J Abnorm Child Psychol (2018) 46:1111–1120
DOI 10.1007/s10802-017-0351-0

I Think We're Alone Now: Solitary Social Behaviors in Adolescents with Autism Spectrum Disorder

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Published online: 10 October 2017

Abstract Research into emotional responsiveness in Autism Spectrum Disorder (ASD) has yielded mixed findings. Some studies report uniform, flat and emotionless expressions in ASD; others describe highly variable expressions that are as or even more intense than those of typically developing (TD) individuals. Variability in findings is likely due to differences in study design: some studies have examined posed (i.e., not spontaneous expressions) and others have examined spontaneous expressions in social contexts, during which individuals with ASD—by nature of the disorder—are likely to behave differently than their TD peers. To determine whether (and how) spontaneous facial expressions and other emotional responses are different from TD individuals, we video-recorded the spontaneous responses of children and adolescents with and without ASD (between the ages of 10 and 17 years) as they watched emotionally evocative videos in a non-social context. Researchers coded facial expressions for intensity, and noted the presence of laughter and other responsive vocalizations. Adolescents with ASD displayed more intense, frequent and varied spontaneous facial expressions than their TD peers. They also produced significantly more emotional vocalizations, including laughter. Individuals with ASD may display their emotions more frequently and more intensely than TD individuals when they are unencumbered by social pressure. Differences in the interpretation of the social setting and/or understanding of emotional display rules may also contribute to differences in emotional behaviors between groups.

Keywords ASD · Affect/emotion · Social context · Facial expressions · Laughter · Display rules

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In all cultures, facial and vocal (e.g., laughter) expressions reflect internal states (Eisner et al. 2015; Ekman 2004), and some expressions are universal (Ekman and Friesen 1971). However, social context and display rules dictate how and if expressions are modulated (Rinn 1984; Robbins and Vandree 2009; Ruch and Ekman 2001; Smoski and Bachorowski 2003). Display rules depend on individual factors, including one's gender, cultural background and status, and on features of the context during which emotions are displayed (Buck et al. 1992; Matsumoto et al. 1998; Matsumoto et al. 2008; Safdar et al. 2009; Zeman and Garber 1996). These rules mandate the manipulation of emotional responses even in situations only imagined to be social. For example, studies have shown that people are more emotive when they believe there is a social element to a solitary activity, such as when they watch a video and are told somebody else is watching it, too (Fridlund et al. 1991). Socially modulated variances are distinguished not only by differences in display, but also by the neural regions mediating them; involuntary facial expressions originate from subcortical regions, while socially modulated expressions involve cortical networks used in verbal communication (Rinn 1984). Similarly, involuntary, genuine laughter originates in subcortical regions, while the production of voluntary social laughter and the socially motivated suppression of involuntary laughter are regulated by cortical regions involved in language production (Bryant and Aktipis 2014; Scott et al. 2015). In summary, involuntary emotional reactions are distinct in neural sources and surface presentation from those evoked in social contexts.

Research findings conflict on how measurable responses of expressiveness, i.e. facial expressions and laughter, differ in individuals with ASD as compared to TD individuals (Begeer et al. 2008): Many describe them as more uniform and flat than those of TD individuals' (Kanner 1943; Kasari et al. 1990; Kasari et al. 1993; Rozga et al. 2013; Stagg et al. 2014; Stel et al. 2008; Yirmiya et al. 1989); while some recent studies assert the opposite— at least as much variability and intensity in the emotional expressions of individuals with ASD as compared to TD individuals, and sometimes even greater variability and intensity (Faso et al. 2015; Grossman et al. 2013). These mixed findings likely stem from numerous factors, including differences between participant populations (age, autism severity, etc.) and task design. Focusing on the latter factor, there are variations in the methods by which researchers have elicited facial expressions and other emotional behaviors in adults and children with ASD (See review in Begeer et al. 2008). Many examine posed/mimicked expressions in non-social contexts (e.g., Grossman et al. 2013; McIntosh et al. 2006; Yoshimura et al. 2015), even though posed expressions have been shown to be different from naturally evoked expressions in TD populations (Namba et al. 2016). Other studies have examined spontaneous expressions evoked in social contexts (e.g., Kasari et al. 1990, 1993; Yirmiya et al. 1989), and have generally found participants' emotional behaviors to be less expressive than TD individuals. Since ASD is characterized by pervasive social impairment (American Psychiatric Association, 2013), it is perhaps not surprising that the details of social context may influence the expressions of many individuals with ASD and that social interaction overall may not be conducive to generating emotional expressiveness in this population. In fact, Faso et al. (2015) directly compared facial expressions in the two conditions (i.e., non-social, posed expressions versus spontaneously evoked expressions in a semi-social setting), and found that posed/mimicked expressions were significantly more intense than those that were evoked during an interaction with another person.

