the experimenters for the current experiments. The models wore the same shirt in all the photographs, which were cropped just below the shoulders and included external facial features. Images used in the experiment were selected from a larger set of photographs based on a pilot study where we obtained percent agreement for each model across expressions. None of these individuals participated in the current study. The mean percent agreement across models for each expression were calculated based on responses from 15 participants (4 males; mean age = 22 years) was .89 for arrogant, .84 for bored, .97 for flirtatious, and .95 for thoughtful. Each image was displayed at visual angle of 15.19° by 12.17° at a viewing distance of 60 cm.

Trustworthy Perception Task

Fourteen images of male models were used in this task. Images were taken from a database of police photographs of individuals who had been arrested, and therefore were likely to include untrustworthy looking faces. Images were selected from a larger set of photographs based on a pilot study obtaining percent agreement for each model. The mean percent agreement for each category were calculated based on responses from 16 participants (5 males; mean age = 23.9 years) who did not participate in the current study and was .77 for trustworthy faces and .90 for untrustworthy faces. Each image was displayed at a visual angle of 15.19° by 12.37° at a viewing distance of 60 cm.

All stimuli were presented and data were compiled in MatLab Student Version 7.4 on the same Apple Macintosh mini Dual 2.7 GHz PowerPC G5 computer with OS X operating system with a 17-inch LCD monitor set to a resolution of 1280 × 1024 and a refresh rate of 60 Hz.

Participants

Participants were 23 high-functioning adults (5 females, average age 30.8 years, range 20–60) with a diagnosis of autism or Asperger's syndrome and 23 typical adults (5 female, average age 28.4, range 20–50). The groups did not differ in chronological age and IQ, which was measured using the Wechsler Adult Intelligence Scale (see Table 1 for demographic information). Due to equipment failure, data were not saved for three ASD participants for the Identification Task, one ASD participant for the Basic Emotion Recognition Task, and two ASD participants for the Trustworthy Perception Task. As a result the number of ASD participants varies across the four tasks.

Participants with ASD were recruited from a local assisted living group home as well as from a database of

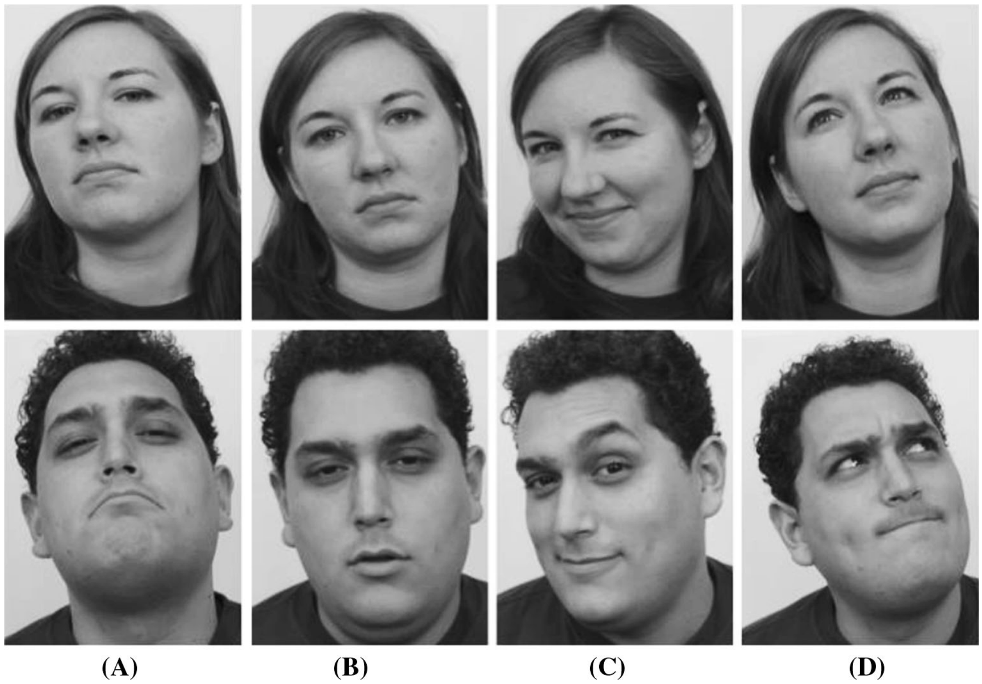

Fig. 1 Examples of stimuli used in the Complex Expression Recognition Task. The Complex Expression Recognition Task included greyscale images of four males and four females displaying each of the following expressions: **a** arrogant, **b** bored, **c** flirtatious, **d** thoughtful

