Abstract

Background: Children with Autism Spectrum Disorder (ASD) may require interventions for communication difficulties. One type of intervention is picture communication symbols which are proposed to improve comprehension of linguistic input for children with ASD. However, atypical attention to faces and objects is widely reported across the Autism Spectrum for several types of stimuli.

Method: In this study we used eye-tracking methodology to explore fixation duration and time taken to fixate on the object and face areas within picture communication symbols. Twenty-one children with ASD were compared to typically developing matched groups.

Results: Children with ASD were shown to have similar fixation patterns on face and object areas compared to typically developing matched groups.

Conclusions: It is proposed that children with ASD attend to the images in a manner that does not differentiate them from typically developing individuals. Therefore children with and without autism have the same opportunity to encode the available information. We discuss what this may imply for interventions using picture symbols.

Keywords: Autism Spectrum Disorder, Communication, Cognitive Behaviour, & Eye-tracking

Children with Autism Spectrum Disorder (ASD) attend typically to faces and objects presented within their picture communication systems.

Accepted in the Journal of Intellectual Disability Research

Introduction

Many children with an Autism Spectrum Disorder (ASD) require interventions, particularly for communication difficulties, since a high proportion of individuals with this disorder remain without functional speech (Charlop & Haymes, 1994; Volkmar, Lord, Bailey, Schultz, & Klin, 2004). Many problem behaviours are proposed to be related to this inability to communicate effectively using language. Research has shown direct links between improved communicative ability and less disruptive behaviours (Carr & Durand, 1985; Durand & Carr, 1991; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998) highlighting the importance of communicative capabilities and general social functioning across the autism spectrum.

Picture Communication Symbols

One communicative intervention which is used to convey information to children with ASD is Picture Communication Symbols. These Picture Communication Symbols (PCS) show cartoon-like images which represent concepts important to everyday functioning within the learning and living environments of children with ASD. For example, picture symbols are sometimes presented alongside real (perhaps photographic) images to convey important information or in the school classroom to communicate a timetable. The application of visual schedules and prompts within a learning environment is said to aid communication and has been reported to reduce disruptive behavior (Dooley, Wilczenski & Torem, 2001) and improve task engagement (Masey & Wheeler, 2000). One picture system which is currently widely used for aiding communication in ASD is Boardmaker (BM). Visual prompts such as BM were introduced due to reports of impaired attention and comprehension of linguistic input in children with ASD (Hodgon, 1995). This visual system uses picture images which depict actions or objects (for example, snack time, play, and worksheet) to convey information to children with ASD regarding their environment and daily routine. This system is used to produce visual timetables and rule reminders (such as "wash hands in the bathroom").

The Picture Exchange Communication System (PECS; Bondy & Frost, 1994) is another picture communication system that is aimed at improving a child's ability to express their wants, needs and feelings to others. PECS is an alternative communication method which aims to teach *spontaneous* socio-communicative skills. PECS images can be used similarly to the BM images to make up visual schedules or rule reminders. However, PECS expands previous visual strategies to promote *initiations* of communication in children with ASD by utilising a behavioural paradigm. The PECS symbols are paired with an 'I want' image when the child is requesting an item or activity of interest.   The child partners their 'I want' strip with a symbol representing what they desire. The child must then exchange their symbol for the requested item which is unique to the PECS system (Bondy & Frost, 1994, 1998). Receipt of the requested item reinforces the communicated behaviour, i.e. producing a symbol. The system makes use of functional communicative responses that promote interactions between the child and the environment as it requires the child to approach a listener and initiate an interaction (Frost & Bondy, 1994). These steps may be difficult to overcome for some children functioning on the autism spectrum but is critical to everyday social skills.

