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Emotion recognition in animated compared to human stimuli in adolescents with Autism Spectrum Disorder.

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Emotion recognition in animated compared to human stimuli in adolescents with Autism Spectrum Disorder

Abstract:

There is equivocal evidence as to whether there is a deficit in recognising emotional expressions in Autism Spectrum Disorder (ASD). This study compared emotion recognition in ASD in three types of emotion expression media (still photo, dynamic video, voice) across human stimuli (e.g. photo of a human face) and animated stimuli (e.g. cartoon face). Participants were 37 adolescents (age 11-16) with a diagnosis of ASD (33 male, 4 female). 42 males and 39 females served as typically developing, age-matched controls. Overall there was significant advantage for control groups over the ASD group for emotion recognition in human stimuli but not animated stimuli, across modalities. For static animated images specifically, those with ASD significantly outperformed controls. The findings are consistent with the ASD group using atypical explicit strategies.

Keywords: Autism Spectrum Disorder; Emotion recognition; multimodal; Animated cartoon stimuli.

Autism Spectrum Disorder is defined in terms of deficits in social interaction and communication combined with restricted and repetitive behaviours and interests (APA (2000/2013)). The APA guidelines refer to marked impairments in the use of facial expressions and a lack of emotional reciprocity. This has informed theoretical accounts of ASD such as Baron-Cohen's Extreme Male Brain (EMB) theory of Autism (Baron-Cohen, 2002; 2009), which characterizes ASD as a deficit in Empathizing. Empathizing is defined as the ability to attribute mental states to others, and to respond with an appropriate emotion to the other person's mental state (Baron-Cohen and Wheelwright, 2004). An inability to recognise the emotion typically displayed through facial expression would impair the capacity to respond appropriately. Research has explored whether there are deficits within facial emotion recognition in ASD, many researchers using Ekman and Friesen's (1971) six basic emotions (happy, sad, fear, surprise, disgust, anger). Findings of a facial emotion recognition deficit in ASD have been equivocal, however. A comprehensive literature review of facial emotion recognition in ASD is provided by Harms et al. (2010) who synthesized 65 studies. Overall, the authors report that only slightly more *behavioural* studies demonstrate deficits in facial emotion recognition than do not. However, as most *psychophysiological* studies do identify a deficit in facial emotion recognition, the authors propose that atypical mechanisms may underpin the lack of significant findings within behavioural studies. Harms et al. recommend incorporating stimuli that would be sensitive to any such atypical mechanisms in future research.

In typically developing participants, some measures of Empathizing have been found to positively correlate with measures of intuition and negatively with measures of deliberative thinking (Brosnan et al., 2014a). Consistent with this, Rutherford and McIntosh (2007; Walsh et al., 2013) have suggested that participants with ASD employ a deliberate, explicit, rule-based emotion perception strategy during facial emotion recognition whereas typical participants employ an intuitive, implicit, prototype matching strategy. This use of the term prototype refers to the clearest example of an expression, such as a full or 100% smile, or the apex of a smile (for example). As naturalistically smiles must progress from 0% through to 100%, a full 'apex' smile will represent a clear 'example prototype' but not a mean prototype based upon the average of all the dimensions that typically vary (e.g. Haberman and Whitney, 2007). Subtle facial expressions of emotion may occur as often, if not more often, than the apex of the emotion. Matsmoto and Hwang (2014) define subtle emotions as involving relatively low-intensity and/or few appearance changes in the face. Despite this relatively

impoverished signal, typically developing participants were able to recognise subtle facial emotions significantly above chance. Those with ASD, however, have been found to be able to accurately identify facial emotions at full intensity, but impaired with low or intermediate levels of intensity of expression (Doi et al., 2013; Grossman and Tager-Flusberg, 2012; Law Smith et al., 2010; though see Castelli, 2005). Conversely, Rutherford and McIntosh (2007; Walsh et al., 2013) digitally manipulated facial emotion stimuli to form hyper-exaggerated emotional expressions. The authors extended the differences between a neutral and a happy or sad face to produce extreme (up to 300%) un-naturalistic expressions of emotion. The authors found a preference for more exaggerated facial expression in those with ASD, and suggested that atypical, explicit, rule-based strategies were being used to recognise emotions by those with ASD as an exaggerated representation of sadness (corners of mouth turned down, lowered eyebrows, for example) is easier for rule-based strategies than strategies based upon prototypical exemplars. This is also consistent with subtle emotions being difficult for those with ASD. One implication of this is that whilst static stimuli may afford the application of a deliberative, rule-based, systematic analysis, this may not extend to rapidly-moving and changing dynamic stimuli.

Developmental research has suggested that by 3-4 years of age, the use of labels for prototypical images of happy and sad (or angry) has developed, which further progresses into subtle emotion recognition by adulthood (Calder et al., 1996; Widen and Russell, 2003). Though those with ASD may show an impairment in emotion recognition, there is still improvement with age (e.g. Kuusikko et al., 2009). Rump et al. (2009) demonstrate a developmental improvement in rapidly presented facial emotion recognition from childhood to adulthood for typically developing participants. Within a cross-sectional ASD sample, however, the authors found a deficit in young children (aged 5-7) who managed to 'catch up' by late childhood (between ages 8 and 12), but then showed no further improvement through adolescence or adulthood. This is in contrast to both groups of participants being able to recognise stills of full facial expressions (with unlimited time). There are a number of ways to interpret these findings. One is that young children with ASD have delayed development of typical facial emotion recognition processing and 'catch up' by late childhood - but then development stalls. Alternatively, in the presence of a deficit in the development of typical (implicit) facial emotion recognition, young children with ASD may develop an atypical (explicit) strategy that is effective until adolescence. However, whilst typical development refines to discriminate subtle expressions of emotion, the atypical strategies are unable to

develop accordingly. Consistent with this latter argument, Strauss et al. (2012) report that children with ASD (aged 5-12 years) were delayed in correctly identifying the gender of faces that had been rated as typical male or female faces. However, by adolescence the performance of those with ASD matched the performance of typically developing controls (which was retained into adulthood). For faces rated as atypical for their gender, however, comparable performance was never reached by the ASD group. Correlates between gender categorization and IQ for the ASD group also led the authors to suggest that facial gender categorization is typically an implicit task, and that explicit learning strategies are required for those with ASD. The facial emotion recognition difficulty in ASD may therefore be an aspect of a broader difficulty in abstracting prototypic representations from faces (Gastgeb et al., 2009; 2011).

