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ORIGINAL PAPER

Emotional Processing in Autism Spectrum Disorders: Effects of Age, Emotional Valence, and Social Engagement on Emotional Language Use

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Abstract
Children with autism spectrum disorders (ASD) show deficits in reporting others' emotions (Lartseva et al. in Front Hum Neurosci 8:991, 2015) and in deriving meaning in social contexts (Klin et al. in Handbook of autism and pervasive developmental disorders, Wiley, Hoboken, 2005). However, researchers often use stimuli that conflate salient emotional and social information. Using a matched-pairs design, the impact of emotional and social information on emotional language in pre-school and school-age children, with and without ASD, was assessed with a picture description task comprising rated stimuli from the Pictures with Social Contexts and Emotional Scenes database (Teh et al. in Behav Res Methods, https://doi.org/10.3758/s13428-017-0947-x, 2017). Results showed both groups with ASD produced fewer emotional terms than typically developing children, but the effects were moderated by valence, social engagement, and age. Implications for theory and clinical practice are discussed.

Keywords Autism spectrum disorders · Emotional language · Emotion deficits · Emotional development · Social context · Picture descriptions

Introduction

Autism spectrum disorders (ASD) are diverse neurodevelopmental conditions characterized by social communication impairments and a pattern of repetitive, stereotyped or rigid interests or behaviors (American Psychiatric Association 2013). A key social impairment for individuals with ASD is in the processing of emotions (see reviews by Begeer et al. 2008; Lartseva et al. 2015). There is evidence of deficient, or atypical, use of emotional language in their story narratives, emotional descriptions, and conversations (Lartseva et al. 2015). Furthermore, children with ASD may not develop social and emotional processing skills in the same way as typically developing children. In typical development, children show an ability to spontaneously process social and emotional information, such as facial expressions, from infancy upwards (Goren et al. 1975). Their social and emotional competences develop in complexity with age, language, and cognitive development, partly as a result of exposure to more social situations over time (Peterson et al. 2012; Pons et al. 2003).

In contrast, there is now evidence to suggest that children with ASD show uneven and more limited development of emotional and social processing skills. Reviews have reported greater impairments in processing emotional information in the context of social vs non-social stimuli (Begeer et al. 2008; Nuske et al. 2013). Additionally, age-based emotional skill development appears to be moderated by the cognitive abilities of children with ASD (Begeer et al. 2008). Specifically, Begeer et al.'s (2008) review shows that for children with ASD and intellectual disabilities, preschoolers' emotional expressions are equivalent to those of typically developing children or mentally retarded controls with the same mental-age, but deficits are evident for older school-aged (9–12 years) populations. For children with ASD and average or higher cognitive abilities, little is currently known about emotional skills in the younger population, but there

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are mixed findings of impairments and normative performance for older school-aged samples (Begeer et al. 2008).

These cohort differences prompted us to investigate emotional processing skills cross-sectionally with two age-groups of children with ASD with average or higher cognitive abilities, specifically, a preschool group (aged 5–6 years) and a primary school group (aged 8–12 years). In particular, we were interested in studying emotional language use in children with ASD, which has implications for social and cognitive theories of ASD as we will discuss later. Lartseva et al.'s (2015) review of emotional language studies in ASD found that emotional language deficits in ASD were not consistently associated with language development, age, or IQ, but the reviewers noted that there have been relatively few empirical studies in this area compared to emotional facial expression studies in ASD. The next sections will present current findings on emotional language use in the literature and highlight some empirical gaps to be addressed.

Emotional Language Production in ASD

One paradigm that previous researchers have used to study emotional language in children with ASD is story-telling from pictures. For this paradigm, participants tell a story by referring to wordless picture books (e.g., Capps et al. 2000; Rumpf et al. 2012; Siller et al. 2014), or sequenced picture cards (e.g., Canfield et al. 2016; Kristen et al. 2015). The use of pictures provides an opportunity to compare language use, including emotional language production and narrative skills, between children with ASD and typically developing children (or other clinical groups) matched on variables such as gender, age, cognitive and/or language skills. Among other narrative measures, researchers have calculated the frequency, or proportion, of words indicating internal states, including emotions, perceptions, physiological conditions, moral judgments (e.g., *naughty, strange*), and/or mental states.[1]

To date, three studies have reported specifically on the production of emotional terms as a subcategory of internal state terms but their findings are inconsistent. Rumpf et al. (2012) and Siller et al. (2014) calculated the frequency and proportion of emotional terms, such as labels of discrete emotions (e.g., *happy, angry*) and terms referring to expressive behavior (e.g., *crying, laughed*), produced in storybook narratives. Rumpf et al. (2012) reported no significant differences in the number of emotional terms produced by children with ASD without intellectual disabilities, typically developing children, and children with attention deficit/hyperactivity disorder. The three groups were matched on age (8–12 years) and nonverbal IQ. In contrast, Siller et al. (2014) found that children with ASD, in a similar age and IQ-range as Rumpf et al.'s participants, produced fewer emotional terms than typically developing children. Additionally, Siller et al. (2014) reported that theory-of-mind skills were positively associated with production of emotional terms in ASD and control groups. In the third study, Kauschke et al. (2016) explored gender effects in children with ASD, aged 8–19 years with average IQ. They reported no significant difference in the number of emotional terms produced by girls with ASD and boys with ASD who were matched case-wise on age and IQ. However, both groups produced significantly fewer emotional terms than age- and IQ-matched typically developing girls, indicating the presence of ASD-related emotional processing deficits but a lack of gender effects in the ASD sample (Kauschke et al. 2016). In all three studies, the pattern of findings was unchanged when the researchers used proportions to control for story length or narrative volume, yet the three studies' outcomes were different.

One limitation of using story-telling for investigating emotional processing in children with ASD is that narrative production is a complex task which also depends on language, pragmatics, memory, planning and organizational skills (Diehl et al. 2006). By comparison, using single-picture stimuli for emotional tasks avoids possible methodological confounds resulting from other narrative-discourse skill deficits often observed in children with ASD, including reduced syntactic complexity (Tager-Flusberg 2001), reduced pragmatic abilities such as use of cohesive devices and maintaining listener involvement (Capps et al. 2000; Siller et al. 2014), and/or limited cognitive skills (Hill 2004). Another serious limitation of story-telling studies is that experimenters have not yet examined the possible effects of picture properties on emotional language production. These include important variables such as emotional valence and the social cues in the stimuli.

Effects of Valence on Emotional Language Use

The valence of an emotion may affect emotional processing in ASD. Emotion interviews with children with ASD generally show greater impairments with negative than with positive emotions, as well as fewer reports and poorer descriptions of negative emotions (e.g., Ben-Itzchak et al.

[1] Studies on internal state language use in ASD using story-narratives are few at present, and mixed findings have been reported, with some reporting reduced frequency and diversity of internal state language used by children with ASD compared to control groups (Rumpf et al. 2012; Siller et al. 2014), and others reporting no significant difference between groups (Canfield et al. 2016; Capps et al. 2000; Kristen et al. 2015). However, it is beyond the scope of the present study to discuss findings on *internal state language*, as they do not clearly examine emotional language skills.