Several studies have reported that PECS can increase non-verbal communication in children with ASD; some children are even proposed to acquire spoken language through regular PECS use (Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet 2002; Ganz and Simpson, 2004; Kravits, Kamps, Kemmerer, & Potucek, 2002). However, other studies have claimed the PECS system does not increase vocalizations or word utterances, but do report various changes in communicative behavior i.e. communication initiations, requesting actions or increased symbol use (Ganz, Simpson & Corbin-Newsome, 2008; Howlin, Gordon, Pasco, Wade, & Charman 2007; Yoder & Stone, 2006). Despite these encouraging reports for picture symbol use across the Autism Spectrum, some studies have reported that a minority of children with ASD are unable to use the picture systems efficiently as communication aids (Tincani 2004; Yoder & Stone 2006). Ganz *et al.* (2008) proposed that one potential reason for some children with ASD being unable to utilize and apply picture systems may be their impaired comprehension of what these images represent. This lack of image comprehension may involve children not allocating visual attention to relevant areas of the image and therefore not processing and understanding what the image represents. Previous research which explores how children with ASD visually scan images has proposed that areas of images showing people or faces may not attract or hold attention typically (e.g. Riby & Hancock 2008; 2009; Speer, Cook, McMahon, & Clark, 2007). It is important to explore how reported findings of attention orientation atypicalities associated with Autism relate to the images used in picture symbols

.

Attention to images with reduced ecological validity

It has been observed when presented with realistic stimuli individuals across the autism spectrum fixate longer on objects and allocate attention less on face areas than we would expect based on the pattern seen in typical development (for example, Klin, Jones, Schultz, Volkmar, & Cohen, 2002). However, one study conducted by van der Geest, Kemner, Camfferman, Verbaten, & van Engeland, (2002) found that child who were high functioning on the autism spectrum (n = 16) did not show atypical gaze patterns while viewing less realistic stimuli. Children with ASD were observed to fixate on people and objects presented within cartoon-like images in a manner that mirrored that seen in typical development. There was no evidence of atypical attention allocation to faces and people when they were presented about drawn, cartoon-like images. However, Riby and Hancock (2009) also presented stimuli of reduced ecological validity to children with ASD (cartoon images taken from the original TinTin animations), and found that children across the autism spectrum (n = 20) fixated less on the faces of the cartoon characters compared to the typically developing children. The cartoon-like figures shown in the images presented by Riby and Hancock (2009) are similar to the figures presented in the PECS system, both of which are more realistic than the drawings used by van der Geest and colleagues. Importantly, regarding the use of picture symbols, children with ASD may not be able to comprehend what the images represent if they are not fixating long enough on relevant areas of the images, specifically people and faces. To encode and process the images it is critical that children attend to them in a way that allows them access to relevant information.

This study aims to add to existing literature on visual attention allocation and the use of eye-tracking methodology with individuals who are functioning on the autism spectrum by linking research (which is often lab designed and highly controlled) to more realistic applications. Specifically we examine how picture symbols that are widely used in the classrooms of children with autism are attended to by those children functioning on the autism spectrum. In meeting this aim it will also be possible to explore whether images that differ in how natural / realistic the representations are (e.g. .ecological validity), will impact upon gaze patterns for children functioning on the autism spectrum. The images used in this study will be communicative picture symbols; the Picture Exchange Communication System (PECS) symbols and Boardmaker (BM) images. Despite both picture systems representing the same concepts using cartoon-like images; the BM symbols are less detailed and less realistic (less ecologically valid) when compared to the PECS symbols. For example, the BM symbols show oval shapes (with limited features and facial configurations) as faces and various shapes with little detail as objects. The PECS images differ by showing faces with eyebrow configurations (along with eyes, nose and mouth) and actual detail on object shapes such as pattern and colours to help clarify what the objects are. Using eye tracker technology, fixation lengths and patterns on both the PECS and BM images were explored as children with and without autism attend to the pictures. It is predicted that the participants with ASD would fixate less on the face areas regardless of picture symbol type (BM and PECS) compared to their typically developing matches. This prediction was based on previous research which found atypical attention to the face area by children with ASD compared to their typical matches despite viewing images with reduced ecological validity (Riby & Hancock, 2009). It is also proposed that the children with ASD would fixate longer on the object areas across symbol types compared to the typical groups since research has reported increased looking at and engaging with objects compared to typical (Baron-Cohen, Cox, Baird, Swettenham, Nightingale, Morgan, Drew, & Charman, 1996; Klin *et al.,* 2002; Swettenham, Baron-Cohen, Charman, Cox, Baird, & Drew, 1998; Trepagnier, Sebrechts, & Peterson, 2002).