Because individuals with ASD show particular deficits in social communication (American Psychiatric Association, 2013), it is probable that the majority of individuals with ASD struggle to follow display rules to appropriately modulate emotional behaviors in social contexts (Barbaro and Dissanayake 2007; Begeer et al. 2011). This is further supported by evidence that some individuals with ASD don't modulate spontaneous laughter for social purposes (Hudenko et al. 2009). The involuntary, non-social expressions of individuals with ASD may be relatively unimpaired, but it is difficult to know whether this is true since previous studies have mostly examined naturally evoked expressions in social settings or posed expressions in non-social settings, but not naturally evoked expressions in *non*-social settings. Trevisan, Bowering, and Birmingham (2016) used an unusual, semi-social context to evoke facial expressions. They showed video stimuli to children with and without ASD in groups of four: Each child watched videos on his own computer monitor, with a cardboard partition separating each child. Despite a trend for children with ASD to be less responsive, they found no significant difference in responsiveness between groups. To explore the possibility that spontaneous, non-social expressions are unimpaired in ASD, we compared the spontaneous behaviors of adolescents with and without ASD in a context designed to be non-social and non-interactive. Participants watched emotion-inducing videos without a social partner. We hypothesized that ASD and TD participants would show similar facial and vocal expressiveness in this spontaneous, non-interactive task. This result would contribute significantly to the literature by showing that the spontaneous emotional expressions of individuals with ASD may be unimpaired, and that previous reports of atypical emotional responsiveness in this population might be accounted for by different/deficient display-rule understanding.

Methods

Participants Participants were recruited via online postings, print ads, and word of mouth. We conducted a power analysis on the first set of five participants in each group, which showed that differences between proportions of behaviors were large enough that eight participants in each group would be sufficient for detecting group differences with a margin of error at a 95% confidence interval and a degree of variability at 80%. Written, informed consent was obtained for 2 groups: 20 children and adolescents with ASD (17 males, M = 13;7 yrs., SD = 2;0) and 20 TD children and adolescents (13 males, M = 12;8 yrs., SD = 2;0). Additional informed consent was obtained from all individual participants for whom identifying information is included in this article (i.e., in Fig. 1). Based on our power analysis, this cohort size was determined to be more than sufficient to determine group differences and rule out that null findings were based on lack of power rather than a true lack of differences between groups. Participants were only included if their IQ and language scores fell within normal ranges. IQ was measured by the

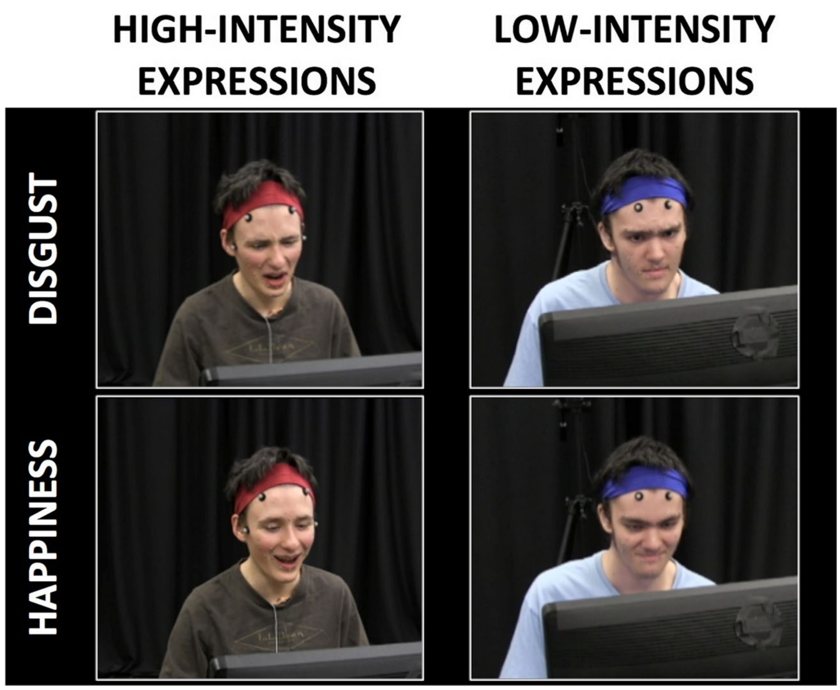

Fig. 1 Participants' facial expression were coded for three levels of expressiveness- high, low, none. Left: A high- intensity expressive participant making a disgusted face (top) and a happy face (bottom); Right: A low-intensity expresser making a disgusted face (top) and a happy face (bottom). Reflective markers on participants' faces were used to record motion capture during the experiment. Motion capture results are not discussed in the current paper. Additional informed consent was obtained from participants whose photographs are included