Taken together, the literature above indicates that those with ASD may be comparable to typically developing controls in tasks of facial emotion recognition, possibly though employing atypical explicit strategies to compensate for a lack of intuitive (implicit) emotion recognition capability. Untimed, static photographs of full, apex emotions may provide stimuli that particularly lend themselves to the application of such atypical explicit strategies, such that evaluations of facial emotion recognition could be accurate in the laboratory but not in everyday life. One method for exploring atypical explicit strategies is to use non-human, animated stimuli (e.g. cartoons). A small body of research has compared human and cartoon stimuli to elucidate differences between those with and without ASD across human and non-human stimuli.

Rossett et al. (2008) used the face inversion effect, which is argued to disrupt the configural processing that supports typical face processing. Controls, but not those with ASD, were disrupted in processing facial expressions when photographs of human faces were inverted. This suggests that the control group were using a configural strategy for human facial emotion recognition (that is disrupted by inversion), but the ASD group were not. However, both groups were disrupted in processing inverted facial expressions of cartoon faces. The authors speculate that greater interest towards cartoons in ASD may lead to greater acquired expertise and consequently cartoon faces elicit processing in the ASD group which is typically associated with human faces in non-ASD participants. This is consistent with Grelotti et al. (2005), who found typical face processing areas (amygdala and fusiform gyrus) to be activated when viewing a cartoon face but not a human face in a child with ASD who had a fascination with this specific cartoon face. This may suggest that expertise is playing a

role in emotion recognition, and there is evidence that those with ASD have different gaze patterns when looking at human faces, looking at mouths more than eyes (Pelphrey et al., 2002; Klin et al., 2002). However, emotion recognition deficits have also been reported in ASD with no evidence of the eye gaze avoidance, which suggests a lack of experience observing emotionally-laden facial features is not a comprehensive account of facial emotion processing deficits in ASD (Sawyer et al., 2012). In addition, multimodal deficits in emotion recognition (visual and auditory) imply a central deficit in emotion recognition, rather than solely a facial emotion recognition deficit (Kleinman et al., 2001). Dio et al. (2013) used a multimodal approach and did not find the same effect within the auditory domain as they did within the visual domain, suggesting emotion recognition deficits in ASD are modality specific to the visual domain (see also Jones et al., 2011). Other authors, however, have found similar effects for both face and tone-of-voice intensity in ASD (Mazefsky & Oswald, 2007). Philips et al. (2010) combined facial emotion recognition and voice emotion recognition with body emotion recognition and found deficits in ASD in all three, suggesting a core, cross-modal, emotion processing deficit rather than a modality-specific deficit. The extent to which atypical explicit strategies may be modality specific or widely-applicable multimodal strategies is unknown, although more local-level processing has been identified in the auditory domain as well as the visual domain (Mottron et al., 2000; see Mottron et al., 2006 for review).

In summary, the behavioural data regarding emotion recognition in ASD is equivocal, although the neurophysiological evidence suggests the potential that this may be due to atypical explicit strategies being used by those with a diagnosis of ASD. Comparing cartoon and human representations of emotion to elucidate the role of atypical explicit strategies within emotion recognition behaviour in ASD represents a potentially significant addition to our understanding. The aim of the present study was to explore emotion recognition differences between human and cartoon stimuli, as explicit atypical strategies may be more applicable to the latter stimuli. We examined this distinction across three sets of stimuli: visual-static, visual-dynamic and auditory to explore whether this methodology could extend from the visual to the auditory domain to address the multimodal debate. The focus is to compare human and cartoon across these modalities, not to compare human dynamic directly with human static and human auditory stimuli (for example). In those with ASD, we hypothesised that emotion recognition would be more impaired in the human than the cartoon representations. Following Walsh et al., (2013; see also Tracy et al., 2011), if atypical explicit

strategies were being used, emotion recognition of visual-static cartoon faces would be preserved or enhanced in those with ASD. However, any enhanced performance would not be hypothesised to extend to rapidly changing dynamic stimuli. Baron-Cohen's EMB theory is based upon ASD representing an extreme variant of sex differences within the typically developing population. Consequently we recruited both male and female control groups and treated them as separate groups.

Methods

Participants

For stylistic convenience the three groups are referred to as ASD, Males and Females. The ASD group were recruited from two specialist education centres. One was a school specifically for those with a diagnosis of ASD. The other was a specialist unit for young people with ASD, which was attached to a large mainstream school.

All participants with ASD had received a formal clinical diagnosis based on international criteria (APA, 2000; ICD-10, WHO, 1992) in order to attend the ASD unit or school. Diagnoses of Aspergers/ High Functioning Autism were confirmed by researchers examining the reports of clinicians who had made the diagnosis, for example, ADOS cut-off scores (Lord et al., 1989). For practical reasons associated with school timetables and a desire to minimise the disruption of research upon participants' education, it was not possible to administer the ADOS. Consequently we used a short version of the Social Responsiveness Scale. The Social Responsiveness Scale-Short (SRS-S) is not diagnostic, but was used here to confirm a group difference in autistic characteristics between the groups. The 11 item SRS-S was developed to be a shorter screening for ASD characteristics based upon the full SRS (Constantino and Gruber, 2005; Kanne, Christ & Reiersen, 2009). Constantino et al. (2007) report extremely high specificity (.96) and sensitivity (.75) for clinical and research diagnoses of ASDs (area under receiver operating characteristics curve = .95) from a range of informants using the SRS. Kane et al. report 11 original SRS items (based on SRS items 6, 15, 16, 18, 24, 29, 35, 37, 39, 42, and 58) all had high loadings on a single unrotated principal components analysis factor. Items from each of three autism symptom domains, social

impairment (e.g., making friends and relating to peers, eye contact, social interest, others' perceptions), communication impairment (e.g., conversational skills, understanding aspects of nonverbal communication), and stereotyped/repetitive behaviours (e.g., restricted areas of interest, cognitive style, difficulty with change, and sensory difficulties) were included.

The short version of the SRS used in this study has been shown to be well validated against the full SRS (Kanne et al., 2009), and has previously been utilised as a screening measure for ASD characteristics in research studies - the format extends to self-report, where items can be read to children (Brosnan et al. 2014b; Christ et al., 2010; Reiersen et al., 2007). Responses were given on a 4 point scale from 0-3 (0 = false, not at all true; 1 = slightly true; 2 = mainly true; 3 = very true) and scores could range from 0 to 33. Reiersen et al. report a Cronbach's alpha of 0.81 for this short version of the SRS and Christ et al. reported this version of the SRS correlates highly (0.75) with the full version of the Autism Quotient (AQ: Baron-Cohen et al., 2001). We excluded those in the ASD group with a score of less than 10 and those in the control group with a score of 10 or more as this maps onto the cut-off criteria of the full SRS (see Brosnan et al., 2014b). This resulted in eight from the ASD group and seven from the control group being excluded. Age-matched participants (groupwise) were recruited from the associated mainstream school.