Method

Participants

Twenty one children with ASD were recruited from special units attached to three mainstream schools, and one specialist ASD school (see Table 1). Participants ranged between 9 years 7 months and 16 years 5 months (mean = 13 years 7 months; SD = 2 years 5 months). Verbal ability was assessed using the British Picture Vocabulary Scale, second edition (BPVS II - Dunn, Dunn, Whetton & Burley, 1997) and provided a mean verbal mental age (VA) for the group of 7 years 3 months (ranging from 3 years 7 months to 15 years 2 months). Non-verbal ability was assessed by the Raven's Coloured Progressive Matrices (RCPM – Raven, Court & Raven, 1990) giving a mean score of 27 (ranging from 11 to 35; max score possible 36). All children with ASD who were recruited in the current study used the PECS and BM images as timetables and rule reminders. Due to the task demands of the formal assessments (BPVS II and RCPM) which are conducted to match children with ASD to typically developing counterparts of comparable ability; lower functioning children with ASD (who use the picture symbols as communication systems) were unable to be included in the current study. However, as noted, all children who took part in the study used and had access to these symbols and communication systems in their classrooms on a daily basis.

Table 1 here

The children with ASD were matched to three typically developing comparison children using individual matching criteria. The chronological age matched group of typically developing children had a mean chronological age of 13 years 6 months ($t(40) = .150$, $p = .96$). The VMA group was matched to the participants with ASD for verbal ability age using the BPVS II and had a mean verbal mental age of 7 years 4 months ($t(40) = -.079$, $p=.973$). The group matched for nonverbal ability (visuo-spatial ability) had a mean RCPM score of 27 ($t(40) = .090$, $p=.766$). The typically developing children were recruited from mainstream schools with ASD units attached. These children were therefore accustomed to the picture symbols being used throughout their schools to convey information.

All participants with ASD had previously been diagnosed by clinicians as functioning on the autism spectrum. The Childhood Autism Rating Scale (CARS; Schopler *et al.* 1988) rated 9 children as mild-moderately autistic and 7 children as severely autistic. The remaining 5 children (who did not score as having autism on the CARS) were further assessed using the Asperger Syndrome Diagnostic Scale (ASDS; Myles *et al.* 2001). All of the remaining children scored over 90 on the ASDS scale which indicates the presence of Asperger Syndrome. The Social Communication Questionnaire (SCQ; Rutter, Bailey, Berument, Lord & Pickles 2003) was conducted for all the children in the ASD group; 19 children obtained a score over 15 (a score of 15 or over implies the presence of ASD or PDD-NOS). The remaining two children showed a score of 13 and 11 which may imply these children have higher socio-communicative ability compared to the other children in the ASD group. Despite these two children manifesting better communicative abilities, they still displayed high levels of behaviour associated with Asperger syndrome as indicated on the ASDS. These scales were filled out and completed by teachers who had known and observed the children for at least two years prior to testing. Ethical approval and informed consent were received prior to the research being carried out.

Design and Procedure

Stimuli

Images from the PECS (pictures used with the permission of Pyramid Educational Consultants UK, Ltd) and BM images (The Picture Communication Symbols ©1981-2012 by DynaVox Mayer-Johnson. All Rights Reserved Worldwide. Used with permission) were selected showing objects or faces. The object images showed one or several objects, and the face images showed cartoon like people (head and shoulders) completing actions such as brushing teeth and shaving. Words were also presented alongside the objects or faces. The images selected were based on the pictures already used in the classroom to communicate a timetable, rules or used to request items and objects. Prior to testing, the researcher examined the symbol use across 4 separate schools (3 mainstream schools with specialist ASD units attached and 1 residential specialist ASD school). Symbols from both the PECS and BM systems that were used the most consistently across the schools were selected and presented as stimuli. The person and object images represented activities, desired objects and daily hygiene behaviours.

Images were also selected that could easily be followed up by the teachers in the classroom. For example, swimming was not chosen as the child may expect to go swimming after being shown the picture which represents this activity.

These picture symbols tend to be small (as part of a portable timetable etc.) and are typically 144x144 pixels (5.08 cm). These were increased in size by 400% which measures 576x576 pixels (20.32cm); using Adobe Photoshop CS (Adobe, San Jose, California, USA) so that eye tracking could be more efficiently used and areas of interest within the images could be readily identified.

The PECS pictures (n=10) and BM images (n=10) were shown in separate trial blocks as part of a battery of eye-tracking assessments. Each picture was presented for 3 seconds (in randomised order within the trial blocks) and separated with a blank screen showing a centralised fixation point for 1 second. It was proposed that presenting the images for 3 seconds was optimal to ascertain what areas of the image captured the children's attention and initially maintained attention. Presenting the images any longer may have allowed the children to conduct an exhaustive search. Participants were told 'please look at the pictures while they are on the screen', and no further instruction was provided.