2016; Rieffe et al. 2007). Uljarevic and Hamilton's (2013) meta-analysis of 48 emotion picture matching/labeling experiments is consistent with uneven emotion recognition deficits. They reported a large mean effect size (Cohen's $d = 0.80$) for emotion recognition difficulties in children and adults with ASD, despite near-normal recognition of one emotion, *happiness*. Similarly, Ben-Itzchak et al. (2016) reported that 8- to 11-year-old children with ASD produced full descriptions only for *happiness*, and gave "odd" (Ben-Itzchak et al. 2016, p. 2365) or incoherent descriptions for *fear, anger* and *sadness*, compared to typically developing controls. However, relatively little is known about valence effects on spontaneous emotional language use at present. Among story-telling studies, only Rumpf et al. (2012) have reported that more negative than positive emotions were produced by all participant groups, but they did not explore the reasons for this finding. Hence, the extant literature indicates that children with ASD have a relative impairment in processing negative emotions, and yet are able to produce greater numbers of negative emotional terms in a story-telling task. These results are contradictory and worthy of further verification. Further, researchers have not yet examined the interplay between valence and social cues on emotional processing outcomes.

Effects of Social Cues on Emotional Processing

It is possible that social context affects how people interpret behaviors and emotions in a situation. In typical development, processing of social information is a spontaneous and progressive skill that facilitates children's ability to understand social interactions and respond in socially-acceptable ways to people around them. This process includes encoding and processing relevant social cues, using background knowledge, and evaluating personal goals/motivations (Crick and Dodge 1994). Further, Lemerise and Arsenio (2000) argued that typically developing children integrate emotional cues with social information, in order to regulate their behavioral responses towards others.

However, children with ASD may not simultaneously process social and emotional information in the same way. Besides the deficits in emotional processing described earlier, researchers have found that children with ASD often show impairments in encoding and evaluating social cues from faces and contexts when asked to judge others' social traits or intentions (e.g., Forgeot d'Arc et al. 2016; Ziv et al. 2014). Similarly, children with ASD do not use social contextual cues to derive emotional meaning as effectively or accurately as typically developing children. Balconi et al. (2012) reported that social situations presented in contextualized pictures and video-clips facilitated conceptual understanding of emotions in children with ASD (aged 6–16 years, $M = 11.5$ years), over photographs of faces. That being said, they observed that the children with ASD (Asperger's syndrome) tended to focus more on inanimate objects than characters and attribute causes of emotions to external events, whereas the typically developing controls talked more about characters and attributed emotions to characters' thoughts or interpersonal relationships.

In a similar way, data from story-telling studies and self-reports of emotional experiences have revealed that children with ASD are less likely to connect emotions to social relationships or situations than typically developing children (Capps et al. 2000; Losh and Capps 2006). More specifically, Ben-Itzchak et al. (2016) found that participants with ASD (aged 8–11 years, $M = 9.6$ years) rarely gave social reasons for *happy* or *fear* emotions in personal experiences, while age-matched typically developing children gave social and/or self-relevant reasons for both emotions. Hence, the effects of social context cues on emotional processing in ASD are not clear at this point. Further, the joint effects of valence and social information on emotional language use have not been tested systematically, representing an empirical gap that may have important implications for our understanding of social and emotional processing mechanisms in ASD.

Gaps in the Literature

It is often unclear if deficits in performance on experimental emotion tasks by children with ASD are related to deficits in processing of emotional or social cues. A common methodological problem in the emotion literature involving children with ASD is that picture stimuli have often contained some degree of social information; for example, photographs of faces, or pictures of people in contextualized situations, require both an understanding of facial expressions and some social insight. Olsson and Ochsner (2008) theorized that emotional and social information may be dissociable constructs, in that some social situations may be emotion-neutral (Olsson and Ochsner 2008), and some emotions may be recognised from surface cues, like smiles or frowns, without reference to social contexts (Ekman 1993). However, reviewers have noted a lack of suitable stimuli to test the effects of social and emotional variables on emotional processing in studies on both neurotypical (Ochsner 2008) and ASD populations (Lartseva et al. 2015) to date. A study is needed to examine how processing is affected when social and emotional information are presented independently and in combination.

Another common problem is that emotion researchers have often contrasted social stimuli (e.g., pictures containing people) with non-social stimuli (e.g., pictures of objects, landscapes, or animals, and without people), rather

than comparing how differences in social situations may affect emotional processing. This is true of studies involving populations with ASD (e.g., Ben-Yosef et al. 2017) as well as neurotypical populations (e.g., Rubo and Gamer 2018). Degree of social engagement is a potentially useful variable in emotion studies using contextualized pictures of people. Social engagement is a multidimensional construct representing situational factors such as social roles, attributed relationships, types of interactions, and actions in particular settings (Teh et al. 2017). Each of these factors is likely to vary across a set of pictures and influence the degree of social engagement perceived, including variability across pictures containing people. To illustrate, interactions between peers (e.g., two girls talking on the phone) were perceived by typically developing young adults as having higher social engagement than interactions with a salesperson or other professional (Teh et al. 2017). Thus, an empirical gap also exists in comparing how varying degrees of social engagement in people-based stimuli affect emotional processing.

Bridging the above gaps would contribute to our theoretical understanding of the interplay of social and emotional processing mechanisms in ASD. Happé and Frith (2014) suggested that social cognition components such as agent-identification, social hierarchy mapping, and emotional processing, could potentially be separable in people with neurodevelopmental disorders, including ASD. In contrast, for typically developing individuals, adult neural studies have revealed that social-cognitive and emotional brain areas are often simultaneously activated during social and emotional processing tasks (Olsson and Ochsner 2008). As Olsson and Ochsner (2008) argued, understanding of other people's emotions often involves an interpretation of their underlying social intentions, and so processing of emotional and social information are often intertwined in real-life social interactions. However, the common observation that children with ASD are less likely than typically developing children to talk about emotions in relation to interpersonal relationships or social situations, has led some reviewers to postulate a 'disconnect' or dissociation in processing of social and emotional information in children with ASD (Happé and Frith 2014; Nuske et al. 2013).

If such a 'disconnect' in social cognition exists in people with ASD, there are implications for at least two existing theories of ASD. First, Minshew and Goldstein's (1998) theory of selective complex cognitive-processing impairments in ASD claims that, in the absence of simple cognitive-processing impairments, cognitive-processing performance declines when more cues are presented and/or more simultaneous processing is required. This theory argues that impairments in processing of social information and facial expressions in ASD could be due, in part, to complex information-processing deficits, because social interactions typically involve lots of details (Minshew and Goldstein 1998). Second, the theory of reduced social motivation in ASD claims that individuals with ASD do not spontaneously pay attention to faces and people in contextualized scenes (Chevallier et al. 2012; Klin et al. 2002). Both theories predict emotional impairments in ASD. However, a disconnect in social and emotional processing would predict greater impairments in high-social than low-social situations under the complex cognitive-processing model (due to increased cognitive loading), but stability of emotional deficits regardless of social content under the reduced social motivation model (due to disconnected social and emotional processes). Therefore, we propose that such a 'disconnect' be examined by manipulating social and emotional cues in an emotional language production task.

The Present Study

The aim of the present study was to test the effects of emotional valence (negative, positive, and neutral) and social engagement (high and low levels) on the production of emotional language terms during a picture description task by children with ASD and typically developing children, matched pairwise for age, gender, nonverbal IQ, and socio-economic status. Both these groups were split by age into preschool (5–6 years old) and primary school (8–12 years old) groups. As emotional processing is a skill that develops with experience (Pons et al. 2003), age effects may have important theoretical and clinical implications. A free-response picture-description paradigm was chosen to enable the study of children's interpretation of depicted situations, including underlying concepts such as emotions inferred from the cues, within the six different test conditions. This study is unique in comparing conditions of high-social engagement and low-social engagement using all people-based pictures. Moreover, single-picture stimuli were selected for this study to facilitate orthogonal separation of emotional and social cues, and to reduce the need for higher-order linguistic and cognitive skills (required for longer narratives) that may be deficient in some children with ASD (Tager-Flusberg 2001), but are not targeted in this project.