Participants had indices of both verbal IQ (VIQ) and performance IQ (PIQ) assessed by the WASI (UK: Wechsler, 1999). One participant with ASD had a verbal IQ index (see below) of 71 and was excluded from the analyses. The final sample comprised of 28 with ASD (24 male, 4 female), 36 males and 33 females, see Table 1. A oneway MANOVA with a Tukey post-hoc test identified a significant difference in the VIQ between the ASD and female groups ($F(2,98)=5.52, p=.005$) and for the SRS-S between the ASD group and both males and females ($F(2,94)=160.95, p<.001$). All other comparisons were non-significant (including PIQ and age, $p>.05$).

Table 1 about here

Multimodal Emotion Recognition Task (MERT)

The test battery used one example from a range of emotions to explore the differences between presentation modality, rather than exploring differences between different emotions. The six emotions were represented within six classes of stimuli: human static image, human dynamic image, human auditory, animated¹ static image, animated dynamic image, and animated auditory. There were therefore 36 stimuli, the blocks of six presented in a random order using Psyscope via a MacBook Pro laptop, with a 17 inch screen. Each stimulus was presented for five seconds and then participants were presented with four options and asked to identify which emotion had been displayed. The four options were the correct emotion and three randomly selected other emotions (which, once specified, remained constant for that stimulus). We did not present all six emotion words as potential responses on every occasion as we wanted the options to change between stimuli to encourage all potential responses to be considered for each trial. Participants were told to make their best guess if they were unsure which emotion had been displayed. The emotion was not displayed whilst the participant made their decision, as we had dynamic image and auditory stimuli.

Stimuli

The stimuli were taken from widely available pre-existing sources, clear exemplars being selected by the authors (see Figure 1). The dynamic human images (no sound) came from the Mind Reading interactive guide to emotions (Baron-Cohen et al., 2004). Each clip showed an actor holding a full expression of an emotion for around five seconds. The emotions to be recognised were excited, kind, sad, surprised, happy, proud. The animated dynamic stimuli were taken from *The Transporters*, which is an animation that grafts real-life faces of actors showing emotions onto the fronts of trains (Golan et al., 2010). The clearest example of each emotion (as independently judged by the authors) were selected and comprised excited, kind,

¹ We use the term 'animated' rather than 'cartoon' as it better describes both the visual and auditory conditions, but does not imply that the stimuli move. We use the term 'dynamic' to indicate movement.

sad, surprised, happy, proud. Again the clips ran for around 5 seconds. The human static images comprised of six full-face colour static images from the Karolinska Directed Emotional Faces (KDEF: Lundqvist, et al., 1998). The emotions to be recognised were angry, afraid, disgusted, surprised, happy, proud. The images were viewed on the computer screen for 5 seconds. Six cartoon faces from the product emotion measurement instrument (PrEmo, see Desmet 2003; Desmet et al. 2000; 2007) were used for the static animated stimuli. The PrEmo characters are black and white line drawings (drawn by a cartoon artist observing human models) of a human-like round face with eyes, nose and mouth. PrEmo is a widely validated instrument that is used to enable respondents to report their emotions non-verbally through the use of these characters. The emotions to be recognised were angry, afraid, disgusted, surprised, happy, sad and shown for 5 seconds. The human auditory stimuli were also taken from the Mind Reading interactive guide to emotions (Baron-Cohen, 2004). In addition to the visual stimuli (above), the software contains sentences spoken with an emotional tone (no visuals). The emotions to be recognised were sociable, unfriendly, excited, unsure, shocked, reassured. Finally, 'earcons' were used for the animated auditory stimuli. Earcons are an abstract series of synthetic tones that have been shown to be effective at communicating complex information in sound (no visuals: see Brewster, 2013). The emotions to be recognised were excited, happy, kind, proud, sad, surprised.

Figure 1 about here

Additional assessments

Testing occurred in a quiet classroom. The researcher explained the task to each participant, and was able to clarify any questions. The SRS-short was also completed at this point in time. VIQ and PIQ assessments took part on separate days within a week of the MERT. This was successful for the VIQ assessment but timetable clashes meant that 14 students with ASD did not complete a PIQ assessment. There were no differences in VIQ or SRS-short between those who did and did not have a PIQ assessment in the ASD population ($t(25)=1.06$, ns; $t(26)=.03$, ns; respectively).

Design

Analysis was a repeated measures ANOVA with a single factor (e.g. Representation) containing two levels (Human and Animated). All analyses controlled for VIQ as a covariate. This provides a within group analysis (human vs animated) in addition to a between group analysis (ASD, males, females). When appropriate, within group differences were confirmed using pair-wise t-tests, and between group differences with oneway ANOVAs. T-tests were two tailed and p level was set at .05. Initially this analysis was conducted for all the stimuli combined, then for each modality separately (visual static, visual dynamic, auditory). Comparisons between emotion recognition for human and animated stimuli for ASD and control groups were undertaken using Pearson partial correlations (controlling for VIQ and gender, 2-tailed). A final Z-score analysis compared the relative human vs. animated scores for each group. Ethical approval for the study was granted by the Departmental Ethics Committee.

Results

The first analysis was a repeated measures ANOVA with a single within-groups factor (Representation) containing two levels (Human, Animated) by three groups (ASD, Male, Female), with VIQ as a covariate. For all the stimuli together, there was a significant between-groups effect ($F(2,97)=15.92, p<.001$) indicating that overall those with ASD recognised less emotions than male and female controls. Within-groups, the main effect for Representation was not significant ($F(1,97)=0.08, ns$) nor was the interaction with VIQ ($F(1,97)=0.63, ns$). There was, however, a significant higher-order interaction by group, which highlighted that both male and female controls had improved human emotion recognition over animated emotion recognition whereas the ASD sample scored comparably across both human and animated stimuli ($F(2,97)=17.02, p<0.001$; see Figure 2). All groups performed comparably recognising the animated emotions. In the human condition, male and female controls outperformed those with ASD ($t(35.60)=5.31, p<.001$; $t(33.66)=6.00, p<.001$;

respectively). Males and females did not differ from each other significantly ($p > .05$). Partial correlations (controlling for sex and VIQ) were conducted between the Human and Animated totals for the ASD and control (male and females combined). There was a significant positive relationship for the control group ($r(70) = .30, p = .01$) and a non-significant negative relationship for the ASD group ($r(23) = -.19, ns$).