Kaufman Brief Intelligence Test, 2nd Edition (KBIT-2: Kaufman and Kaufman 2004) and language abilities were measured by the core language subtests of the Clinical Evaluations of Language Fundamentals, 4th Edition (CELF-4: Semel et al. 2003). Groups did not significantly differ on IQ (ASD M = 115, TD M = 109, p = 0.31), language abilities (ASD M = 108, TD M = 112, p = 0.46), age (p = 0.17), or gender (p = 0.27). Participants in the ASD group were only included if they had previously received an ASD diagnosis, and if their diagnosis was confirmed in the lab. To confirm their diagnosis, a qualified, research-reliable administrator administered the ADOS-2 Module 3 or 4, as appropriate for each participant's age (Lord et al. 2012); participants were included in the current study only when their scores met diagnostic criteria on the ADOS-2 algorithm. Participants in the TD cohort had no reported social communication deficits and scored below the threshold for clinical significance on the Social Communication Questionnaire - Lifetime (SCQ-Lifetime, Rutter et al. 2003). See Table 1 for descriptive statistics.

Experimental Procedure The current paradigm was approved by the Institutional Review Board of Emerson College, and was part of a larger set of studies to explore social, communicative, and emotional behaviors in adolescents with ASD. Participants were in the lab for approximately two hours completing several computer-based studies, including watching videos of short narratives, telling a short story, and providing their perception of short video clips of individuals with and without ASD. After the completion of these studies, a member of the research staff told participants that researchers needed time to set up equipment for subsequent studies, and that participants would watch YouTube video-clips to keep themselves entertained in the interim. The videos began playing on the computer monitor in front of the participant. Because of existing evidence that the visible presence of a researcher can affect children's behavior (Capps et al. 1993), researchers retreated behind a partition in the room, hidden from view and participants were told that researchers were occupied with a separate activity. Thus, researchers did not interact with participants and were not visible during the activity.

Participants watched twenty-six YouTube clips with a total running time of 4 min and 30 s. We concatenated all video clips into a continuous sequence and presented them in the same order for all participants, with the audio played through external Logitech speakers. Participant behaviors were recorded on a high definition video camera (Canon Vixia H5M 500) positioned in front of the participant. The room where participants completed this task contains several cameras, including six motion cameras, a high definition camera, and several webcams. Several of the other tasks completed by participants during these sessions required them to explicitly produce facial expressions in front of the six motion capture cameras. Participants wore headbands so that markers on their faces were visible to the motion capture cameras during these tasks; we explained this to participants prior to those tasks. The motion capture cameras were turned on and off throughout the session, depending on the task, but the high definition camera stayed on during the entire session. The video-watching task described here was introduced to participants as a break, with no explicit task instructions, in contrast to the other tasks they completed. It also occurred approximately

Table 1 Descriptive statistics for participants' ages and sex, along with scores on the K-BIT, CELF, and SCQ-Lifetime. ADOS-2 Comparison Scores are shown for Module 3. For Module 4 Scores, standardized Severity Scores (Hus and Lord 2014) are provided

Measure	ASD	TD	Test Statistic	p	Effect Size
Age	13;7 (2;0)	12;8 (2;0)	$t(1,38) = 1.41$	0.17	$d = 0.45$
K-BIT	114.8 (20.7)	109 (14)	$t(1,38) = 1.04$	0.31	$d = 0.33$
CELF	108.4 (19.9)	112.6 (14.9)	$t(1,38) = 0.76$	0.45	$d = 0.24$
SCQ-Lifetime	17.6 (6.9)	2.3 (1.4)	$t(1,38) = 9.71$	<0.001	$d = 3.07$
ADOS-2 Module 3	6.5 (1.5)	NA	NA	NA	NA
ADO2–2 Module 4	7.0 (1.3)	NA	NA	NA	NA
Sex	3 F; 17 M	7 F; 13 M	$X^2 = 1.2$	0.27	$\varphi_c = 0.03$

mid-way through their time in the lab, meaning that participants had habituated to the high definition camera, which was never explicitly pointed out to them or turned off and on in their presence.