There were two main research questions:

RQ1 How do emotional valence and social engagement information in pictures affect emotional language production in children with ASD and typically developing children?

We predicted that children with ASD would produce fewer emotional terms than typically developing children across all valence conditions (Siller et al. 2014). However, group differences would be greater under high-social-and

emotional engagement conditions, due to the increased cognitive load for children with ASD (Ben-Yosef et al. 2017; Minshew and Goldstein 1998) in contrast with the synergistic integration of emotional and social cues by typically developing children (Lemerise and Arsenio 2000). No direction was predicted for valence effects given the lack of consistent evidence in emotional language studies in ASD to date.

RQ2 How does emotional language production change with age in children with ASD, compared to children with typical development?

We predicted that for both groups, the older children (8–12 years) would produce more emotional terms than younger (5–6 year-old) children (Begeer et al. 2008; Pons et al. 2003) but that there would be an interaction such that age effects would be enhanced by social engagement information for the typically developing group as a result of increased learning from social exposure over time (Crick and Dodge 1994), but no such enhancement under higher social engagement conditions would be found for the ASD group, consistent with the predictions in RQ1 above.

Method

Participants

The participants were ten children with an ASD diagnosis aged 5–6 years (younger group) and ten children with an ASD diagnosis aged 8–12 years (older group), and 20 typically developing (TD) children, matched pairwise on age (from 0 to 4 months' age difference), gender, nonverbal IQ (NVIQ) and socio-economic status (SES). Parents of participants completed a brief questionnaire regarding the child's age, educational history, language background, visual/hearing impairments (if any), ASD diagnosis (if any), co-morbid conditions and interventions/medications (if any), as well as indicators of family socio-economic status (housing type and parents' highest educational level).

All participants were enrolled in mainstream preschools or primary schools in Singapore and were from English-dominant language backgrounds, to minimize possible group differences in language exposure. The older participants were recruited through schools, while the younger participants were recruited through preschools, childcare centers, and word-of-mouth by parents of other participants. A total of eight potential participants were excluded, five from the control group (for having Mandarin as the dominant language, $n=1$; having first-degree relatives with ASD, $n=1$; or requiring high support to complete the practice trials, $n=3$); and three from the group with ASD (for having Mandarin as the dominant language, $n=1$; or not meeting ADOS criteria on verification (see below), $n=2$). Participants were compensated SGD30 in shopping vouchers, and parents received a confidential summary report of their child's language and cognitive skills.

Assessment Measures

ASD Diagnosis

Diagnoses were verified for the 20 participants in the ASD group by experienced clinicians using the *Autism Diagnostic Observation Schedule* (ADOS-2; Lord et al. 2012). The ADOS-2 is a standardized, semi-structured observational assessment of children's social interaction, communication, play and imaginative use of objects, with good to excellent reliability for autism vs non-spectrum comparisons (Lord et al. 2012). We used Module 3, for verbally-fluent children.

Cognitive and Language Skills

Nonverbal IQ development was assessed using *Raven's Colored Progressive Matrices* (CPM; Raven et al. 1995) for all participants in the younger group, or *Standard Progressive Matrices* (SPM; Raven et al. 1998) for participants in the older group. Language development was assessed using the *Comprehensive Assessment of Spoken Language* (CASL; Carrow-Woolfolk 1999), a standardized assessment of receptive and expressive language skills in English at word, sentence and paragraph levels, and pragmatic judgments. CASL tasks are presented verbally (no reading or writing is required) so it was deemed suitable for measuring skills relevant to the experimental tasks. The CASL has good test–retest reliability ($\alpha=0.92$, Carrow-Woolfolk 1999), and is appropriate for children and youths from 3 to 21 years old with typical development or language delays. Additionally, as many children in Singapore are exposed to Mandarin, Malay or Tamil at home from young,[2] the *Bilingual Language Assessment Battery* (BLAB; Rickard Liow and Sze 2009) was used to assess bilingual language development. The BLAB is a locally-developed computerized task that assesses single-word receptive vocabulary, with parallel English-Mandarin or English-Malay versions. The

[2] Some of the participants with ASD, and all the typically developing participants, were likely to be from bilingual homes and/or learning a second language in school. In mainstream primary schools in Singapore, all subjects are taught in English, except for the Mother Tongue subject, which is in Mandarin Chinese, Malay or Tamil. However, students with special educational needs, such as children with ASD, are sometimes exempt from the Mother Tongue requirement upon request by parents and approval by the Ministry of Education.

Table 1 Category descriptions and examples of stimulus pictures

Test conditions	Description	Example
Low social and emotion-neutral	Pictures include one main agent and action only.	A man swimming in the sea.
Low social and negative emotions	Pictures show one main agent performing an action, with an emotion depicted via facial expressions and/or body postures.	A boy has dropped his ice-cream on the floor.
Low social and positive emotions		A girl playing with a toy aeroplane.
High social and emotion-neutral	Pictures show two or more agents performing an action within a social context.	A waiter taking an order from two people at a table in a restaurant.
High social and negative emotions	Pictures show two or more agents, with emotional expressions, performing various actions within a social context.	Children waiting in line for the slide at a playground.
High social and positive emotions		A boy giving flowers to a woman.

short forms have 30 items each, where the children see four pictures on the computer screen, listen to the target word over the speaker simultaneously, and then respond by pointing to the picture they think best matches the spoken target. For three bilingual English/Tamil participants, English language dominance was confirmed with their parents.

Participants also completed a theory-of-mind (ToM) battery, consisting of seven play-based tasks (maximum score = 38) adapted from Steele et al. (2003) and Fisher and Happé (2005). These included tasks evaluating understanding of pretend (Kavanaugh et al. 1997), desire (Wellman and Woolley 1990), false belief (Wimmer and Perner 1983; Baron-Cohen et al. 1985), knowledge access (Fisher and Happé 2005; Pratt and Bryant 1990), and second-order false belief (Sullivan et al. 1994).

Behavioral Profile

Lastly, parents of all participants completed the *Social Responsiveness Survey* (SRS-2; Constantino 2012) and the *Strengths and Difficulties Questionnaire* (SDQ; Goodman 1997). The SRS-2 is a 65-item questionnaire, with a 4-point scale, rating the child's social awareness, social cognition, social communication, social motivation, and autistic mannerisms, as a measure of the presence and severity of ASD-related behaviors. It has excellent established reliability ($\alpha > 0.93$) and clinical validity (sensitivity of 0.77, specificity of 0.75). T-scores are reported ($M = 50$, $SD = 10$), with higher scores indicating more autistic traits. The SDQ has 25 items, with a 3-point scale. Ratings from four subscales covering hyperactivity, conduct problems, emotional symptoms and peer relationships are summed to provide a total difficulty score (range 0–60, higher scores indicate more difficulties). The SDQ has very good reported internal reliability ($\alpha = 0.82$; Goodman 2001) so it was used in this study to check for emotional problems that might have an effect on emotional processing.