Figure 2 about here

The three types of stimuli (static image, dynamic image, auditory) were then investigated separately. For the static image stimuli in isolation, the between-group analysis again showed those with ASD identified less emotions overall compared to males and females ($F(2,97)=6.79, p=.017$). Within-groups there was not a significant main effect for Representation ($F(1,97)=.70, ns$) nor interaction with VIQ ($F(1,97)=0.01, ns$) but there was a significant higher order interaction by group ($F(2,97)=25.34, p<0.001$, see Figure 3). Whilst male and female controls showed enhanced performance for human static images, the ASD group showed enhanced performance for animated static images. Independent t-tests confirmed that the ASD group significantly *under-performed* when compared to male and female controls with human static images ($t(36.67)=4.64, p<0.001$; $t(35.97)=4.64, p<0.001$; respectively) and significantly *over-performed* with the animated static images when compared to male and female controls ($t(64)=2.58, p=0.012$; $t(62)=3.27, p=0.002$; respectively). Males and females did not differ from each other significantly ($p > .05$). Partial correlations (controlling for sex and VIQ) were conducted between the Human and Animated static image totals for the ASD and control (male and females combined). There was a significant positive relationship for the control group ($r(70) = .31, p < .01$) and no relationship for the ASD group ($r(23) = .00, ns$).

Figure 3 about here

For the dynamic image stimuli in isolation, there was again a significant between group difference indicating that those with ASD had lower emotion recognition ($F(2,97)=8.30$, $p<.001$). Within-groups there was no significant effect of Representation ($F(1,97)=1.40$, ns) with no significant interaction with VIQ ($F(1,97)=1.46$, ns) nor group ($F(2,97)=0.44$, ns, see Figure 4). Overall male and female controls scored higher than the ASD group, and this was irrespective of animated or human emotion. Males and females did not differ from each other significantly ($p>.05$). Partial correlations (controlling for sex and VIQ) were conducted between the Human and Animated dynamic image totals for the ASD and control (male and females combined). Consistent with the static image totals, there was a significant positive relationship for the control group ($r(70) = .39$, $p = .001$) and no relationship for the ASD group ($r(23) = .03$, ns).

Figure 4 about here

Finally, with the auditory stimuli there was again a significant between-group effect ($F(2,97)=9.89$, $p<.001$) indicating those with ASD scored lower than males and females. Within-groups there was not a significant main effect for Representation ($F(1,97)=0.38$, ns) nor a significant interaction with VIQ ($F(1,97)=.27$, ns) with a significant higher order interaction by group ($F(2,97)=9.51$, $p<0.001$, see Figure 5). Figure 5 highlights that there were no differences recognising animated auditory stimuli between those with ASD and males and females ($t(42.29)=1.12$, ns; $t(44.36)=.54$, ns, respectively). Both male and female controls demonstrated a significantly enhanced performance when recognising emotion from human auditory stimuli, whereas those with ASD did not ($t(35.26)=5.94$, $p<0.001$; $t(34.83)=6.73$, $p<.001$). Males and females did not differ from each other significantly ($p>.05$). Partial correlations (controlling for sex and VIQ) were conducted between the Human and Animated auditory totals for the ASD and control (male and females combined). There was a significant negative relationship for both the control group ($r(70) = -.25$, $p < .05$) and the ASD group ($r(23) = -.41$, $p<.05$).

Figure 5 about here

A final analysis explored the bias toward correctly identifying human or animated representations of emotion. Z-scores were calculated for the four variables above, namely overall mean emotion score and individual scores for static image, dynamic image and auditory stimuli. The z-score for the animated representation was then subtracted from the z-score of the human representation. A score of zero would indicate an equal performance upon human and animated representations of emotion. A positive score would represent a higher score was obtained on human compared to animated representations of emotion. Conversely, a negative score would indicate a higher score on animated compared to human representations of emotion. In this way a ‘bias’ towards human or animated emotion recognition could be derived. A score of +1 would indicate that human representation scores were one standard deviation above those of animated representation scores. A score of -1 would indicate animated representation scores were one standard deviation above those of human representation scores. Figure 6 highlights that for the overall total and the static image and auditory subtotals, there was a bias towards animated stimuli for the ASD group and a bias towards the human stimuli for the control groups, with a small difference for the dynamic image stimuli. A oneway MANOVA analysis highlighted the differences were significant for the total ($F(2,99)=12.27, p<.001$), static image stimuli ($F(2,99)=29.47, p<.001$) and auditory stimuli ($F(2,99)=14.72, p<.001$) but not dynamic image stimuli ($F(2,99)=0.52, ns$). Finally, the demographic variables were correlated with these z-score difference totals. A Pearson correlation revealed that the SRS measure correlated with total z-score difference ($r=-.44, p<.001$), static image z-score difference ($r=-.62, p<.001$) and auditory z-score difference ($r=-.43, p<.001$) but not dynamic image z-score difference ($r=.00, ns$). There were no significant correlations for VIQ or PIQ (all $p>.05$).

Figure 6 about here

Discussion

There is equivocal evidence as to the nature of an emotion processing deficit in ASD, possibly as a function of atypical explicit strategies being employed during emotion processing tasks. In the present study, for all types of stimuli (static image, dynamic image, auditory) those with ASD underperformed on emotion recognition tasks compared to male

and female controls (between-groups analyses). Examining the differences between human and animated representations of emotion across the different sets of stimuli revealed an interesting pattern of results. For static images and auditory stimuli, emotions within human and animated stimuli were comparably recognised by those with ASD. However, male and female controls showed a significant advantage for human stimuli over animated stimuli. For static image stimuli, those with ASD showed a significant advantage for recognising emotion in animated stimuli whereas male and female controls showed a significant advantage for recognising emotion in human stimuli. No significant sex differences were identified. Within the visual domain (static and dynamic images) emotion recognition performance for human and animated stimuli significantly correlated for controls but there was no correlation for the ASD group.

For both male and female controls there was a significant advantage of human representation across the modalities of static images (photos) and sounds (voice). The advantage typically afforded by human representation did not extend to those with ASD. Indeed, those with ASD showed an advantage for animated representation with static image stimuli, to the extent that those with ASD were superior to typically-developing male and female controls at identifying animated emotions in static image stimuli. This bias in performance toward human or animated representations of emotion was quantified in the z-score difference analysis. Overall, those with ASD had a bias towards correctly identifying animated representations of emotions relative to human representations of emotion (which equated to one standard deviation). The male and female controls had a bias towards human representations of emotion relative to animated expressions of emotion (which equated to around a third of a standard deviation). Overall, the tendency to recognise emotion from animated stimuli relative to human stimuli significantly correlated with autistic symptomology, but appeared independent of both verbal and performance IQ (as assessed by the WASI).