After the video sequence ended, a research staff member appeared from behind the partition and engaged the participants in a brief conversation about the videos (e.g.," Which was your favorite?", "Did you think any of them were gross?") to ensure that participants had attended to the videos. All participants were able to accurately describe the videos they had seen. To further gauge attention, we used eye tracking to determine the percent of time the participants' gaze was captured by the eye tracker and directed at the computer monitor (tracking ratio). The tracking ratios for thirty out of forty participants were at least 75%, suggesting that their eye gaze was fixed to the computer monitor for the majority of the video-watching activity. For nine of the participants with ASD and one TD participant, tracking ratios were below 75%. In order to ensure that participants with low tracking ratios were attending to the videos, researchers watched the videos of all participants and confirmed that all of them kept their gaze fixed to the screen while the stimulus videos were presented. Based on close viewing of the videos of participants, we determined that low tracking ratios for these ten participants were caused by the participant shifting in their seat after eye-tracking calibration values were obtained and/or moving throughout the activity (e.g., briefly turning away from disgusting scenes), which prevented the eye-tracker from consistently locating their eyes. Some of the participants with poor tracking ratios wore glasses, which also made it more difficult for the eye-tracker to capture their gaze. Based on our video analysis of each participant's behavior, the content of the conversation participants had with researchers about the videos after the conclusion of the task, and the very vivid and engaging nature of the videos themselves, we are confident that all participants included in this analysis were paying attention to the videos throughout the task.

Stimulus Videos We elected to use YouTube videos as stimuli, since these are common sources of entertainment for children and adolescents. Trevisan et al. (2016) used clips from animated movies, and found that they did not reliably yield either disgusted or surprised facial expressions. We therefore selected brief and very evocative YouTube videos to arouse emotions, focusing on joy/amusement, disgust and surprise. We could not determine videos that reliably evoked anger and we excluded fear-inducing videos due to ethical considerations. We selected 64 YouTube videos that we predicted would elicit smiles, laughter, disgust, and/or surprise in children and adolescents. To select the final stimulus videos, we presented all 64 clips to four TD children/adolescents, and video-taped their reactions. A group of researchers not involved in the analysis presented here determined that 26 of the original 64 videos evoked spontaneous facial and vocal responses in all four children. These 26 videos were therefore selected for the study. We clipped extraneous content from the videos in Adobe Premier so that they contained only the scenes that had elicited expressions from the pilot group of children. Four of the 26 final video clips were selected to elicit disgusted expressions (e.g., a woman eating a spider), seven to elicit positive affect (e.g., a kitten being tickled), one a surprised expression (a man catching a football through a wall), and fourteen a combination of surprise and positive affect, including laughter (e.g., a sleeping dog running into a wall while dreaming). These edited clips ranged from 6 to 30 s in length, and were exported as a single, continuous video from Adobe Premier. Audio was normalized across all videos using Adobe Audition and edited to minimize background noise.

Response Coding To determine the overall responsiveness of participants to these videos, we developed codes to capture the: 1) intensity of facial expressions; 2) the occurrence of laughter; 3) the occurrence of other vocalizations. We decided to measure proportions of behaviors (e.g., whether participants did or did not laugh) to capture the overall differences in responsiveness between groups during this simple, spontaneous task. We coded the full four-minute-long video recording of each participant's reactions as they watched the YouTube clips. Two researchers, who were blind to participant diagnosis, watched each video and completed coding of the videos independently of one another. These two coders were trained on a sample set of 10 videos. Inter-rater reliability, as calculated by Cohen's Kappa, was satisfactory for all three codes (κ = 0.88 for Facial Expressiveness, κ = 0.81 for

Laughter, and κ = 0.81 for Vocalizations,). A third member of the research staff watched the videos and resolved the remaining coding disagreements ($N = 5$). Final code assignments reflect the majority opinion of the three coders.

Even though coders were blind to diagnosis, it is possible that they attempted to use participant behaviors to determine diagnosis. We therefore specifically instructed coders to try not to guess at participant diagnosis. We did not evaluate the blindedness of our coders, but previous research shows that naïve coders are not always accurate at deriving ASD-specific characteristics, such as social awkwardness, from videos of adolescents with ASD (Grossman 2015), indicating that there likely was no systemic bias introduced into the data even if a coder had attempted to "diagnose" participants based on these short video clips.

Facial Expressiveness We quantified each child's level of facial expressiveness to the video clips on a three-level scale: High, low, and non-expressive. This code captured the intensity of the facial expressions occurring across the majority of the full length of the video presentation. Participants were considered highly expressive if they exhibited energetic, sustained facial expressions that showed clear facial feature muscle movement (e.g., eyebrows raised, tongue out, mouth open wide vertically/laterally, etc.). Participants who showed fleeting facial expressions with little intensity were coded as low expressers (See Fig. 1). Non-expressers were participants who exhibited no discernable facial expressions, or whose facial movements were not emotive (e.g., sneezing, blinking). Participants were still considered non-expressive when they exhibited brief (i.e., lasting a fraction of a second) stifled, inaudible laughter, but showed no other facial expressions. Only one participant exhibited this behavior.