Table 1 Chronological age and IQ of participants

	ASD (n = 23)			Typical (n = 23)			Group difference	
	Mean	SD	Range	Mean	SD	Range	$t(44)$	p
CA (years)	30.8	8.54	20–60	28.39	9.33	20–50	.91	.37
Verbal IQ	97.39	12.09	75–114	94.83	14.01	70–127	.67	.51
Performance IQ	98.48	12.80	81–135	98.83	14.80	74–118	–.09	.93
Full scale IQ	97.43	11.02	77–118	97.39	13.09	73–116	.01	.99

CA chronological age

individuals who had previously participated in research studies in our lab. The participants with ASD had been given a diagnosis of autism or Asperger's by outside agencies, and were also evaluated using the ADOS-G (Lord et al. 2000) Module 4 to confirm diagnosis and group membership for this study, see Table 2. The typical participants were recruited off-campus, via online advertising. Participants were given a small honorarium for their participation in the study.

Procedure

Prior to beginning the computer tasks, participants were asked to match the category labels used in the experimental tasks (i.e., anger, fear, happy, sad, arrogant, bored, flirtatious, thoughtful, trustworthy, and untrustworthy) with the correct definition. If a participant made a mistake, the experimenter corrected them and elaborated of the meaning of the word that was incorrectly matched. This matching

Table 2 ADOS (module 4) scores for ASD participants

	Mean	SD	Range
Communication	4.64	2.46	1–9
Reciprocal social interaction	8.64	3.00	3–16
Imagination/creativity	1.41	0.91	0–3
Stereotyped behaviours and restricted interests	0.36	0.66	0–2
Total score	13.23	4.77	4–25

procedure was repeated until the participant understood all of the category labels (i.e., was able to correctly match all category labels with the correct definition). All participants completed the four experimental tasks in the same order: Identification Task, Basic Expression Recognition Task, Complex Expression Recognition Task, Trustworthy Perception Task. All four tasks were completed with participants seated such that their eyes were 60 cm from the monitor with the lights on. The entire experiment took approximately 60 min to complete.

For the Identification Task, participants completed a practice block in order to familiarize them with the task. Each trial began with a 500 ms central fixation point. A single test face was displayed centrally on the screen for 250 ms and then disappeared. A response screen appeared immediately with eight faces (four males and four females) each labeled with a number 1 through 8. Participants were asked to identify the face that they had seen via key press with unlimited response time. The next trial began after a 500 ms intertrial interval (ITI). During the practice block, participants received feedback on their performance on each trial; a tone was emitted for each correct response, but not for incorrect responses. Each practice block consisted of 16 trials. If a participant was correct on 80 % or more trials, the experimental task began. If their accuracy was below 80 %, participants repeated the practice block for a maximum of three attempts. In the ASD group, one participant completed one practice block, five completed two practice blocks, and 14 completed three practice blocks. In the typical group, four participants completed one practice block and 19 completed three practice blocks. After three practice blocks, the experimental task began regardless of participants' accuracy; eight participants in the ASD group and 10 participants in the typical group did not reach 80 % accuracy on the third block. The experimental task consisted of the same trial sequence as in the practice block, however eight novel faces were used and no feedback was given to participants.

For the Basic Expression Recognition Task, each trial began with a 500 ms fixation point, followed by a single face displayed for 250 ms. Participants were asked' "Which label best represents this facial expression?" The labels angry, fearful, sad, and happy were written at the top of the response screen and participants responded via key press. The word labels remained on the screen until the participant made his or her response and then the next trial began after a 500 ms ITI. The task consisted of 128 trials total; eight models for each of four expressions with each image repeated four times. Expressions were presented in a randomized order.