This pattern was most extreme with the static image stimuli. This is significant as many assessments of emotion recognition use still photographs, such as the Ekman and Friesen photographs of prototypical emotional expressions. The finding of a superior performance in ASD compared with controls with animated static image stimuli is consistent with the literature suggesting atypical explicit strategies are employed. Animated stimuli evoke exaggerated representations of emotion that are amenable to explicit rules being used to identify the emotion. Rutherford and McIntosh (2007) and Walsh et al. (2013) report that

artificially exaggerated static human facial expressions of emotion are perceived to be typical expressions of emotion by those with ASD. However, these extreme variants are not prototypical - rarely, if ever, appearing statically (for prolonged periods) in everyday life. In daily life, typical human emotion expression is most likely to be lower intensity and fleeting (Matsmoto and Hwang, 2014). The use of explicit atypical rules would be expected to fail under dynamic conditions, and no advantage for animated dynamic image representations of emotion was identified in the present study for those with ASD. The lack of advantage for the animated dynamic image stimuli may therefore be due to the transitory nature of the emotional expression or the dynamic stimuli not being as extreme as the static stimuli. The PrEmo stimuli used within the present study are cartoons based upon actual human expression (rather than intentionally exaggerated). A reduction in emotion intensity or processing time would be expected to impair the effectiveness of a deliberative compensatory strategy (Brosnan et al., 2014a; Clark et al., 2008; Rump et al., 2009).

Rump et al. (2009) found a pattern of data that suggested by ages 8-12, children with ASD had 'caught up' with the emotion recognition skill of their typically developing peers, however, unlike their typically developing peers, they failed to progress further in adolescence or adulthood. Similar data from Strauss et al. (2012) suggest that deficits may become apparent in adolescence and adulthood that are not evident at an earlier age. Age may be a crucial variable in the discrepancy between behavioural and psychophysiological levels of evidence for emotion processing deficits in ASD, especially as most research projects are conducted upon children and adolescents (71.6% in the UK: Pellicano et al., 2013). If indeed, younger children (aged 5-7) have not yet developed atypical explicit strategies for emotion recognition, we would not expect any advantage in ASD for static animated stimuli, such as that used in the present study. This is a question for future research, as is *why* atypical explicit strategies should develop. De Martino et al. (2008) report that those with ASD failed to integrate emotional contextual cues into their decision-making process. The authors suggest that the consequent reliance upon deliberative, explicit strategy is attributable to impairments within intuitive processing in ASD. This would suggest that the use of atypical explicit strategies are cognitive compensation for impaired implicit (intuitive) processing. Brosnan et al. (2014b) also demonstrate greater deliberation in decision making in people with ASD but argue it cannot necessarily be inferred that this is as a result of impaired implicit (intuitive) processing. The use of atypical explicit strategies may therefore be a processing bias rather than a compensatory strategy. The term atypical explicit strategy

refers to a comparison with when an implicit strategy might typically be used. The actual strategy itself, may be a strategy that is employed by those without ASD in different circumstances. In the present study, for both dynamic and static images, emotion recognition for human and animated stimuli correlated with each other for the control group but not the ASD group. It is speculative at this stage, but one interpretation of the data is that this is consistent with the control group using more similar strategies for both human and animated stimuli than the ASD group.

Rossett et al. (2008) speculate that animated stimuli remove the social context allowing those with ASD to process emotional content within non-social stimuli without the impairments associated with social processing. The present data does not wholly support this, as the accuracy for animated stimuli in the ASD group was never as high as the accuracy for the human stimuli in the control groups. Rossett et al.'s proposal is consistent with EMB theory (Baron-Cohen, 2002; 2009), which proposes that non-social abilities can compensate for deficits in Empathizing. However, EMB suggests that ASD is an extreme variant of sex differences that can be identified within the general population. In the present study, however, we did not find any significant sex differences. It could be argued that the insignificant trends were more often than not in the predicted direction, but overall the pattern between males and females was remarkably similar (Figure 6). Mottron et al. (2006) argue that typically mandatory higher-order processing is optional in ASD. Within the visual domain, though defaulting to a local level, those with ASD can perform typically when primed to a global level. It is interesting to speculate that the perceived social nature of the stimuli may provide a prime that evokes atypical explicit strategies in ASD. However, the nature of these deliberative, explicit, atypical strategies is still an open question – how explicit and how many rules are there? Increased understanding of these questions and of the primes that may trigger the application of atypical explicit strategies would inform interventions designed to support emotion recognition in ASD, and crucially how to generalise any benefits of intervention.

Overall, in the present study those without ASD showed relative superior emotion recognition performance on human compared to animated stimuli, whereas those with ASD showed relative superior emotion recognition performance on animated compared to human stimuli (Figure 6). This is consistent with proposals that those with ASD are using atypical explicit strategies that are more tolerant of exaggeration than implicit prototypical strategies

(Rutherford and McIntosh, 2007; Walsh et al., 2013). Also in the present study, sound was presented as dynamic auditory stimuli which demonstrated a similar overall pattern of z-score difference to the static stimuli (but not the dynamic image stimuli). This is consistent with deficits in appreciating human voice intonation in ASD (Golan et al., 2007). For the auditory stimuli, however, there was no advantage of animated stimuli for the ASD group which again would be consistent with dynamic stimuli preventing any advantage being gained from atypical explicit strategies. Those with ASD were able to identify animated emotional sounds as effectively as controls. The similarity in patterning between visual static and auditory stimuli would also be consistent with group differences in emotion recognition being cross-modal (Mazefsky & Oswald, 2007; Philips et al., 2010). However, despite the difference between control and ASD groups when correlating human and animated visual (static and dynamic) stimuli above, there was a similar pattern for both groups for auditory stimuli. For both those with ASD and controls, human auditory emotion recognition significantly negatively correlated with animated auditory emotion recognition. Why there should be a negative relationship is unclear, but the similarity between the groups may be of interest.