Laughter We assigned each participant a binary code for the presence or absence of laughter. Presence was coded for all laughter, ranging from unconstrained and highly audible to inaudible and partially suppressed, made evident by a brief nasal exhalation and/or shaking shoulders. The laughter code was independent of the facial expressiveness code, so that coders indicated whether a participant had laughed regardless of the participant's overall level of responsiveness.

Vocalizations Like laughter, vocalizations were quantified via a binary (presence/absence) code.

Presence of vocalization was defined by speaking out loud in response to the videos. Vocalizations that were not in response to the videos – e.g., "Can I go to the bathroom after this?" – were not included in this code, along with vocalizations that were not language-based (such as coughs, or gasps). Like laughter, this category was distinct from facial expressiveness coding, and coders watched the participants' mouths while listening for vocalizations in order to observe vocalizations at any level of facial expressiveness. Vocalizations were coded as present regardless of the quality, length, or audibility, and ranged from exclamations to whispers, and from full sentences to single-word utterances.

Responsiveness We also created a code that determined the variety of overall responsiveness between groups. To do this, we combined the codes for facial expressions, laughter and vocalizations. Participants who exhibited all of these behaviors were described as very responsive, those who produced at least one of these behaviors were somewhat responsive, and those who exhibited no behaviors were not responsive.

Analysis To determine whether there were group differences between the TD and ASD cohorts for each code, we compared the frequencies of participants who fell into each coding category (facial expressiveness, laughter, vocalization, and responsiveness) across diagnostic groups. Based on the sample size and data type, we used Fisher's exact tests to compare proportions. All analyses were performed in R-Studio using the gmodels package (Warnes et al. 2013).

Results

When watching emotion-inducing videos, 100% of adolescents with ASD produced facial expressions, 55% of which were highly intense/variable expressions. In contrast, 35% of TD participants displayed no discernable facial expressions at all, and only one TD participant's facial expressions were highly expressive, $p < 0.001$, w = 0.63 (Table 2). Vocal expressions within each group patterned similarly: 100% of participants with ASD laughed, while only 50% of TD participants did, $p < 0.001$, 95% C.I. [3.4,∞], w = 0.58; 79% of the ASD cohort vocalized in response to the videos, but only 20% of the TD group did, $p < 0.01$, 95% C.I. [2.24, 70.43], w = 0.55 (Fig. 2).

We also analyze general responsiveness by consolidating codes for facial expressions, laughter and vocalizations (see *Responsiveness* code in Methods section). Participants who exhibited all three behaviors were described as very responsive, those who produced one or two behavior types were somewhat responsive, and those who exhibited no behaviors were not responsive. All participants with ASD were responsive: 75% were very responsive; 25% were somewhat responsive, and 0% were not responsive. Among the TD cohort, 20% were very responsive, 50% were somewhat responsive, and 30% were not responsive, $p < 0.001$, w = 0.59.

Overall, results show that adolescents with ASD produced a variety of spontaneous emotional responses in this non-interactive context. All participants with ASD produced facial expressions, and a slight majority was highly expressive. All participants with ASD also laughed and 75% of them

Table 2 More participants with ASD produced intense/variable facial expressions, laughed, and vocalized in response to the videos. Table shows number and proportion of participants within group and at each level of each coding category

	TD	ASD	Total
Expressiveness Level			
No Expressions	7	0	7
Proportion in category	100.00%	0.00%	17.50%
Proportion in group	35.00%	0.00%	
Low Expressiveness	12	9	21
Proportion in category	57.14%	42.86%	52.50%
Proportion in group	60.00%	45.00%	
High Expressiveness	1	11	12
Proportion in category	8.33%	91.67%	30.00%
Proportion in group	5.00%	55.00%	
Presence of Laughter			
No Laughter	10	0	10
Proportion in category	100.00%	0.00%	25.00%
Proportion in group	50.00%	0.00%	
Laughter	10	20	30
Proportion in category	33.33%	66.67%	75.00%
Proportion in group	50.00%	100.00%	
Presence of Other Vocalizations			
No Vocalizations	16	5	21
Proportion in category	76.19%	23.81%	52.50%
Proportion in group	80.00%	25.00%	
Vocalizations	4	15	19
Proportion in category	21.05%	78.95%	47.50%
Proportion in group	20.00%	75.00%	

produced all three responses (facial expressions, laughter, and other vocalizations). These results suggest that adolescents with ASD exhibit their emotions clearly and even to a higher degree than TD adolescents in this non-interactive and relatively non-social situation Fig. 3.