Apparatus

The research used a Tobii 1750 eye-tracker (Tobii Technology, Stockholm, Sweden), using ClearView 1.5.10 (Tobii Technology) for the presentation of stimuli and recording eye movements. The eye-tracker was controlled via a Dell Inspiron 6400 (Dell, Round Rock, Texas, USA) laptop computer. The system is portable and was moved to the testing location of each individual. The system is also completely non-invasive, with no need to constrain the head or body and little indication that eye movements are being tracked. The Tobii 1750 system tracks both eyes to a rated accuracy of 0.5 degrees, sampled at 50 Hz and was calibrated for each participant using a 5-point infant calibration of each eye. Infant calibration was used so that low functioning children with ASD were able to be calibrated more easily (as this calibration method helps maintain attention for longer in lower functioning children).

ClearView 1.5.10 provides a ‘definition tool’ to identify areas of interest (AOI) for analyses. For all images, AOI were designated to faces and objects. The face AOIs were marked with the polygon definition tool covering the face region with a hairline boundary. AOI for the objects were defined using polygon definition tools also to mark the outline of the object or objects presented together.

To ensure accuracy of gaze recordings for each AOI, a bespoke programme was designed using Matlab (Mathworks, Natick, Massachusetts, USA). This ensured calibration was consistent across all stimuli (as calibration is only checked via the Tobii software at the beginning of the trial).

Design

This study employed a mixed design with between-subject factor of Group (4 levels: ASD, CA, VA, NVA) and within-subject factor being Symbol Type (2 levels: BM, PECS) and the AOI (2 levels: face, object).

Procedure

Participants were tested individually at home or at school. The whole session (battery of eye-tracking assessments) lasted 10-12 minutes with each trial block being presented for 2-3 minutes. Participants were seated approximately 50 cm from the eye-tracking screen with the experimenter sat to one side to control the computer but not interfere with viewing behaviour. The participant was told that they would see different types of pictures during the session and the first eye-tracking task involved calibration of the eye-tracker.

For this purpose, the participant followed a bouncing cat around the screen to five locations. All participants in this experiment were able to comply with task demands with their gaze calibrated successfully and therefore it was not necessary to remove any participants from the study. Following calibration, participants viewed the stimuli (the PECS trial block and the BM trial block) as part of a battery of eye-tracking assessments. All trial blocks were presented in a random order. Once all the conditions were complete the experimenter thanked and debriefed the participant.

Results

Task Engagement

Task engagement was calculated by examining total fixation time spent looking at the images. It was found that group had a significant effect on task engagement $F(3, 83) = 11.260$, $p<.001$. The ASD group engaged with the task significantly less compared to the CA and NVA group. Post-hoc bonferroni showed that the ASD group ($m=37970$ms) engaged significantly less than the CA group ($m = 48716$ms) ($p<.001$) and the NVA group ($m = 49190$ms) ($p<.001$). There was no significant difference between the ASD group and the VA ($m= 38828$ms; $p = .740$). The VA group also engaged with the task significantly less compared to the CA group ($p<.001$) and the

NVA group ($p<.001$). Therefore, to take into consideration this difference in the overall time spent attending to the images, proportional data are used for further analyses.

Proportion of mean total task fixation time.

The proportions of fixation time spent orienting to the areas of interest (faces and objects) were examined. The symbol type (PECS and BM) was examined as a within subjects factor also to highlight the different or similar ways that attention was allocated to the two symbol types, which present different levels of ecological validity within their images.

A mixed 4x2x2 ANOVA was carried out with between-subject factor Group (ASD, CA, VA, NVA) and within-subject factors Symbol Type (2 levels: BM; PECS) and AOI (2 levels: face or object). There was no significant main effect of Symbol Type $F (1, 80) = .032$, $p = .858$, $\eta^2_p = .000$ or Group $F (3,80) = 2.015$, $p =.119$, $\eta^2_p = .070$. There was a significant main effect of AOI with a larger proportion of gaze time to the face AOI ($m = .189$) compared to object AOIs ($m = .144$), $F (1,80) = 28.388$, $p <.001$, $\eta^2_p = .262$. Critically, the interactions between Group and Symbol Type $F (3, 80) = 1.697$, $p = .174$, $\eta^2_p = .060$ and Group with AOI $F (3,80) = 2.015$, $p =.119$, $\eta^2_p = .070$ (see Figure 1) were not significant.