The degree of self-reported ASD traits identified by the SRS-short correlated significantly with the bias towards more accurate recognition of animated relative to human representations of emotion. This finding is not causal, but does suggest there is a link between autistic symptomology and a bias away from processing human emotion effectively. This is not novel, but the present study highlights that autistic symptomology also relates to a bias towards processing animated emotional expressions more effectively. As noted above, this is superior in ASD with static image stimuli. It is also interesting that this bias did not correlate with either VIQ or PIQ. VIQ had no significant impact upon the findings above, which is inconsistent with previous research (e.g. Jones et al., 2011). Jones et al. found IQ to be significantly related to emotion recognition abilities when they compared low (<80) to high (≥ 80) IQ groups. The participants' IQ range in the present study only maps onto the high IQ group of Jones et al. and it may be that IQ has more influence within the lower range. Again, inconsistent with Jones et al., the present study consistently found that those with ASD underperformed with human stimuli across modalities. Our findings may therefore be specific to our stimuli, and it may be that differences in stimuli can explain the variation in findings with respect to behaviour testing of emotion recognition in ASD (Harms et al. 2010). We used stimuli that are widely used to assist with emotion recognition deficits in ASD

(Golan et al., 2010) whereas Jones et al. used the black and white halftone photographs from the Ekman–Friesen test of affect recognition (Ekman & Friesen, 1971).

Crucially, this study is not able to compare human dynamic with human static with human auditory stimuli (or the same comparison for animated stimuli). The present study examined differences between human stimuli and animated stimuli of three types. However, we cannot infer that human dynamic stimuli may be different from human static stimuli as there were many potential differences between these stimuli, such as background or degree of emotional expression. The human stimuli were producing full, apex examples of the emotions but comparison between levels is potentially confounded by using different sources for the stimuli. It may be, for example, that the full emotion displayed by the actors in the dynamic stimuli were more subtle than those displayed by the actors in static stimuli. As all the stimuli contained actors producing prototypical expressions, ratings of the stimuli for intensity, for example, would be of limited utility and problematic to compare across modality. The differences between the stimuli may therefore be attributable to a range of factors when interpreting the overall score and within group effects. The aim of this study was not to directly compare static with dynamic visual and auditory stimuli. This would require a high degree of control over stimuli variables. Rather the aim of the present study was to compare widely available human and animated stimuli across a range of modes.

As noted above, the stimuli were not controlled for between conditions, which limits the implications that can be drawn. Our relatively small number of stimuli were presented only once to each participant. Repeated exposures of multiple stimuli (e.g. Jones et al., 2011) would allow for an analysis of whether specific emotions (such as surprise) were susceptible to the effects of human compared with animated representation. Any such patterns were not observable in our data, but this may be due to the limited number of stimuli. We were not able to undertake an ADOS-based diagnosis with the ASD sample but we did use a cut-off methodology to ensure no overlap of autistic features between the groups. The sample was also Aspergers/ High Functioning Autism and, especially given the findings of Jones et al. (2011), may not extend to the lower functioning end of the continuum. The extent to which the findings are stimuli-specific also needs to be determined. We used stimuli that have been developed for people with ASD. Transporters, for example, have very human-like faces transposed onto the front of vehicles. It may be that less human-like dynamic images may illicit enhanced emotion recognition in ASD groups. The degree to which stimuli are

perceived to be social may prove to be an important variable in determining whether atypical explicit strategies are employed by those with ASD. The findings of the present study are consistent with atypical explicit strategies being employed to recognise emotion by those with ASD. Features such as available processing time and intensity of emotion may also be salient variables for future research to consider. As noted above, no significant sex differences were identified in the present study, which again may be a feature of the stimuli used within the present study.

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Table 1: Demographic means, standard deviations and ranges by group.

	ASD	males	females
Number	28	38	36
Age (in years)	13.43 (1.4)	13.29 (1.1)	13.36 (1.0)
	11-16	12-15	12-15
VIQ	97.78(9.25)	102.00(11.36)	107.36(13.00)
	81-119	80-129	80-134
PIQ	104.16(12.92) ¹	105.13(12.84)	105.44(11.44)
	80-126	85-126	87-126
SRS-S	17.54(5.09)	3.22(2.51)	2.97(3.03)
	10-26	0-9	0-9

¹note n=14

Figure captions

Figure 1. Examples of the six types of stimuli

Figure 2. Overall emotion recognition by group for human and animated representations of emotion.

Figure 3. Emotion recognition by group for human and animated representations of static image stimuli.

Figure 4. Emotion recognition by group for human and animated representations of dynamic image stimuli.

Figure 5. Emotion recognition by group for human and animated representations of auditory stimuli.

Figure 6. Bias towards correctly identifying human or animated emotion expression.

Figure 1.

					
<p>Human dynamic</p>	<p>Animated dynamic</p>	<p>Human static</p>	<p>Animated static</p>	<p>Human auditory</p>	<p>Animated auditory</p>

Figure 2.