Materials

The main experimental task comprised 48 black-and-white line drawings depicting children and/or adults in everyday scenes (see Appendix). These stimuli were selected from the Pictures with Social Context and Emotional Scenes (PiSCES) database (Teh et al. 2017), which was developed and normed on typically developing adults. There were eight pictures from each of six conditions varying on emotional (negative, neutral, or positive valence) and social (high or low engagement) information. Negatively- and positively-valenced pictures were matched on emotional intensity, but were predictably more intense than emotionally-neutral pictures. The scenes in the drawings ranged from single-person situations to groups of four people, in order to ensure the presence of social information, albeit to varying extents, in all pictures. Examples of the pictures in each category are described in Table 1.

The use of familiar everyday scenes of school or family life was considered important because social/motivational

theorists have suggested that children with ASD may lack exposure to a wide range of social experiences due to their diminished social motivation, and this could reduce their ability to process social and emotional information (Chevallier et al. 2012). The PiSCES pictures are relatively free from contextual details that would be irrelevant or non-essential for social and emotional interpretation. This is also important because the children with ASD might be distracted from emotional information due to possible attentional biases towards objects instead of people in scenes (Klin et al. 2002).

Procedure

Ethics approval was obtained from the National University of Singapore Institutional Review Board, and informed parental consent was obtained for all participants prior to recruitment into the study including consent for voice-recording of the experimental task, to facilitate subsequent transcription. Verbal assent was also obtained from the children before commencing the tasks. Children were tested individually by the researcher or a trained assistant in a quiet room. Most children completed the tasks over two sessions, with testing taking about 3 h for children with ASD and 2.5 h for typically developing children. The sequence of presentation of tasks was sometimes altered but generally the participants first completed the CPM or SPM, BLAB, theory-of-mind tasks, and CASL, before completing the experimental task. For participants in the ASD group, the ADOS was also administered in the first session.

For the experimental task, children viewed the picture stimuli on a laptop computer (Fig. 1). The picture was shown on the center of the screen, underneath the written task prompt, "What is happening in this picture?", which was also read aloud by the experimenter.

Pictures were presented one at a time, in randomized order. The task prompt was deliberately kept short and simple to avoid taxing participants' receptive language skills. There were six practice trials prior to the experimental trials using pictures that were not included among the experimental set, but with one picture drawn from each test condition. During the practice trials, participants were encouraged to answer in sentences and to say as much as they wanted to about the picture. However, during the test trials, no encouragement or guidance was provided. Following Siller et al. (2014), the experimenter only interrupted to request clarification of statements, such as when the participant used pronouns (e.g., *he, she*) without clear referents. When the child stopped talking, the experimenter gave a standard prompt question, "Anything else?" to check if the child had any further descriptions. This prompt sometimes yielded further information. When the child indicated, "No", the experimenter moved to the next picture. Pictures were presented in blocks of eight, and breaks were provided according to the child's needs. Most participants completed the experimental task in 15–20 min.

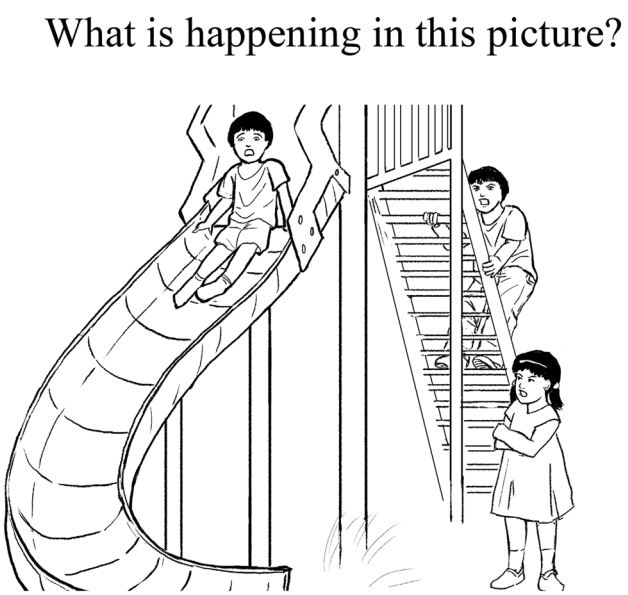

Fig. 1 Example of an experimental trial of the picture description task

Coding Protocol

Participants' responses were transcribed and subsequently coded for emotional terms following methods used in existing studies on emotional language in ASD (e.g., Rumpf et al. 2012; Siller et al. 2014). To facilitate this, a taxonomy of terms was produced from data collected in an earlier pilot study with 20 typically developing adults. In that study, spoken descriptive data were collected on the full set of pictures in the PiSCES database ($N = 203$, Teh et al. 2017) using the same experimental protocol. From this large dataset, emotional terms were first picked out by referring to empirically-derived emotion words in existing studies, namely those of Bretherton and Beeghly (1982), Shaver et al. (1987), and Tager-Flusberg (1992). Next, to glean further emotional terms from the collected data, all words (including inflections of stem-words) that connoted emotional states (e.g., *happy, sad, angry*), and emotionally-laden actions (e.g., *play, have fun, quarrel*), conditions (e.g., *hurt, in pain*), situations or events (e.g., *celebration, a fight*), were identified in the context of the sentence. This method follows qualitative methods for analyzing discourse data where the speakers' intentions and meanings are derived by interpreting data in context using inductive reasoning (Willig 2001). Two raters completed the coding analysis independently and achieved high agreement ($ICC = 0.98$) on emotional terms derived using this method. The few disagreements were then

Table 2 Sample characteristics

Variable	ASD ($n=20$) 18 males, 2 females		TD ($n=20$) 18 males, 2 females		t	p
Gender	M	(SD)	M	(SD)		
Chronological age (years)	8.10	(2.60)	8.12	(2.63)	−0.47	.65
SES	2.95	(1.05)	3.10	(0.91)	−0.59	.56
NVIQ	98.35	(13.07)	102.55	(15.16)	−1.04	.31
TOM	21.35	(6.52)	33.10	(2.85)	−6.98	< .001
CASL SS	75.35	(15.15)	108.40	(18.77)	−7.06	< .001
BLAB (English)	23.50	(5.40)	27.65	(1.96)	−3.71	.001
SRS total T-scores	69.16[a]	(11.00)	48.37[a]	(4.79)	7.70	< .001
SDQ	14.79	(5.87)	6.54	(5.03)	4.97	< .001

BLAB (*English*) Bilingual Language Assessment Battery (English version) raw scores, *CASL SS* standard score ($M=100$, $SD=15$), *NVIQ* nonverbal IQ ($M=100$, $SD=15$), *SDQ* Strengths and Difficulties Questionnaire (higher scores indicate more difficulties), *SES* social economic status indexed by housing type (1 = 1–3 bedroom flat, to 4 = private housing), *SRS* Social Responsiveness Scale (higher scores indicate more severe symptoms)

[a]$n=19$, one participant in each group did not return complete SRS form

resolved by discussion on items to be included/excluded from the final inventory. Additionally, following methods used in existing story-telling studies (e.g., Rumpf et al. 2012; Siller et al. 2014), the total number of words (tokens) produced were also counted; but unlike those studies, we did not count the number of utterances and propositions since our experiment generally elicited one utterance per picture.

Reliability

All participant responses were transcribed by the first author, and 25% of the sample were randomly selected and transcribed by a trained psychology undergraduate. An agreement of 99.2% was achieved (percentage of concordantly transcribed tokens). Next, all transcripts were coded by the first author for emotional terms, and 22 randomly-selected transcripts (55%) were independently coded by a second trained coder who was blind to participant group status. Inter-rater agreement was very high for coding of emotional terms ($ICC=0.99$) and total word counts (TWCs) ($ICC=1.0$).