Figure 1 here

There was a significant interaction between Symbol Type and AOI $F (1, 80) = 163.759$, $p < .001$, $\eta^2_p = .672$ and to investigate this significant interaction post-hoc paired samples t-tests were carried out. Participants fixated for a larger proportion of their time on the face AOI when attending to the PECS condition ($m = .256$) compared to the face AOI of BM images ($m = .122$) $t(83) = 10.790$, $p < .001$. Figure 2 shows that the PECS faces were fixated on longer than any other area of interest. In contrast, more attention was given to the object AOI of the BM images ($m = .213$) compared to PECS objects ($m = .075$) $t\ (83) = 6.819$, $p < .001$. Finally, the three way interaction between Symbol Type, Group and AOI was not significant $F\ (3, 80) = 2.597$, $p >.05$, $\eta^2_p = .089$.

Figure 2 here

<u>*Time Taken to Fixate*</u>

Time taken to fixate was examined to show which areas of the picture symbols were selected for attentional priority by the children with and without autism.

A mixed 4x2x2 ANOVA was carried out with between-subject factors being Group (ASD, CA, VA, NVA) and within-subject factors being Symbol type (BM and PECS) and the AOI (face and object). There was a significant main effect of Symbol type with faster fixation on the PECS images ($m = 599.9$ ms) compared to BM images ($m = 839.9$ms) $F\ (1, 80) = 34.471$, $p < .001$, $\eta^2_p= .301$, which can be clearly seen in Figure 3. There was no significant main effect of Group $F\ (3, 80) = 1.062$, $p = .370$, $\eta^2_p = .038$. There was no significant interaction between Group and Symbol Types $F\ (3,80) = .481$, $p = .696$, $\eta^2_p = .018$ indicating a lack of image preference for those with and those without autism.

Figure 3 here

There was a significant main effect of AOI, with faster fixation to objects AOIs (m = 634.9ms) compared to the face AOIs (m = 804.9ms) $F (1,80) = 26.131$, $p < .001$ $\eta^2_p = .246$ (Figure 3). The interaction between Symbol type and AOI was not significant $F (1,80) = 1.875$, $p = .175$, $\eta^2_p = .023$ and neither was the interaction between Group membership and symbol type $F (3, 80) = .223$, $p = .880$, $\eta^2_p = .008$. furthermore the three way interaction was not significant $F (3,80) = .707$, $p = .551$, $\eta^2_p = .026$.

Correlational Analysis

A Pearsons correlation was conducted to examine if attention to the object and face AOIs was significantly related to level of functioning across the autism spectrum (the CARS and SCQ).

There were no significant correlations between the CARS or SCQ scores and fixation duration or time taken to fixate on the face and object AOI s in the picture symbols (all ps>.05).

Discussion

This study extended the current literature on visual attention allocation in autism by using eye-tracking technology to investigate attention distribution in typical and atypical development when attending picture communication symbols. It was predicted that participants with ASD would look less than typical at face regions regardless of the type of picture symbol they were looking at (BM and PECS), however the results did not support this prediction. The participants with ASD fixated on the face AOI (irrespective of image type) in a typical manner. There was no significant reduction in the time spent attending to the faces for the individuals with ASD (against the suggestions of Riby & Hancock, 2009 but supporting van der Geest et al., 2002). Indeed, in the same manner as the typically developing participants, those with autism fixated for longer on the faces than the objects (irrespective of image type) compared to their typically developing matches. All groups including the ASD group fixated longer on the face AOIs across the stimuli types compared to the object AOIs. Therefore the current results, using picture images from communication systems used in learning environments, does not support predictions made at the beginning of the study which were based on previous research using more complex visual images and reporting increased attention to objects in ASD (for example, Klin *et al.* 2002; Swettenham *et al.* 1998).