Discussion

We predicted adolescents with ASD would display spontaneous emotional behaviors that were similar to those of TD adolescents. Findings did not support this prediction. In comparison to TD participants, the ASD group was significantly more responsive, suggesting fundamental differences in the presentation of spontaneous emotional behaviors between groups in a context that was designed to be non-social and non-interactive. Our data clearly show that even simplistic measures of global responsiveness (e.g., whether the participant did or did not laugh) across the video-watching activity were enough to capture highly significant differences in behaviors between participant groups.

To understand these data, we propose that responses of TD participants were socially modulated, despite our intentions to create a non-social context and despite the fact that the context was non-interactive. Display rules dictate that individuals dampen facial expressions and laughter when they are socially inappropriate (Hochschild 1979). Studies have shown that TD children will inhibit emotional responsiveness when researchers are present (Capps et al. 1993; Yarczower and Daruns 1982), or in the proximity of any stranger, even when that stranger cannot see them (Buck et al. 1992; Kraut 1982). Although researchers in our study did not explicitly say where they would be while the videos played, participants were surely aware that researchers were behind the partition (rather than outside the room entirely). Additionally, there were several cameras present in the room while participants watched videos, which may have reminded participants that their behaviors could be observed and recorded. As a result, TD participants likely suppressed emotional expressiveness, which could explain the reduced amount of laughter and vocalizations in this group. Relatively few TD participants laughed and even fewer produced other vocal responses to the videos, despite the fact that video clips were highly evocative in pilot testing. Our current coding system did not differentiate

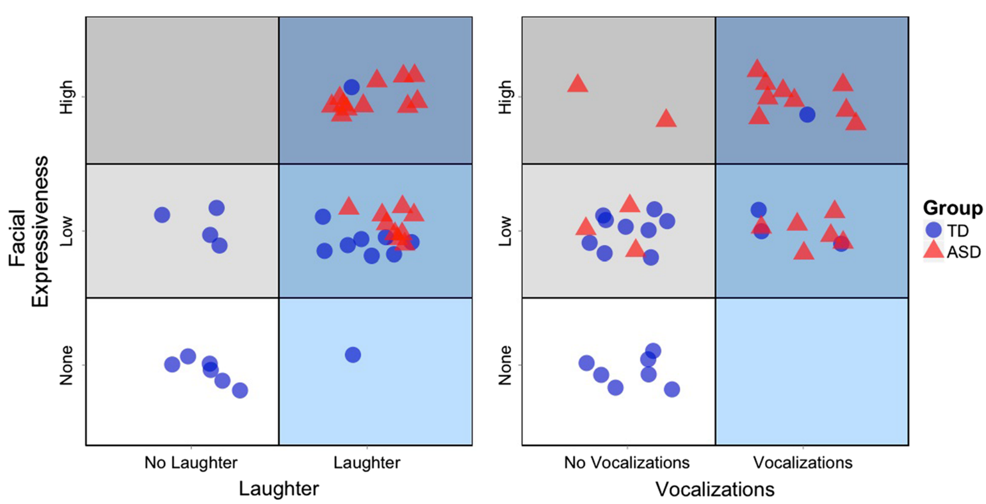

Fig. 2 More participants with ASD produced intense/variable facial expressions, laughed, and vocalized in response to the videos. (a) Left: Number of participants in each group (TD and ASD) who laughed at each level of facial expressiveness (None, Low, High). (b) Right: Number of participants in each group (TD and ASD) who vocalized at each level of facial expressiveness (None, Low, High)