Analyses

The dependent variable was the frequency of emotional terms produced by participants. To examine valence effects under negative/positive conditions, the difference in emotional terms produced in the positive and negative conditions from the neutral (control) was calculated for each condition, for each participant. Frequency of emotional terms was considered more appropriate than proportion of TWCs because we expected that shorter descriptions would generally be obtained for low-social pictures than high-social pictures due to less content in the stimuli. Mathematically, for the same number of emotional terms produced, a shorter sentence description would yield a higher proportion of emotional terms than a longer sentence description. Thus, the use of proportions in this study may inflate emotional terms calculated in the low-social conditions and underestimate production in the high-social conditions, thereby obscuring potential effects of social engagement on emotional processing. Paired t tests were used to verify the expected pattern of description lengths in the preliminary analysis.

Preliminary analyses using Pearson's r were also conducted to examine the correlations between individual variables and task outcomes. Finally, a $2\times2\times2\times2$ mixed-design ANOVA was used for the main analysis, with the within-subject factors being emotional valence (positive and negative valence) and social engagement (high and low), and the between-subject factors being age (younger and older) and participant group (ASD and TD).

Results

Sample Characteristics

Participants were matched pairwise on age, gender, NVIQ and SES (Table 2), and no significant group differences were found for these variables ($p>.05$). Consistent with other research, children with ASD scored significantly lower than typically developing (TD) children on measures of theory-of-mind and language (CASL and BLAB scores) skills, and were significantly more severe in parent-rated autistic and behavioral symptoms (SRS and SDQ scores). There were no significant correlations between participants' nonverbal IQ, severity of ASD symptom (SRS) or behavior (SDQ) scores, and the number of emotional terms produced (Table 3). For participants with ASD, only theory-of-mind and BLAB

Table 3 Correlations between participant variables and the frequency of emotional terms produced

	ASD *r*	TD *r*
Age	.43	.55*
Gender	.32	.38
SES	.18	−.45*
NVIQ	−.11	−.41
ToM	.54*	.10
CASL	.06	−.64**
BLAB English	.67**	.23
SRS	.23	.22
SDQ	.11	.06

BLAB Bilingual Language Assessment Battery, *CASL* Comprehensive Assessment of Spoken Language, *NVIQ* nonverbal IQ, *SES* socioeconomic status, *SDQ* Strengths and Difficulties Questionnaire, *SRS* Social Responsiveness Survey, *TOM* theory-of-mind test battery

*$p < .05$; **$p < .01$

(English) scores were significantly and positively associated with emotional terms. For the TD group, age and socioeconomic status were positively associated with emotional terms produced. Surprisingly, language scores (CASL) were negatively associated with emotional terms production; follow-up testing revealed that this may be due to the language scores being significantly higher in TD younger than TD older participants (*M*s 123.10 vs 93.70, $t(18) = 5.73$, $p < .001$). We also found that most TD participants attained nearly full scores on the ToM task, resulting in a problem of restricted range for statistical analyses. For this reason, ToM scores will not be considered further for the TD group. As there were no common participant variables that correlated significantly with emotional terms in both groups, participant variables were not included as covariates in subsequent analyses.[3]

Descriptive Statistics

The average number of emotional terms produced by the four groups in each experimental condition is presented in Table 4, while the mean difference scores (difference from neutral for each valence condition) are shown in Fig. 2.

The TWCs produced under high social engagement conditions were significantly greater than TWC under low social engagement conditions, for both the ASD group [$t(19) = 6.38$, $p < .001$] and the TD group [$t(19) = 13.18$, $p < .001$]. Thus, we decided to use frequency counts of emotional terms, as being more reflective of emotional language production than proportions of TWC, for all further analyses.

Main Analyses

The 4-way interaction of social engagement, valence, age, and group was not significant [$F(1, 36) = 0.46$, $p = .50$]. However, there were two 3-way interaction effects that approached or reached statistical significance: social engagement × valence × group (consistent with RQ1) and social engagement × age × group (consistent with RQ2).

Social Engagement × Valence × Group

The 3-way interaction of social engagement × valence × group was marginally significant, $F(1,36) = 3.85$, $p = .06$, $\eta^2_p = 0.10$. To examine this interaction further, the effects within participant groups were examined. In the ASD group, significant main effects of social engagement [$F(1,18) = 13.87$, $p < .01$, $\eta^2_p = 0.44$], and of valence [$F(1,18) = 8.41$, $p = .01$, $\eta^2_p = 0.32$], were qualified by a medium-sized 2-way interaction effect between social engagement and valence, $F(1,18) = 4.61$, $p < .05$, $\eta^2_p = 0.20$ (Fig. 3a). Specifically, in the low-social conditions, there was a marginally significant difference between negative and positive valence conditions (*M*s = 0.59 vs 0.48 respectively, $p = .09$, $d = 0.38$). Contrasting with this, in the high-social conditions, the frequency of emotional terms produced was significantly higher in the negative than in the positive valence conditions (*M*s = 0.50 vs 0.22 respectively, $p = .01$, $d = 0.73$). Descriptive means for both valence conditions were lower in high-social than low-social conditions. The results suggest that social engagement limits emotional language production in children with ASD, although these effects were attenuated in the negative valence condition.

In the TD group, significant main effects of social engagement [$F(1,18) = 9.72$, $p = .01$, $\eta^2_p = 0.35$] and valence [$F(1,18) = 5.03$, $p = .04$, $\eta^2_p = 0.22$] were similarly qualified by a significant 2-way interaction between social engagement and valence, $F(1,18) = 14.67$, $p < .001$, $\eta^2_p = 0.45$ (Fig. 3b). In the low-social conditions, there was no significant difference between negative and positive conditions (*M*s = 1.28 vs 1.33, $p = .60$). However, in high-social conditions, significantly more emotions were produced in negative than positive valence conditions (*M*s = 1.69 vs 1.29, $p < .001$, $d = 1.32$). In contrast to the pattern of findings for the ASD group, descriptive means were higher in high-social than low-social negative conditions for the TD group. The results suggest that social engagement did not limit emotional language production in the TD group, and in fact enhanced production in the negative condition (Fig. 3b). Thus, Hypothesis 1 was supported: children with ASD produced fewer emotional terms than typically developing children in all

[3] We did not statistically control for language and theory-of-mind skills by entering them as covariates in our analyses because the assumption of equal values of the covariates in all participant groups is not met in this sample (Schneider et al. 2015).