These results may imply that when children with autism attend to images of this nature containing faces (e.g. with overall reduced ecological validity) they attend to them in a 'typical' manner. It is possible therefore that reduced ecological validity, as seen in the images used here, may reduce the atypicality of gaze behaviour which is often associated with functioning on the autism spectrum (see Speer, Cook, McMahon, & Clark, 2007; Pelphrey, Sasson, Reznick, Paul, Goldman, & Piven, 2002). This supports results reported by van der Geest *et al.* (2002) who found that children with ASD were able to fixate on the faces of cartoon-like figures similar to typically developing children because of their reduced 'realism'. However, investigating attention distribution patterns across the PECS and BM images does not suggest that by reducing ecological validity further increases face gaze. Faces in the PECS images (most realistic category used in this study) were attended to for longer than faces in the BM images (least realistic representation in current study)? It is a little difficult to compare across the categories of picture images used here but this does warrant further exploration in terms of how much these different types of image / picture symbol attract the attention of children with and without autism, especially if this is coupled with an exploration of symbol comprehension. Unfortunately it was beyond the scope of the current study to investigation the relationship between symbol comprehension and attention allocation but we will touch on this issue later. Importantly, the current results may have implications on how picture symbols are designed.

No significant correlations were observed between the CARS or SCQ scores and attention allocation to the different areas of interest in the picture symbols. Although caution is required due to the small sample size for a robust correlation analyses, the result does imply that level of functioning associated with autism is not related to the degree of typicality or atypicality of gaze behaviour and attention allocation for these picture symbols. This is important because the current sample included a wide range of abilities of children on the autism spectrum (it was not restricted to children with or without language for example) and therefore this allows us to know that similar attention and engagement may be seen for these symbols across the spectrum. This is important where teachers may use the symbols to capture attention and give direction in a class of pupils with different levels of functioning on the spectrum. These correlation results are inconsistent with Riby and Hancock (2009) who found that low functioning children with ASD fixated less on face areas even in images of reduced ecological validity. The results in the present study being inconsistent with Riby and Hancock’s (2009) findings is highly likely to be due to the different stimuli used and it may be that as the images increase in complexity (the images used by Riby and Hancock was far more complex than those used here) there is more relationship with typicality / atypicality of gaze behaviour. Some of the stimuli from Riby and Hancock (2009) presented more than one character within a static image, therefore presenting a social scene to the children with ASD. The picture symbols presented in the current study showed a single person depicting an action (a crucial difference of stimuli). Furthermore, a recent study by Hanley, McPhillips, Mulhern, and Riby (In press) highlights the importance of social complexity and how this impacts on attention allocation for individuals with ASD. The researchers compared gaze behaviour to social and isolated scenes in adolescents (n = 14) with Asperger Syndrome (AS). They found that the group with AS attended face and eye areas significantly less compared to typically developing counterparts during social scenes only. This study therefore highlights that social complexity increases atypical gaze behaviour in ASD and may explain the discrepancy between the results reported in the current line of enquiry and previous research (e.g. Riby & Hancock 2009). When there is only a single or isolated person presented, children with ASD may be able to fixate typically and attend the important information presented within the images.

The findings within this study also did not support the prediction that children with ASD would fixate longer on object AOIs due to previous reports of a pre-occupation with objects (Klin *et al.* 2002; Swettenham *et al.*, 1998). This difference is likely to be related to the type of stimuli used once again. Klin *et al.* (2002) presented dynamic social scenes showing real people engaged in interactions. The reduction of ecological validity in the present study may have reduced any preferential looking at objects by children with ASD. Klin *et al.*'s study not only presented scenes showing real objects to individuals with ASD but also varying numbers of people engaged in social interactions. Individuals with severe autism may lack the motivation to attend social stimuli such as faces during social interactions and therefore instead fixate on something they are interested in such as objects. It has also been proposed that increased attention to objects only takes place when objects are of unique interest to specific individuals with ASD (Pierce & Redcay, 2008). Therefore reduced attention to objects within this study may have been caused by the presentation of objects that did not provoke interest in children with ASD and where there was little competition presented between the face versus object.