For the Complex Expression Recognition Task, each trial began with a 500 ms fixation point, followed by a single face displayed for 250 ms. Participants were asked' "Which label best represents this facial expression?" The labels bored, flirtatious, thoughtful, and arrogant were displayed at the top of the response screen and participants responded via key press. Word labels remained on the screen until the participant made his or her response and then the next trial began after a 500 ms ITI. The task consisted of 128 trials total; eight models for each of four expressions with each image repeated four times. Expressions were presented in a randomized order.

For the Trustworthy Perception Tasks, each trial began with a 500 ms fixation point, followed by a single face displayed for 250 ms. Participants were asked' "Is this person trustworthy or untrustworthy?" The labels trustworthy and untrustworthy were written at the top of the response screen and participants responded via key press. The word labels remained on the screen until the participant made his or her response and then the next trial began after a 500 ms ITI. The task consisted of 140 trials total; 7 models from each category with each image repeated 14 times. Trustworthy and untrustworthy faces were presented in a randomized order.

Results

We calculated each participant's overall accuracy (the proportion of correct trials) for each of the four tasks. To compare performance between the ASD and typical groups we conducted a 4 (task type) × 2 (group) repeated measures mixed-model ANOVA, depicted in Fig. 2. The results revealed significant main effects of task type, $F(3, 117) = 18.66$, $p < .001$, $\eta_p^2 = .32$, and group, $F(1,39) = 19.0$, $p < .001$, $\eta_p^2 = .33$. However, these main effects were qualified by a significant interaction between task type and group, $F(3,117) = 5.67$, $p = .001$, $\eta_p^2 = .13$. Follow up independent samples *t* tests were corrected for multiple comparisons with a Bonferroni correction ($\alpha = .0125$). These comparisons revealed no significant group differences for the Identification Task, $t(41) = 1.78$, $p = .08$, or the Trustworthiness Perception Task, $t(42) = .81$, $p = .42$. For the Basic Expression Recognition Task, the ASD group ($M = .87$, $SD = .11$) was significantly less accurate compared to the typical group ($M = .94$, $SD = .03$), $t(43) = 3.15$, $p = .003$, $d = .96$. Similarly, for the Complex Expression Recognition Task, the ASD group ($M = .69$, $SD = .19$) was significantly less accurate compared to the typical group ($M = .87$, $SD = .07$), $t(44) = 4.22$, $p < .001$, $d = 1.27$ (Fig. 3).

To examine whether the results of the current study were due to higher language demands required for the basic and complex emotion tasks, we tested whether, for each group, the correlation between scores on each of the tasks and participants' verbal IQ score were significant. In the ASD