Table 4 Mean frequency of emotional terms produced by groups, per experimental condition

Groups	Low social/negative *M* (*SE*)	Low social/neutral *M* (*SE*)	Low social/positive *M* (*SE*)	High social/negative *M* (*SE*)	High social/neutral *M* (*SE*)	High social/positive *M* (*SE*)
ASD younger (*N* = 10)	0.50 (0.11)	0.05 (0.04)	0.28 (0.09)	0.43 (0.13)	0.09 (0.03)	0.15 (0.05)
ASD older (*N* = 10)	0.78 (0.11)	0.05 (0.03)	0.79 (0.11)	0.69 (0.15)	0.03 (0.02)	0.40 (0.09)
TD younger (*N* = 10)	1.28 (0.11)	0.06 (0.03)	1.34 (0.10)	1.60 (0.11)	0.13 (0.07)	1.23 (0.11)
TD older (*N* = 10)	1.44 (0.08)	0.10 (0.05)	1.49 (0.09)	2.03 (0.09)	0.12 (0.06)	1.59 (0.07)

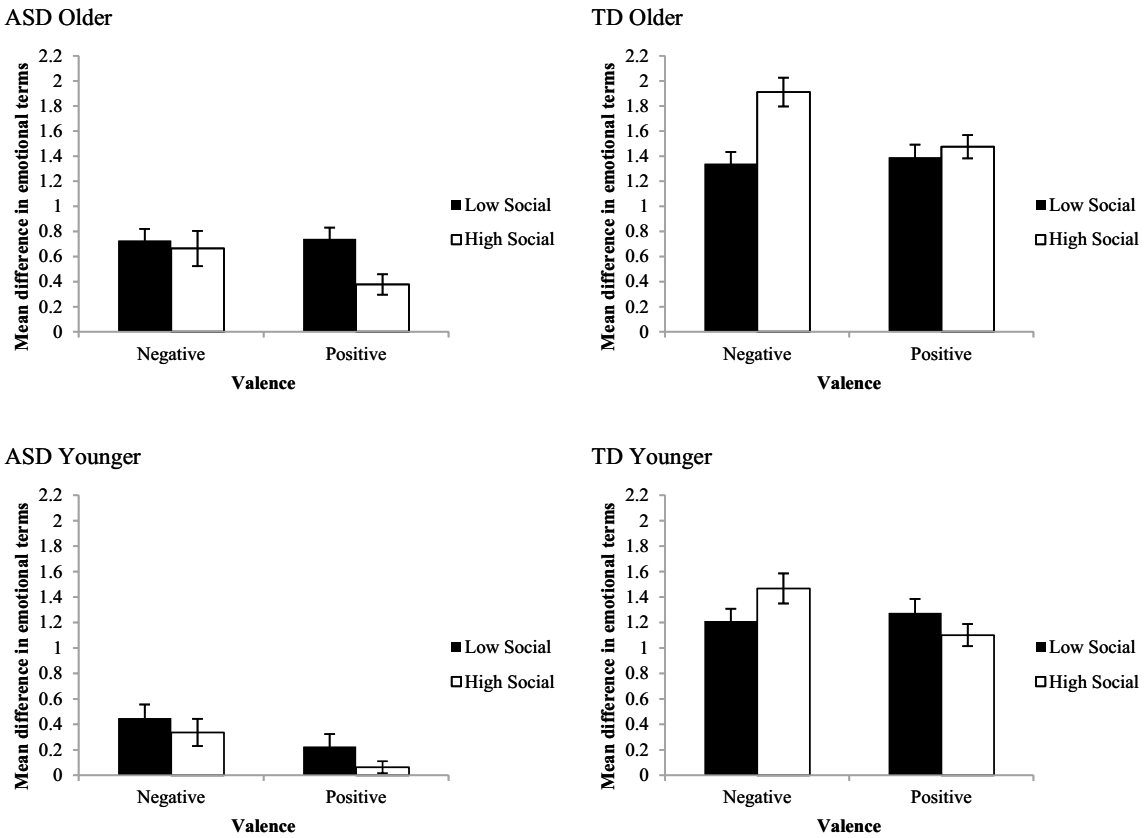

Fig. 2 Emotional terms produced by ASD and TD participant groups

emotional conditions, with greater group differences in high-social (especially in negative valence) than low-social conditions.

Social Engagement × Age × Group

As noted, the second significant 3-way interaction effect was social engagement × age × group, $F(1,36) = 5.78$, $p = .02$, $\eta^2_p = 0.14$. In the ASD group, significant main effects were found for both social engagement, $F(1,18) = 13.87$, $p < .01$, $\eta^2_p = 0.44$, and age, $F(1, 18) = 11.32$, $p < .01$, $\eta^2_p = 0.37$. There was no significant interaction effect between these two factors, $p = .44$ (Fig. 4a). Fewer emotional terms were produced in high-social than low-social conditions (*M*s 0.36 vs 0.54), consistent with the results for ASD reported above. Also, fewer emotional terms were produced by younger than older children with ASD (*M*s = 0.26 vs 0.63), suggesting the development of emotional language skills occurs over time in children with ASD.

In the TD group, significant main effects of social engagement [$F(1,18) = 9.72$, $p = .01$, $\eta^2_p = 0.35$], and age [$F(1,18) = 8.91$, $p = .01$, $\eta^2_p = 0.33$], were qualified by

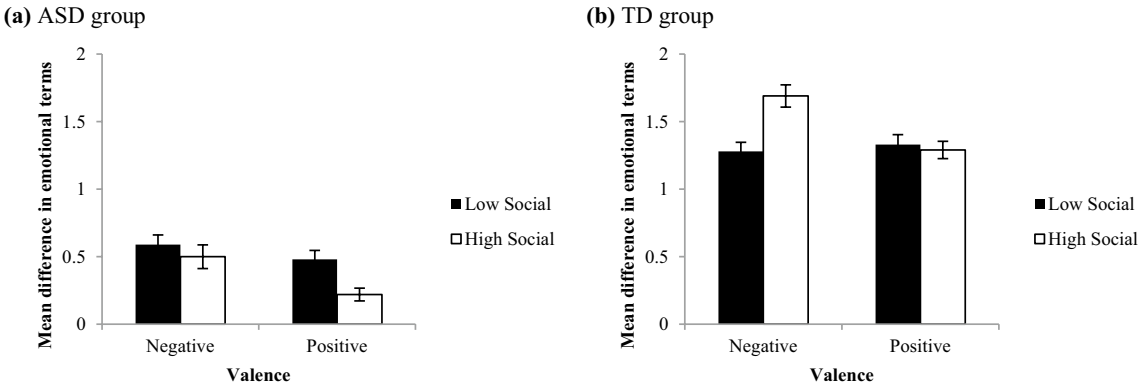

Fig. 3 Emotional language production, by valence conditions within social engagement levels

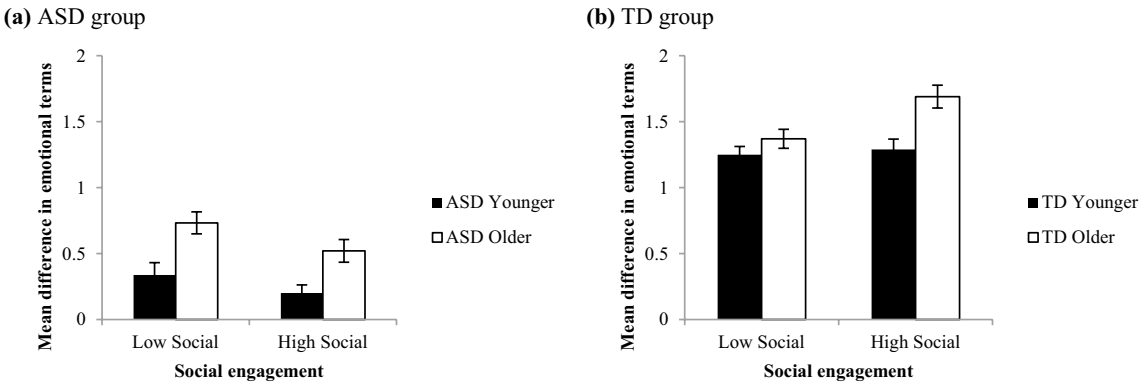

Fig. 4 Emotional language production, by age and social engagement conditions

an interaction effect between social engagement and age, $F(1,18) = 5.95$, $p = .03$, $\eta^2_p = 0.25$ (Fig. 4b). For older TD children, more emotional terms were produced in the high-social than low-social conditions (Ms = 1.69 vs 1.37, $p < .01$, $d = 0.75$), which is in contrast with the ASD groups where more emotional terms were produced in the low-social than high-social conditions. For younger TD children, there was no significant effect of social engagement ($p = .64$). Further, age effects in the TD group were significant in the high-social condition (Ms = 1.69 vs 1.28, $p < .001$, $d = 1.18$), but not in the low-social condition ($p = .22$), indicating greater development of emotional language production under high-social conditions only. In sum, Hypothesis 2 was also supported: Older children were able to produce more emotional terms than younger children, in both the ASD and the TD groups, but higher social engagement increased production only in the older TD group. For the children with ASD, consistent with the earlier analyses, higher social engagement reduced emotional terms produced in both younger and older groups.