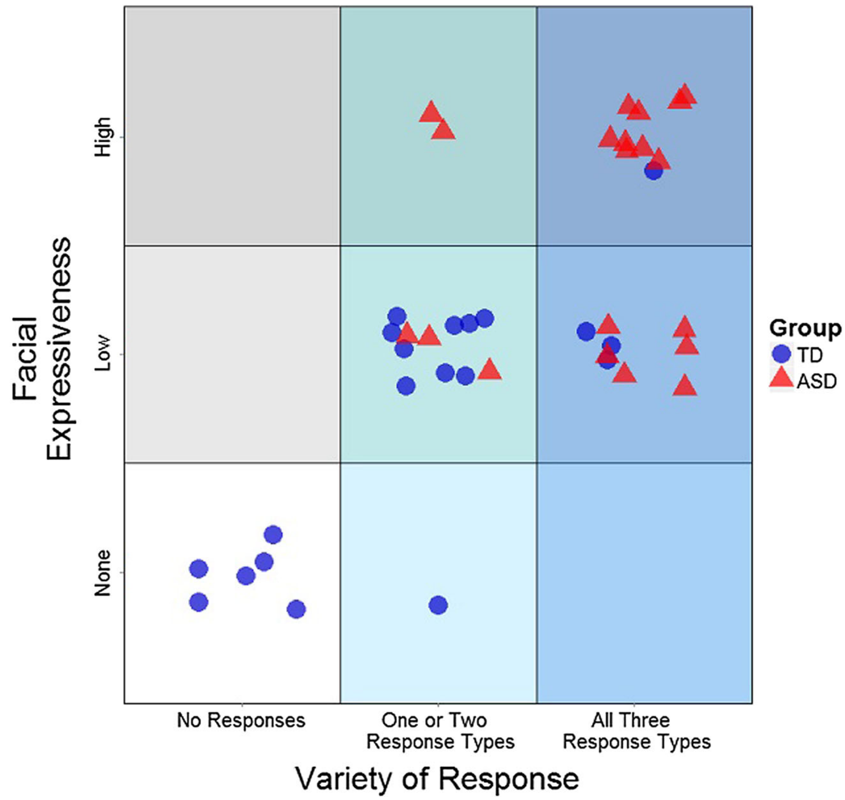

Fig. 3 More participants with ASD produced all three types of emotional behaviors (facial expressions, laughter and other vocal responses). Figure displays number of participants in each group (TD, ASD) who displayed none, one or two, or three types of responses at each level of facial expressiveness (None, Low, High)

between inaudible and audible laughter, which could provide more information on whether either group was suppressing spontaneous responses. Follow-up studies should explore this possibility with more fine-grained coding. Still, the overall paucity of vocal responses in the TD group, like their infrequent and subtle facial expressions, was likely caused by response suppression, and may explain why 30% of TD adolescents did not display any measurable emotional response.

In contrast to TD adolescents, ASD adolescents did not show evidence of response suppression, despite the laboratory environment, and despite the (unseen) presence of researchers. Possibly, participants with ASD ignored the researchers once they were out of eyesight and behaved as though they were truly alone, therefore not suppressing their responses. It is also possible that participants with ASD were aware of the researchers' presence, but because they could not see them, they were unable to gauge their attention, which encouraged them to be uninhibited. And finally, the ASD cohort may have been aware of researchers, but did not modulate their emotional responses, perhaps because they were unable to. Emotional dysregulation has been proffered as inherent to ASD (Mazefsky and White 2014); though a recent study reports that adolescents with ASD are not any worse at voluntary emotional regulation strategies than their TD peers (Mazefsky et al. 2014). Thus, it is possible that in the current study, participants with ASD had the ability to suppress emotional responsiveness, but did not do so because they did not understand or use display rules that mandate stifled behaviors in this context. Prior research supports this, showing that children with ASD are less able to effectively apply display rules to regulate emotional behaviors, even when they demonstrate some understanding of these rules (Barbaro and Dissanayake 2007; Begeer et al. 2011). This lack of display-rules-based suppression could account for the increased expressiveness in the ASD group.

One previous study that investigated spontaneous responses to videos in preschool-aged children with and without ASD in a relatively non-social context also found that TD children were less expressive (Capps et al. 1993). That study's authors also attributed results to display rules, which prevented TD children, but not children with ASD, from behaving spontaneously in front of a researcher. The results of our study may therefore show that possible display rules deficits in ASD continue even through adolescence, when children become increasingly aware of social pressures and norms. A novelty of our study is that it shows differences in the expressiveness of emotional behaviors between diagnostic groups even when researchers are hidden from view and are not interacting with participants. This suggests that the mere implicit presence of a researcher can inhibit emotional responsiveness in TD participants, but may not have had the same effect in this cohort of adolescents with ASD. Interestingly, when the implicit presence in the room is composed of peers instead of researchers, the opposite effect may result. Fridlund et al. (1991) showed that the suggestion that an activity is shared among peers enhances responsiveness in TD participants. In the study conducted by Trevisan et al. (2016), it is not made clear whether participants were aware that their peers, who were sitting on either side of the cardboard partitions, were watching the same videos that they were. If so, it is possible that this knowledge led to enhanced responsiveness in the TD group, thereby explaining the trend of increased expressiveness in this cohort compared to participants with ASD.