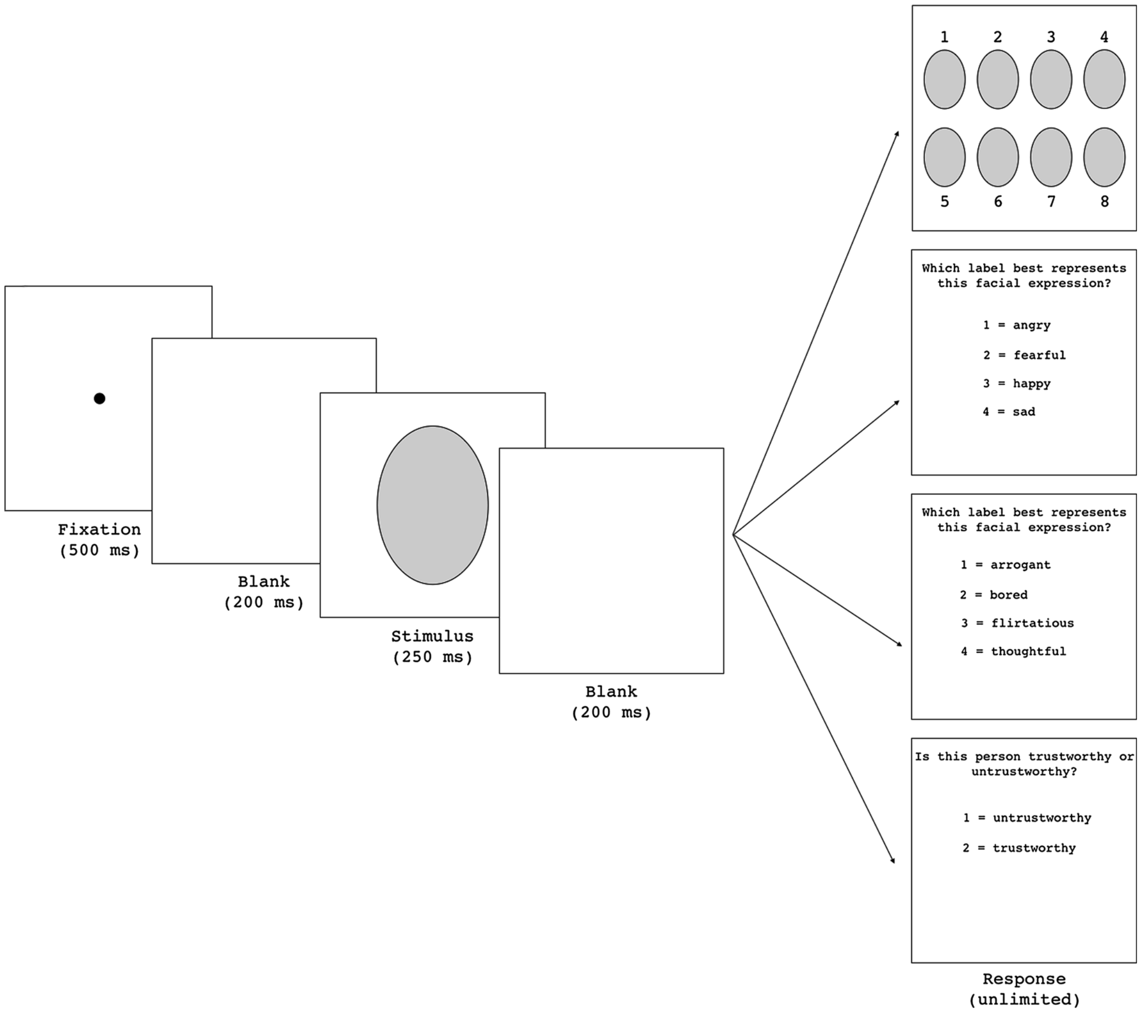

Fig. 2 Trial sequence for the experimental tasks. All four tasks had the same trial sequence, however the response screen differed for each task

group, we failed to find significant relationships between performance and verbal IQ for any of our tasks (identity: $r = -.08$, $p = .74$; basic: $r = -.23$, $p = .30$; complex: $r = .32$, $p = .14$; trustworthiness: $r = .07$, $p = .78$). In the TD group, a significant positive correlation was found for the face identification task ($r = .50$, $p = .02$), but not the other tasks (basic: $r = .18$, $p = .41$; complex: $r = .23$, $p = .28$; trustworthiness: $r = .22$, $p = .32$). To determine whether the group correlations differed from one another, we used Fisher's r to z test (see Meng et al. 1992). This test revealed the correlation between verbal IQ and performance was marginally different between the two groups only on the face identification task ($z = 1.89$, $p = .06$). No other significant group differences existed (basic: $z = 1.3$, $p = .19$; complex: $z = 0.28$, $p = .78$; trustworthiness: $z = 0.49$, $p = .63$). Taken together, these results fail to support the idea that the significant group differences found for the two emotion tasks are attributable to group differences in language ability.

Discussion

The current study was designed to examine whether face processing deficits in adults with ASD are driven by deficits in perceiving emotional expressions, or deficits in processing social cognitive complexity. If face processing deficits in ASD are restricted to tasks involving processing emotional expressions, the ASD group would perform poorly on the Basic and Complex Expression Recognitions tasks compared to the typical group, but no group differences in performance on the Identification and Trustworthy Perception tasks would be found. In contrast, if face processing deficits in ASD are driven by deficits in processing social cognitive complexity, there would be no group differences in performance on the Identification and Basic Expression Recognition tasks (which require relatively simple social judgments), but poorer performance in the ASD group on the Complex Expression Recognition and Trustworthy Perception tasks (which involve more