The results reported in this study are encouraging for the use of picture symbols (both BM and PECS) with children on the autism spectrum as they attend to the varying aspects of the images and therefore (if their cognitive capacity allows them to do so) they have the ability to process the information that they attend to. With the typical nature of attention allocation seen here, there is the same opportunity for children with autism to process and encode this visual information as seen in typical development. The current findings suggest that they are attending to the faces shown within their communicative systems long enough to encode the relevant information. Further research may add to these findings by exploring how attention to the symbols is associated with understanding what the symbols represent and being able to use the picture systems efficiently. In this way eye tracking may be particularly useful to explore any difference in the symbols that appear to be understood and those that children may struggle with. Involving children who regularly view these symbols in their classrooms / school was essential to the current task but taking the next step to link attention distribution and the interpretation of the symbols, plus their use in communication, is essential to advance our understanding of using picture symbols to aid communication for children with autism. Taking the next step in this type of exploration will allow the results to have clear applied implications.

This study also set out to clarify the discrepancies raised by the different results reported by Riby and Hancock (2009) and van der Geest *et al.,* (2002). Both these studies explored the impact of reduced ecological validity on gaze behaviour in children with ASD. The present findings show that when ecological validity is reduced and images are not complex then children with ASD attend typically to relevant areas of the images. The results from the current experiment further suggest that regardless of impairment level, children across the Autism Spectrum (from low functioning to high functioning) attend to picture symbols of reduced ecological validity similarly. It is particularly important that children with severe autism are able to fixate to the symbols for a sufficient amount of time and not show the reduced fixation which previous studies may have implied (Riby & Hancock, 2009). This is due to the picture systems being used specifically as an augmentative communication method for lower functioning children with ASD who show impaired speech and communicative abilities (APA, 2000) and therefore rely more on these alternative communicative strategies.

The results reported here provide important groundwork for further exploration of attention allocation when children utilise picture communication systems to aid their everyday functioning and communication.

References

American Psychological Association. (2000). Diagnostic *and statistical manual of mental disorders,* (DSM-IV text revision). Washington, DC: Author.

Baron-Cohen, S., Cox, A., Baird, G., Swettenham, J., Nightingale, N., Morgan, K., Drew, A., & Charman, T. (1996). Psychological markers in the detection of autism in infancy in a large population. *British Journal of Psychiatry, 168,* 158-163.

Bondy, A. S., & Frost, L. A. (1994). The picture exchange communication system. *Focus on Autistic Behaviour, 9,* 1-9.

Bondy, A. S., & Frost, L. A. (1998). The picture exchange communication system. *Seminars in Speech and Language, 19,* 373-389.

Carr, E. G., & Durand, V. M. (1985). Reducing behaviour problems through functional communication training. *Journal of Applied Behaviour Analysis, 18,* 111-126.

Charlop, M. H., & Haymes, L. K. (1994). Speech and language acquisition and intervention: Behavioural approaches. In J. L. Matson (Ed.), *Autism in children and adults: Etiology, assessment, and intervention* (pp. 213-240). Pacific Grove, CA: Brooks/Cole.

Charlop-Christy, M. H., Carpenter, M., Le, L., LeBlanc, L. A., & Kellet, K. (2002). Using the picture exchange communication system (PECS) with children with autism: Assessment of PECS acquisition, speech, social-communicative behaviour, and problem behaviour. *Journal of Applied Behaviour Analysis, 35,* 213-231.

Dooley, P., Wilczenski, F. L., & Torem, C. (2001). Using an activity schedule to smooth school transitions. *Journal of Positive Behavior Interventions, 3,* (1), 57-61.

Durand, V. M., & Carr, E. G. (1991). Functional communication training to reduce challenging behaviour: Maintenance and application in new set things. *Journal of Applied Behaviour Analysis, 24,* 251-264.

Ganz, L. B., & Simpson, R. L. (2004). Effects on communicative requesting and speech development of the picture exchange communication system in children with characteristics of autism. *Journal of Autism and Developmental Disorders, 34,* 395-409.

Ganz, L. B., Simpson, R. L., & Corbin-Newsome, J. (2008). The impact of the Picture Exchange Communication System on requesting and speech development in pre-schoolers with autism spectrum disorders and similar characteristics. *Research in Autism Spectrum Disorders, 2,* 157-169.

Hagopian, L. P., Fisher, W. W., Sullivan, M. T., Acquisto, J., & LeBlanc, L. A. (1998). Effectiveness of functional communication training with and without extinction and punishment: A summary of 21 inpatient cases. *Journal of Applied behaviour Analysis, 31,* 211-235.

Hanley, M., McPhillips, M., Mulhern, G. and Riby, D. M. (In press). Spontaneous attention to faces in Asperger Syndrome using ecologically valid static stimuli *Autism.*

Hodgon, L. G. (1995). *Solving social-behavioural problems through the use of visually supported communication.* USA: QuirkRoberts Publishing.