Thus far, we have argued that differences in responsiveness across groups occurred because TD participants modulated emotional behaviors based on display rules, while ASD participants did not, or at least not as effectively. However, it is also possible that participants with ASD were actually modifying emotional responsiveness for social reasons, but interpreted the social context differently. While suppressed responses in TD participants indicate that they interpreted researchers as strangers or potential observers of their behavior, participants with ASD may have regarded researchers as implicit social partners and therefore amplified their responses in order to communicate with them (Buck et al. 1992; Chapman 1973; Chapman and Wright 1976). If so, heightened expressiveness in this group may not reflect unsuppressed and involuntary reactions, but instead augmented responses that were attempts at social overtures. In other words, participants with ASD may have used different display rules to modify their behaviors, namely American cultural rules that promote magnified emotional behaviors in a shared, social environment with non-strangers (Safdar et al. 2009). Relatively high proportions of vocal responses – laughter and other vocalizations – in the ASD group may support this explanation. Research shows that TD children laugh more frequently when engaged in a shared activity than when they experience the activity alone (Chapman 1973; Chapman and Wright 1976), and will even perceive the shared activity as more humorous (Chapman and Wright 1976). Participants in our ASD cohort may have laughed more because they believed the activity was shared. Their frequent exclamations and comments may have been intended to share their reactions with researchers; indeed, they may have been especially vocal in order to reach researchers, who were several feet away, behind a partition. Thus it is possible that significant differences in behaviors across groups may have been caused by context-dependent *suppression* among TD adolescents, alongside context-dependent *amplification* in the ASD group, indicating that the two groups used different display rules to modulate their behavior.

This last explanation – that amplified responsiveness in the ASD group signifies an effort at sharing with the researchers – may seem less probable, since affective sharing is frequently challenging for this population (Kasari et al. 1990; Reddy et al. 2002). Reduced affective sharing is even included as a deficit in the diagnostic criteria for ASD (American Psychological Association, 2013), and is evaluated on tests such as the ADOS (Lord et al. 2012) and the Autism Diagnostic Interview-R (ADI-R: Lord et al. 2003; Robertson et al. 1999). Still, it is possible that participants with ASD in this study felt encouraged to share with researchers who were non-interactive and invisible to participants.

In conclusion, responses of individuals with ASD were similar to one another and significantly different from TD individuals, indicating unified behavior patterns within each diagnostic cohort. TD participants seemingly inhibited emotional behaviors due to the hidden presence of a stranger, but participants with ASD were highly expressive in this context. It is probable that increased responsiveness in the ASD cohort was caused by ignorance of the researchers' presence or an inability to regulate emotional behaviors appropriately for social contexts. But it is also possible that participants with ASD were actually intensifying emotional responsiveness in order to socially engage with researchers. This latter interpretation would imply that adolescents with ASD who have preserved cognitive and language abilities demonstrate communication strategies motivated by a desire to engage socially with other people, even when those people are unseen. These data cannot, however, be generalized to all adolescents with ASD, regardless of communication abilities. Because we did not record participants' emotional behaviors during a different social context, either while participants were alone or while they watched videos with a visible social partner, the current data cannot help determine which interpretation of our findings is more probable. We are currently collecting data to address this question. We also cannot determine whether particular videos (e.g., a video of a person eating a spider) evoked the same emotional response type in each group (e.g., a disgusted face). It is possible that participants with ASD produced highly intense facial expressions that nevertheless did not appropriately match the emotional content of the videos they watched. Follow-up studies should analyze facial expressions to particular video clips and determine whether the type of emotional facial display appropriately matches the intent of the corresponding video clip. It would also be interesting to explore the details of these behaviors, including the timing, length, and intensity of individual facial expressions. And finally, although a power analysis determined the sample size to be more than sufficient for the analyses presented in this paper, we recognize that twenty participants per group is a relatively small sample that can't lead to generalization of the results. The sample size also prevents us from calculating relationships between characteristics of individual participants (e.g., their age, IQ scores, and/or scores on social-communication tests) and their behaviors during the current paradigm. Variability of such characteristics may have led to the variability seen within groups, and we endeavor to collect larger samples in order to conduct within-group analyses.

However, our data do show a remarkable uniformity of the target characteristic in the ASD sample, in that 100% of participants in this cohort laughed and showed facial expression. The variability of these characteristics was greater in the TD, than the ASD group, indicating that a within-group analysis may not reveal more information. These limitations notwithstanding, our results show that individuals with ASD in our study were emotionally more expressive than their TD peers when engaged in a pseudo-solitary activity. This suggests that adolescents with ASD are not less emotive than TD individuals, but that their emotional expressiveness may be differently modulated by social context. Future research into expressiveness in ASD should carefully manipulate the social context within which emotional responses are recorded in order to determine how context affects emotional behaviors in this population.

Acknowledgements The research reported here was funded by a grant from the NIH (NIDCD 1R01DC012774-01, Grossman PI). We are thankful to the staff at FACE Lab, Emerson College, for help with editing stimulus materials, collecting data and preparing participant videos for coding. We also extend appreciation to the children and families who generously gave their time to participate in this study.

Compliance with Ethical Standards

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

Ethical Approval Ethical approval was obtained from the Institutional Review Board at Emerson College.

Informed Consent Written informed consent was obtained from the parent or guardian of every child who participated, and written assent was obtained from the children themselves.

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