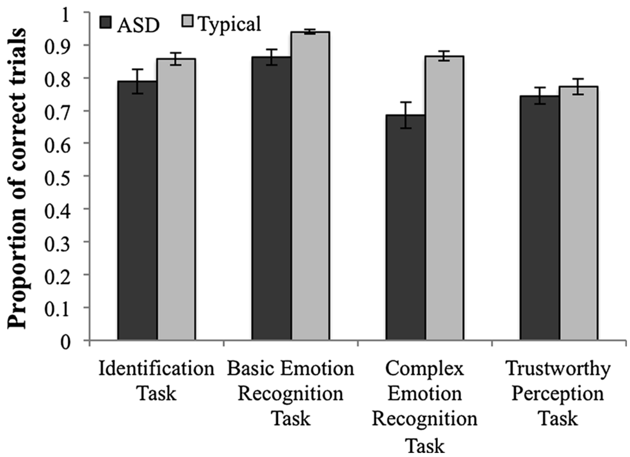

Fig. 3 Accuracy across tasks. Proportion of overall correct trials for the Identification, Basic Expression Recognition, Complex Expression Recognition, and Trustworthy Perception tasks for adults with ASD and age and IQ matched typical adults. Results indicated no significant differences between groups in performance on the Identification and Trustworthy Perception tasks, but worse performance on the Basic and Complex Expression Recognition tasks for the ASD group compared to the typical group. *Error bars* represent the standard error of the mean

complex social cognitive judgments). The results of the current study supported our first hypothesis: participants with ASD showed poorer performance on the two expression recognition tasks. The second hypothesis was not supported: we found group differences in performance on the Identification and Trustworthy Perception tasks. This suggests that adults with ASD do not have a global face processing deficit, rather they have a deficit restricted to processing facial expression information in faces. Additionally, we did not find any significant group differences in the correlation between performance and verbal IQ score, suggesting that these results cannot be attributed entirely to potential group differences in language abilities.

The results of the Identification Task in the current study contrast with the results of several previous studies, which used a similar delayed-match to sample tasks (although with fewer response options) and found poorer performance of the ASD participants compared to typical participants (Gepner et al. 1996; Scherf et al. 2008; Wilson et al. 2010). One key difference between the current study and previous studies is the ages of the participant groups. It may be that facial identity processing is atypical in children with ASD but reaches typical levels by adulthood. This may be a true developmental delay in ASD. Future studies employing longitudinal designs in order to investigate the developmental trajectory of facial identity processing deficits in individuals with ASD may shed light on these discrepant findings.

The current study demonstrated that individuals with ASD were able to make perceptual judgments of the trustworthiness of faces, similar to that of typical adults. These results contrast with those of Adolphs et al. (2001) who reported that adults with ASD gave abnormally high trustworthiness ratings to faces typical individuals consistently rated as most untrustworthy. There are several differences between the current Trustworthiness Perception Task and the task used by Adolphs and colleagues. First, the previous study only included five ASD participants, so the generalizability of the results is limited. Another key difference between the two studies is the nature of the experimental tasks. In the current study, participants were asked to make a forced choice response indicating if they thought each face was trustworthy or untrustworthy. Adolphs et al. (2001) had participants rate the trustworthiness of each face. It may be that ASD participants found Adolph et al.'s task unclear, whereas a forced-choice type of task constrains responses, making the task more tractable. Interestingly, in the Adolphs et al. (2001) study participants also rated the approachability of the same set of faces and found no group differences in these ratings. This discrepancy between trustworthiness and approachability, which one would assume should be closely related, may suggest that the ASD participants' trustworthiness ratings are not reliable or valid, perhaps due to a misunderstanding of task requirements.

In the current study, adults with ASD showed poorer performance on both the Basic Expression Recognition and Complex Expression Recognition tasks. Previous studies measuring expression recognition in individuals with ASD have produced mixed results [see Harms et al. (2010) for review]. Some studies have found typical recognition abilities for basic emotions (e.g., Capps et al. 1992; Adolphs et al. 2001; Baron-Cohen et al. 1997; Robel et al. 2004; Castelli 2005; Loveland et al. 1997) while others have found measurable deficits in recognition abilities (e.g., Bormann-Kischkel et al. 1995; Kuusikko et al. 2009; Philip et al. 2010). For example, Baron-Cohen et al. (1997) reported normative performance in recognition of basic emotional expression, but poorer recognition of complex facial expressions such as thoughtful, guilt, or scheming. In contrast, participants with ASD in the current study showed poorer performance in the recognition of *both* simple and complex emotional facial expressions.