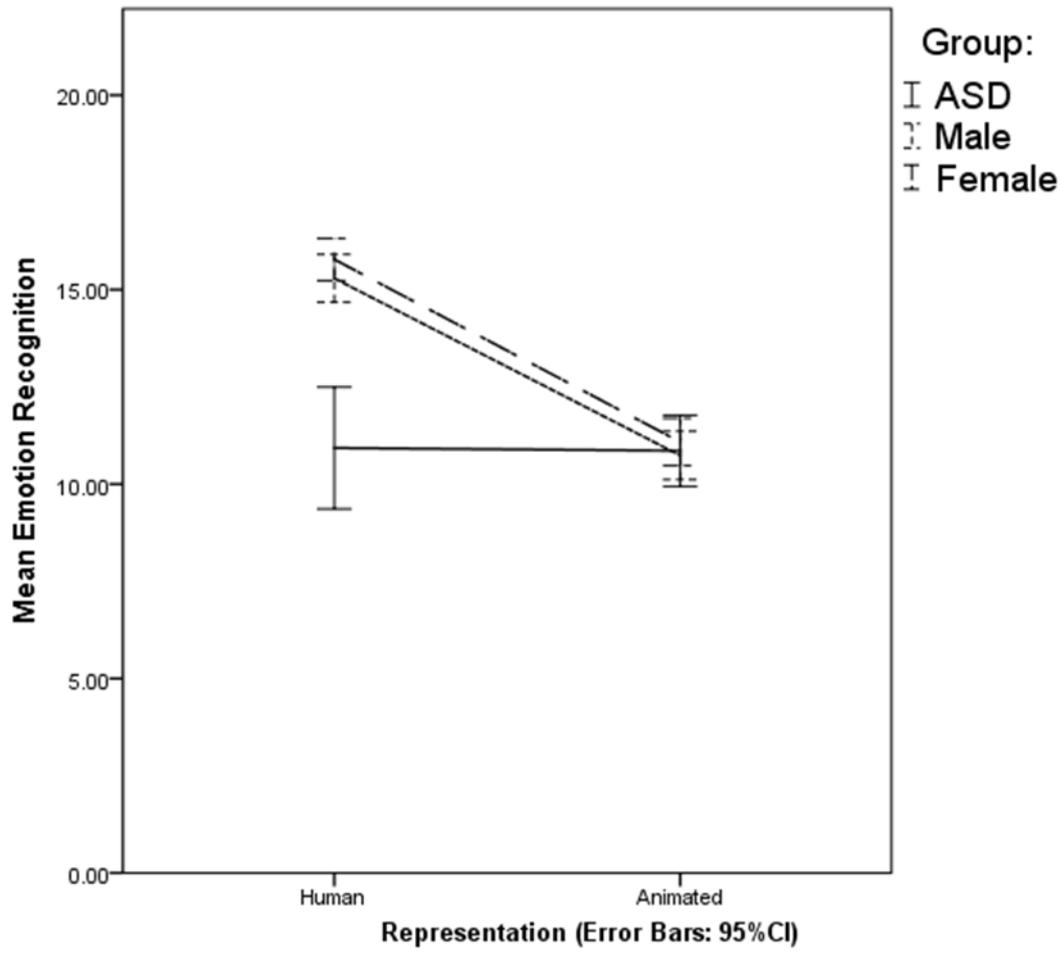


Figure 3.

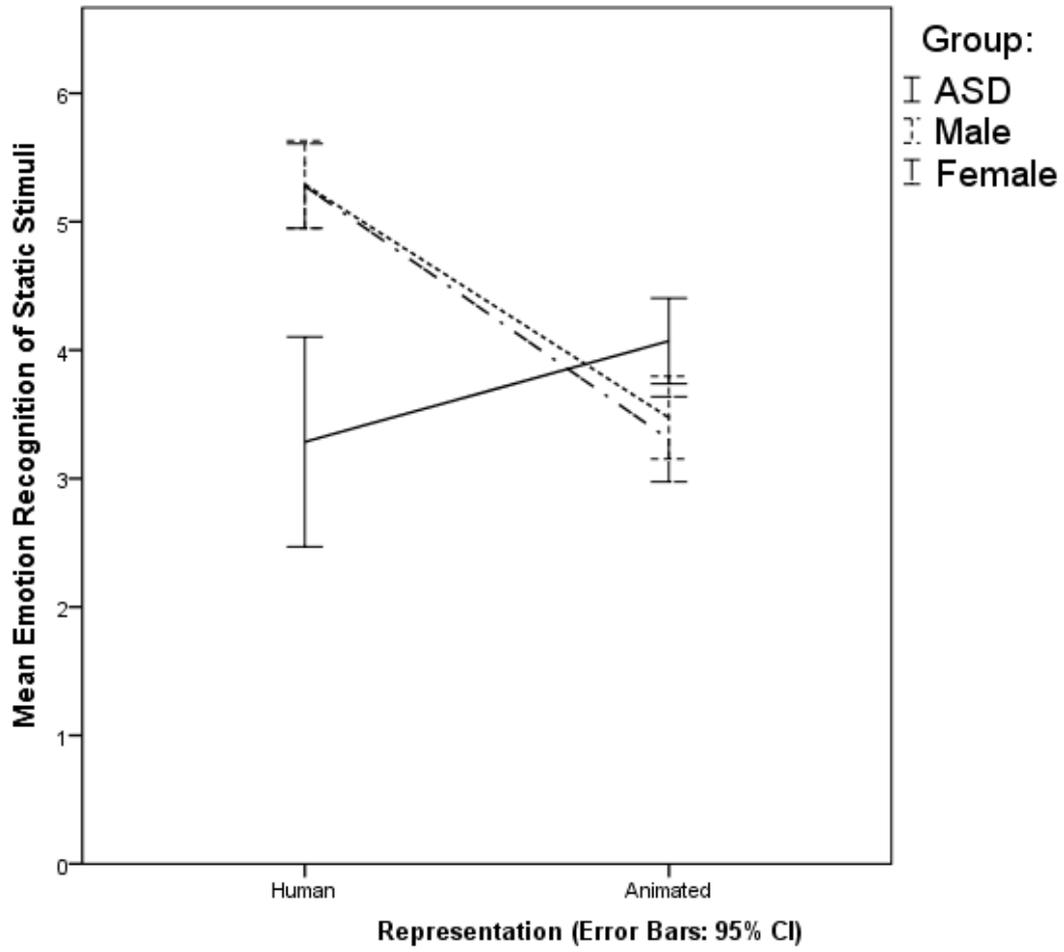


Figure 4.