Other Significant Effects From the main analyses, significant 2-way interactions were also found for social engagement × valence [$F(1,36) = 19.14$, $p < .001$, $\eta^2_p = 0.35$], and social engagement × group [$F(1,36) = 22.64$, $p < .001$, $\eta^2_p = 0.39$], together with main effects of group [$F(1,36) = 188.27$, $p < .001$, $\eta^2_p = 0.84$], valence [$F(1,36) = 12.91$, $p = .001$, $\eta^2_p = 0.26$], and age [$F(1,36) = 20.21$, $p < .001$, $\eta^2_p = 0.36$]. These effects were qualified by the two higher-order 3-way interaction effects reported above, except for the main effect of group that remained consistent in describing a pattern of deficit in ASD compared to TD in emotional language production (see Fig. 2).

Discussion

The aim of this study was to compare emotional language production by younger (5–6 years) and older (8–12 years) children with and without an ASD diagnosis using a social and emotional picture-processing task. The children with ASD were matched pairwise for age, gender,

socioeconomic status and non-verbal IQ (all > 70) to the typically developing children. Consistent with diagnostic status, the children with ASD scored significantly lower on measures of language and theory-of-mind, and significantly more severely in parent-rated autistic and behavioral symptoms. ToM scores were positively correlated with emotional terms in the ASD group, consistent with Siller et al. (2014), although this relationship could not be tested in the TD group. Both age-cohorts of children with ASD produced fewer emotional terms in their picture descriptions compared to the TD children for both positive and negative emotions. Valence effects were moderated by social engagement information, but in opposing directions for ASD and TD groups. As we predicted, in the ASD group, social engagement information limited the production of positive emotional terms, whereas in the TD group, social engagement information had no significant effect on production of positive emotional terms but enhanced production of negative emotional terms. These different patterns were observed despite high-social pictures generally eliciting more words overall than low-social pictures, indicating that increased overall output did not necessarily increase the likelihood of emotional terms being produced by children with ASD or typically developing children. Further, consistent with findings of age-based emotional development in the literature, the older children produced more emotional terms than the younger children in both groups. However, as we predicted, social engagement information enhanced the age effect in the TD children, but not in the children with ASD. This is the first cross-sectional study to empirically test the effects of social engagement and valence on emotional language production in children with ASD. The implications of the key findings for emotional processing skills in ASD and typical development will now be considered.

Social Engagement Moderates Emotional Language Production

Social engagement is a construct which refers to the degree of interaction in a context involving people, can be determined by the situation's setting, actions, or attributed relationships, and is separable from the emotionality of the situation (Teh et al. 2017). For this study, social and emotional variables were manipulated orthogonally in picture stimuli containing people and objects, and participants made free-response picture descriptions. One key finding from this study was that, like the typically developing children, participants with ASD generally made emotional judgments for positively- and negatively-valenced pictures but not in emotionally-neutral pictures. This was despite the fact that the experimental task did not explicitly require participants to comment on emotions in any pictures. According to theories of reduced social motivation in ASD (Chevallier et al. 2012), diagnosed individuals prefer to process non-human stimuli and avoid social stimuli such as people and faces in pictures. Thus, the present findings only partially support this theory, since children with ASD evidently showed some spontaneous processing of social/emotional cues to derive emotional judgments.

However, consistent with our prediction, the data suggest that increased social engagement generally reduces emotional language production in children with ASD. One probable explanation is that in high-social conditions, the combination of social and emotional information creates a cognitive-processing overload in children with ASD, which has an adverse impact on emotional language production. Minshew and Goldstein (1998) characterized ASD as a complex information-processing disorder, where simple cognitive-processing abilities appear intact but task performance declines with increasing number of elements contained in the stimulus material and/or multiplicity of cognitive processes involved. The authors further theorized that ASD-characteristic social communication impairments could be due, in part, to complex information-processing deficits, because social interactions typically involve lots of details. In the present study, information complexity was represented by increased number of cues available and/or multiplicity of processes required in the high-social/emotional conditions. This seems to have resulted in higher deficits in emotional terms used by children with ASD compared to typically developing children. The same cognitive-overloading is less likely to occur in typically developing children because social and emotional information are processed in an integrated way in the neurotypical brain (Olsson and Ochsner 2008). Thus, our TD participants displayed no reduction in emotional language production due to increased social engagement information, and rather showed increased production under negative valence conditions, bringing us to another finding with important theoretical implications.

Negative Valence Increases Emotional Language Production

The finding that both ASD and TD groups produced more emotions in negative than positive conditions is consistent with Rumpf et al.'s (2012) results using story narratives by ASD, ADHD and TD children. Both sets of data suggest that children with ASD and typically developing children display an attentional bias towards negative emotional information, which may be an adaptive, spontaneous response to threatening conditions (Balconi et al. 2012). Negative bias has also been demonstrated in emotion studies on normal adults: negative valence

enhances memory for pictures (Charles et al. 2003), speed of search-response and fixation time on pictures (Ohman et al. 2001), and physiological ERP responses when viewing pictures (Johansson et al. 2004). Thus, the results of the present study are consistent with other work suggesting that negative emotional stimuli tend to activate or capture more attentional resources than the perception of positive emotional stimuli. In addition, the novel manipulation of social engagement in the picture stimuli, makes it clear that negative situations with more people are likely to be more threatening than single-person situations. In other words, the heightened threat-awareness under high-social conditions in our study led to an increase in the production of negative emotional terms by the TD group. For the ASD group, increased production of negative terms in the high-social condition also served to attenuate emotion deficits due to social engagement.

Interestingly, studies using explicit emotional task designs of self-reports of past emotional experiences (e.g., Ben-Itzchak et al. 2016; Rieffe et al. 2007) and emotional matching/labeling paradigms (e.g., Brewer et al. 2017; Doody and Bull 2013) have reported poorer performance on negative than positive emotions in ASD. Rieffe et al. (2007) found that both children with ASD and typically developing children were less likely to report having experienced negative emotions, and they argued that this is because negative emotions are uncomfortable for children to re-live and report. One possible explanation for this inconsistency is that heightened threat-awareness and attention-capture by negatively-valenced stimuli, particularly in high-social situations, depends on the nature of the task. Describing negatively-valenced picture stimuli appears to facilitate the use of emotional terms in free-response picture-description tasks, whereas labeling negatively-valenced stimuli may interfere with accuracy of recognition and describing negative personal experiences might inhibit production of self-reports. Further work varying valence and social engagement across different paradigms is needed to better understand how these variables interact in emotional processing and language production.