There is no clear explanation in the current literature for the discrepancies in results among studies examining emotional expression recognition in individuals with ASD. Two studies have investigated the perceptual strategies employed by individuals with ASD when processing basic facial expression. Rutherford and McIntosh (2007) and Walsh et al. (2014) both found that adults with ASD rely on a deliberate, rule-based perceptual strategy when processing emotional information in faces, whereas typical participants use an intuitive, prototype-matching strategy to categorize emotional facial expressions. It may be that certain experimental designs facilitate the atypical perceptual strategy favored by those with ASD and therefore do not reveal group differences in labeling emotional expression perception. In this case, there would be no group differences in accuracy, even if the two groups were employing different perceptual strategies to complete the task. Other experimental designs may not allow the use of a learned rule-based strategy (e.g., because of time limits, or using complex and less common facial expressions), and therefore find significant group differences in recognition accuracy.

The findings of Baron-Cohen et al. (1997) indirectly support this explanation, as they found no group difference in recognition of basic emotional expression, but group differences in recognizing complex facial expression. It may be that adults with ASD are able to use an alternative rule-based strategy to recognize basic emotions and therefore are as accurate in recognizing these expressions. However, complex emotional expressions are less frequently encountered and have overlap between exemplars making it difficult to develop an explicit rule-based perceptual strategy to recognize these expressions. While the current study was not a direct test of this hypothesis, it does provide indirect support as both emotional recognition tasks would have made it difficult for ASD participants to employ an alternative learned perceptual strategy because of the brief stimulus presentation time and the use of complex and less common expressions.

Two limitations of the current study should be considered. First, the Trustworthy Perception Task only included male models. These photographs were taken from a database of male individuals who had been arrested. This database was chosen because it had been used in a previous study investigating pregnant females' ability to recognize "creepy" male faces (Anderson and Rutherford 2010), and thus was likely to contain faces that individuals would perceive as untrustworthy. Future research utilizing both male and female faces is needed to examine if the results of the current study extend to judgments of trustworthiness in female faces. The Trustworthy task also differed from our second socially complex task (the Complex Expression Recognition task) in that there were two response options (i.e., trustworthy vs. untrustworthy) versus four (i.e., thoughtful, bored, arrogant, and flirtatious). It is possible that the language demands of the Trustworthy task were lower compared to the language demands of the Complex Expression Recognition Task. Future research directly measuring the language demands of face processing tasks and the effect of individual differences in language abilities is needed to better understand the role of language in social cognitive processing tasks. Second, the Identification Task required a different type of response compared to the other three experimental tasks (i.e., selecting among images vs. category labels). We could have designed the Identification Task to also include a category label response by assigning a name to each face and having participants select the name of the face they just saw, rather than a different image. However, this would have created a significantly higher memory demand, as participants would have had to learn and memorize the name associated with each face. Previous research has demonstrated that individuals with ASD have a domain specific impairment in *memory* for faces (Weigelt et al. 2013). Since the primary aim of the current study was to investigate group differences in face *perception*, we wanted to minimize memory demands as much as possible for this task.

Conclusions

The current study directly compared the performance of a relatively large sample of adults with ASD and a matched control group on four comparable face perception tasks that involved identity, basic emotional expression, complex emotional expression, and trustworthiness perception. The performance of adults with ASD diverged from the typical group as emotion perception demands increased, but did not diverge as social complexity increased. These results suggest that face processing deficits, when seen in ASD populations, result from deficits in emotion perception, not in the social complexity of the stimuli.

Future studies should focus on exploring the developmental trajectories of face processing deficits in individuals with ASD. It will be important to use similar face processing test batteries with children and adolescents with ASD in order to examine whether a similar pattern of face processing deficits is present throughout development for individuals with ASD. Future research should also examine the ability to process other non-emotional but social information in faces other than trustworthiness, such as attractiveness or friendliness, to more thoroughly test whether adults with ASD have a global deficit in processing social information in faces.

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Author Contributions JAW, SEC, and MDR developed the study design; JAW led data collection and management; JAW led statistical analysis and data interpretation; SEC, and MDR participated in data interpretation; JAW, SEC, and MDR participated in drafting the manuscript. All authors read and approved the final manuscript.

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