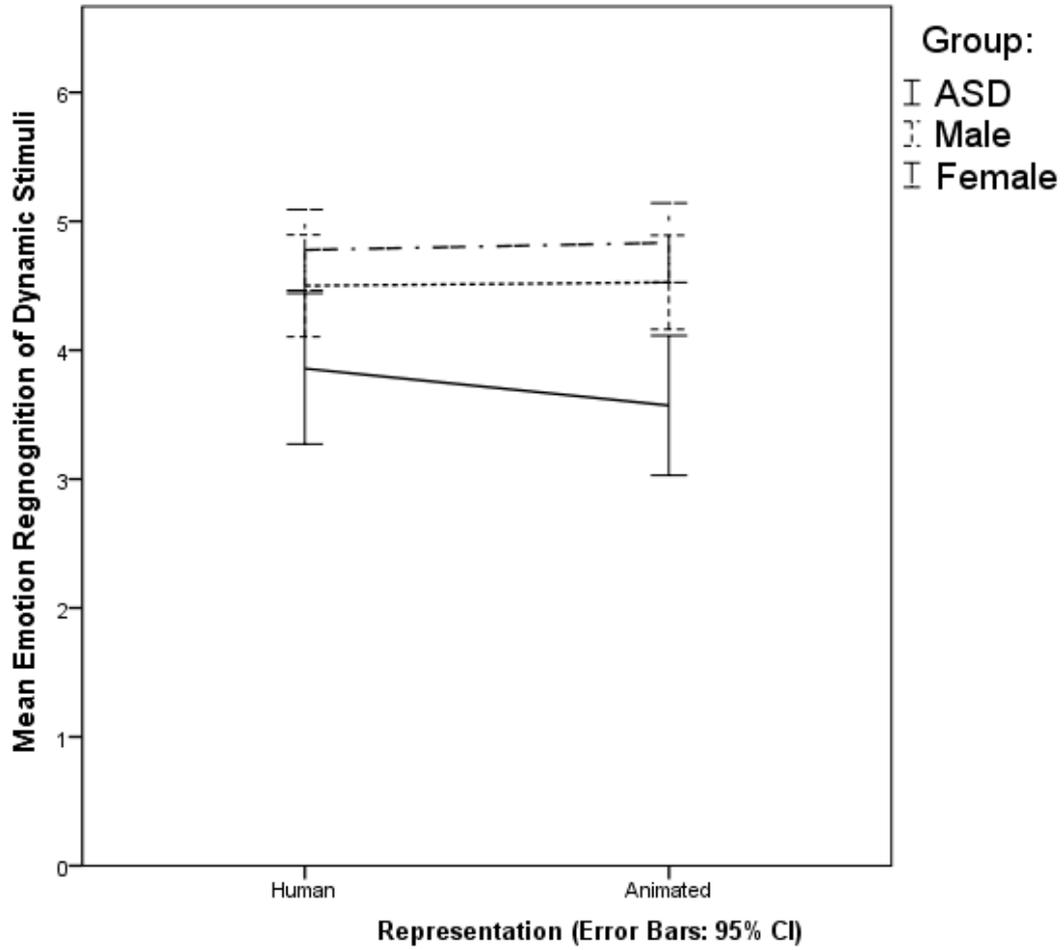


Figure 5.

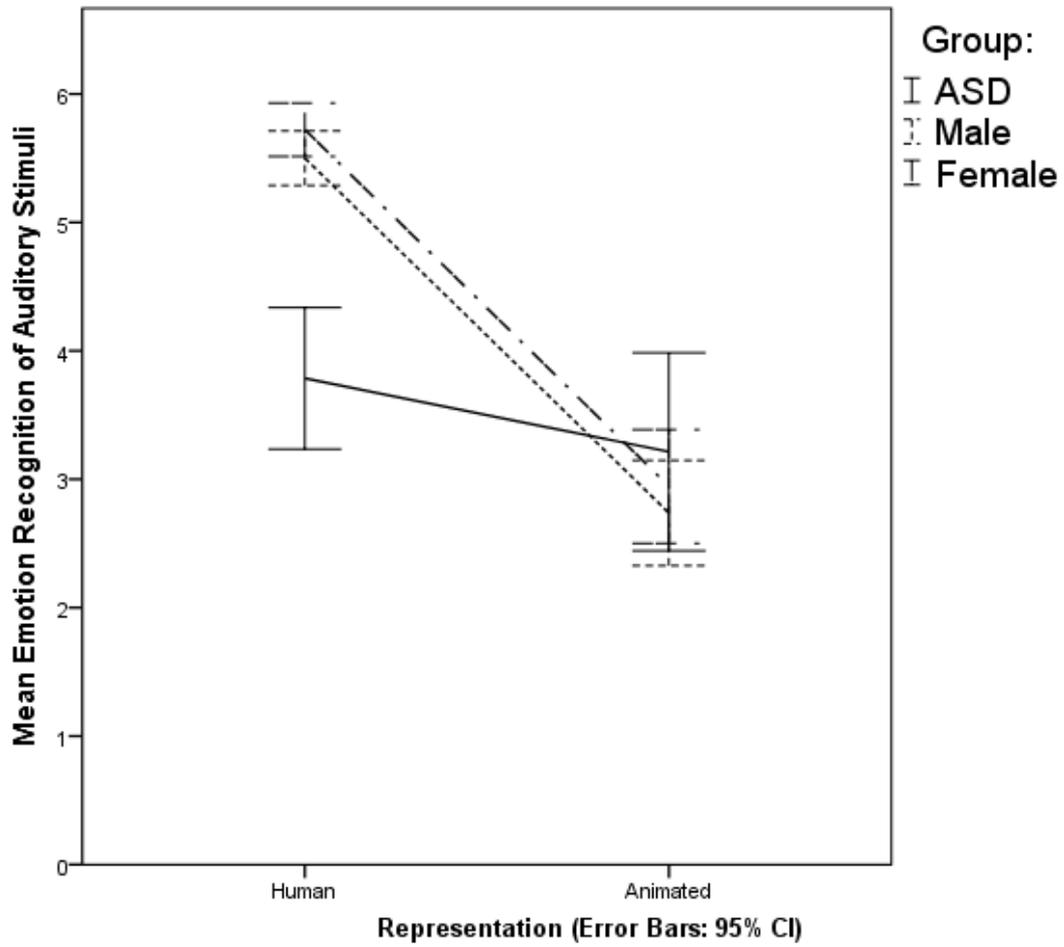
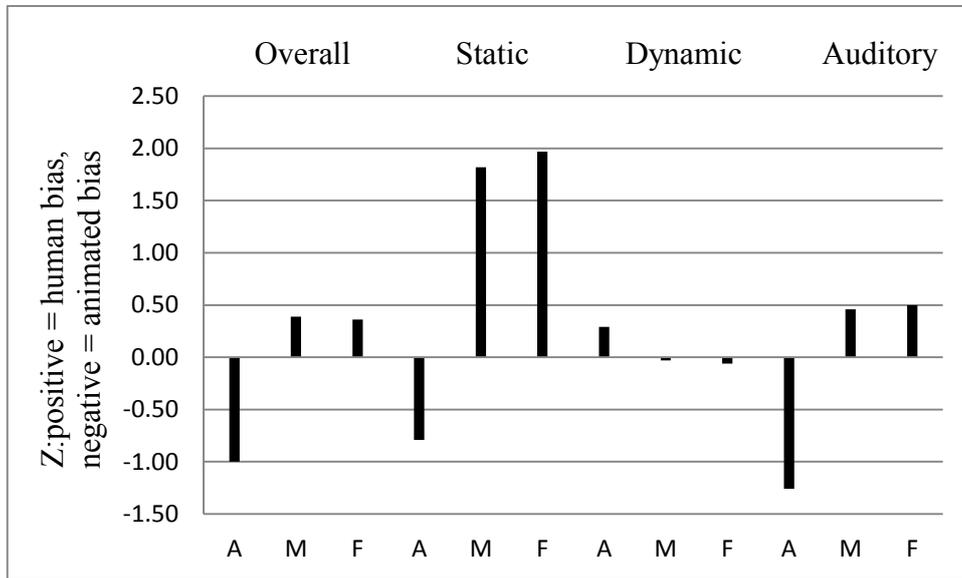


Figure 6.



Key A = ASD, M = Male, F=Female.