Social-Cognitive and Emotional Processing Systems in ASD and Typical Development

This comparison of children with ASD and typically developing children also offers insights into the interplay between their underlying social-cognitive and emotional processing systems. In neurotypical adults, neuroimaging studies indicate that social and emotional areas of the brain are activated simultaneously when viewing social/emotional stimuli (Olsson and Ochsner 2008). Similarly for typically developing children, Lemerise and Arsenio's (2000) model proposes that incoming social and emotional information, together with background social knowledge and personal goals/motivations, are simultaneously processed. This interplay of processing skills develops in complexity with age and allows children to plan and regulate their behavioral responses towards others with increasing sophistication over time. As expected, social engagement effects were greater in older than younger TD participants, suggesting a closer interplay of social and emotional processes as children develop. Moreover, they performed no worse on the emotional task under high-social than low-social conditions, and even showed improved performance under negative valence conditions.

In contrast, for children with neurodevelopmental disorders, including ASD, Happé and Frith (2014) have theorized that the neural mechanisms for emotional processing and other social-cognitive components are potentially separable. Our results provide preliminary support for this account. The deficits in the production of emotional terms in children with ASD (compared to TD participants) increased with the extent of social engagement information in the pictures suggesting a separation in the processing of emotion and social information. Thus, for children with ASD, cognitive-overloading appears to develop whenever more social information-processing is required alongside the emotional processing system. Given that the same deficit pattern was observed in both the younger and older cohorts, it seems that the two systems remain dissociated over time in ASD. This model may also partially explain emerging reports of a unique pattern of greater emotional impairment in the context of social vs non-social/non-human stimuli in ASD (Begeer et al. 2008; Nuske et al. 2013). While more empirical work is needed to verify this account, the present findings raise some practical implications for future researchers and clinicians.

Applications for Research and Intervention

The extent of social engagement in picture stimuli appears to have an impact on emotional language production in children with ASD, as well as the valence of emotional cues presented, so both variables warrant consideration at the design stage. Extant findings in the literature have often been based on experimental stimuli that contained both social and emotional components (Lartseva et al. 2015), and may require revision. Further, we suggest that clinicians consider the extent of social engagement information in pictures when assessing or training emotional processing skills in children with ASD. For example, intervention programs could start with stimuli involving lower social engagement in order to limit the demands on cognitive processing, and then the extent of social information presented could be stepped-up as emotional-processing abilities improve.

Limitations and Future Directions

The present study is part of a wider project on social and emotional processing in ASD. Moving forward, we plan to examine the production of social terms in the various valence/social engagement conditions, to test if there are corresponding effects of emotional information on social-information processing in ASD. The findings may then shed more light on whether/how emotional and social processing systems may be separable and additive in ASD. However, there are at least three unresolved issues worthy of further experimentation.

First, in this study we used an open-ended stimulus question, "What is happening in this picture?" so that we could compare spontaneous emotional language use, as an index of spontaneous emotional-processing abilities in social situations, in children with ASD and typically developing children. However, it is possible that some participants with ASD sometimes made emotional judgments but failed to prioritize producing the corresponding terms when they were describing the pictures. Begeer et al. (2008) highlighted that emotional judgments may approach normative levels when explicit verbal instructions are given to children with ASD. Future work using an explicit elicitation paradigm is needed to clarify emotional-processing abilities in ASD under varying valence and social engagement conditions.

Second, while we found production of some complex emotional terms (e.g., *disappointed, proud, nervous*), the majority of emotions produced by both groups were basic emotional terms (e.g., *happy, sad, angry*). Complex emotions require global-processing of cues including consideration of others' perspectives or social relationships, while basic emotions can often be derived from surface cues like facial expressions (Izard 1992; Lazarus 1982). It may be that our sample was too young to produce complex emotional terms in the absence of explicit instructions to do so. Thus the emotional terms produced did not unambiguously demonstrate global-processing skills by participants, and our present study is unable to comment on weak central coherence theory, which claims that people with ASD tend to use a feature-specific rather than global-based style of cognitive processing (Happé and Frith 2006). Future researchers could address some of these limitations by asking participants to give reasons for their emotional judgments in order to investigate social/contextual or mental-state attributions made by children with ASD.

Further, our findings are relevant to children with ASD with higher cognitive skills and should be verified for those with lower cognitive abilities, as researchers have reported significant differences in emotion recognition in children with ASD with lower and higher cognitive skills ASD (Begeer et al. 2008). Finally, although our sample size was comparable to those in other narrative studies involving children with ASD (e.g., Kauschke et al. 2016; Rumpf et al. 2012), group sizes were small when divided into age and diagnostic groups ($n = 10$ per cell). Thus, we recommend that our findings should be verified with a larger sample. In particular, our preliminary findings on the interaction effect of age, social engagement, and diagnosis on emotional language use was interesting. Begeer et al. (2008) commented that age effects are generally not well researched in the ASD emotional literature, and we support their call for more longitudinal studies to better understand emotional development trajectories in ASD.

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Author Contributions All authors conceptualized and designed the study. EJT coordinated the collection of the data, performed the statistical analyses, and drafted the manuscript; MJY and SJRL provided feedback on the manuscript. All authors read and approved the final manuscript.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interests.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from parents of all individual child participants included in the study, and verbal consent was obtained from all individual child participants included in the study.

Appendix

List of Stimulus Pictures

See Table 5.

Table 5 The picture numbers below refer to numbering in the PiSCES Database (Teh et al. 2017)

Picture no.	Picture description
Low social engagement—negative valence	
1	Woman crying while reading a letter
2	Boy looking at an empty dog basket
4	Child fell down the stairs and broke her glasses
21	Boy frowning at his food
22	Boy drops icecream
23	Girl sitting at table, looking at her homework
32	Boy stuck at the top of a ladder
37	Boy spilled water on his work
Low social engagement—neutral valence	
70	Boy pulling a heavy object
104	Girl playing the piano
106	Girl reading using a torchlight
112	Man pointing a rifle
122	Girl painting a picture
125	Man running
127	Boy blowing a balloon
131	Man swimming in the sea
Low social engagement—positive valence	
147	Boy using a computer
157	Girl holding an umbrella in the rain
160	Boy riding on a toy car
169	Girl holding up a fish on a fishing-rod
170	Girl going down a slide
172	Girl playing in a rain puddle
175	Girl playing with a toy aeroplane
193	Girl holding a test paper with 'A' grade
High social engagement—negative valence	
17	Girl fell before school bus
28	Children standing in line for the slide at a playground
30	Girl sitting alone, while two other girls are chatting behind her
35	Child doing housework, while another girl listens to music
41	People sending off a girl at the airport
44	Woman looking at boy, who has spilled his drink on the table
48	Two girls picking up books and stationery from the floor
52	Two girls trying to complete a puzzle
High social engagement—neutral valence	
65	Man driving with passenger in a taxi
76	Woman examining a child with a stethoscope
87	Girl with hairdresser, getting a haircut
88	Waitress taking an order from two people seated at a table
93	People ordering food at a fastfood counter
103	Man and a child trying on shoes
111	Woman dressing a child
118	Man holding shopping bags and a boy looking at him
High social engagement—positive valence	
149	Two girls and a boy writing in books
152	Woman standing at the door while a boy is working at a table
158	Children doing clay art together
162	Woman waving to man walking past her

Table 5 (continued)

Picture no.	Picture description
180	Woman lifting up a baby
182	Woman and child reading together
184	Boy giving flowers to a woman
195	Boy receiving an award from a woman

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