Howlin, P., Gordon, R. K., Pasco, G., Wade, A., & Charman, T. (2007). The effectiveness of Picture Exchange Communication System (PECS) training for teachers of children with Autism: A pragmatic group randomised controlled trial. *Journal of Child Psychology and Psychiatry, 48,* 473-481.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry,* 59, 809-816.

Kravits, T. R., Kamps, D. M., Kremmerer, K., & Potucek, J. (2002). Brief Report: Increasing communication skills for an elementary-aged student with autism using the picture-exchange communication system. *Journal of Autism and Developmental Disorders, 32,* 225-230.

Masey, G., & Wheeler, J. (2000). Acquisition and generalisation of activity schedules and their effects on task engagement in a young child with autism in an inclusive pre-school classroom. *Education and Training in Mental Retardation and Developmental Disabilities, 35,* 326-335.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders*, *32*, 249–261.

Pierce, K., & Redcay, E. (2008). Fusiform function in children with an ASD is a matter of "who". *Journal of Biological Psychiatry, 64,* (7), 552-560.

Riby, D. M., & Hancock, P. J. B. (2008). Viewing it differently: Social scene perception in Williams syndrome and Autism. *Neuropsychology*, *46,* 2855–2860.

Riby, D. M. & Hancock, P. J. B. (2009). Looking at movies and cartoons: Eye-tracking evidence from Williams syndrome and Autism. *Journal of Intellectual Disability Research*, *53,* 169–181.

Rutter, M., Bailey, A., Berument, S. K., Lord, C., & Pickles, A. (2003). *Social Communication Questionnaire (SCQ).* Los Angeles, CA: Western Psychological Services.

Schopler, E., Reichler, R., & Rocher-Renner, B. (1998). *The childhood autism rating scale (CARS).* Los Angeles, CA: Western Psychological Services.

Speer, L. L., Cook, A. E., McMahon, W. M., & Clark, E. (2007). Face processing in children with autism: Effects of stimulus contents and type. *Autism*, *11*, 265–277.

Swettenham, J., Baron-Cohen, S., Charman, T., Cox, A., Baird, G., & Drew, A. (1998). The frequency and distribution of spontaneous attention shifts between social and non-social stimuli in autistic, typically developing, and non-autistic developmentally delayed infants. *Journal of Child Psychology and Psychiatry, 39,* 747-753.

Tincani, M. (2004). Comparing sign language and picture exchange training for students with autism and multiple disabilities. *Focus on Autism and Other Developmental Disabilities, 19,* 162-173.

Trepagnier, C., Sebrechts, M. M., & Peterson, R. (2002). Atypical face gaze in autism. *Cyberpsychology and Behavior, 5,* (3), 213–217.

van der Geest, J. N., Kemner, C., Camfferman, G., Verbaten, M. N., & van Engeland, H. (2002). Looking at images with human figures: Comparison between autistic and normal children. *Journal of Autism and Developmental Disorders, 32,* 69–75.

Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T., & Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 45,* 135-170.

Yoder, P. J., & Stone, W. L. (2006). Randomised comparison of two communicative interventions for pre-schoolers with autism spectrum disorders. *Journal of Consulting and Clinical Psychology, 74,* 426-435.

Table 1

Participant details for children with ASD and their typically developing comparison groups (standard error within parenthesis)

Group	N	Gender Ratio males:females	CA[i]	VA[ii]	NVA[iii]
Autism Spectrum Disorder (ASD)	21	20:1	13y 7m (30)	74 (27)	27 (7)
Chronological Aged Matched (CA)	21	15:6	13y 6m (24)	113 (19)	32 (6)
Verbal Ability Aged Matched (VA)	21	14:7	8y 4m (28)	75 (23)	22 (7)
Non-Verbal Ability Aged Matched (NVA)	21	18:3	10y 4m (24)	98 (22)	27 (5)

i Chronological age provided in years and full months. Standard deviation provided in full months in parenthesis.
ii Verbal ability is calculated using the mean raw score from the British Picture Vocabulary Scale standard deviation in parenthesis.
iii Nonverbal ability is provided as mean scores on the Ravens Coloured Progressive Matrices task (max. score 36) standard deviation in parenthesis.

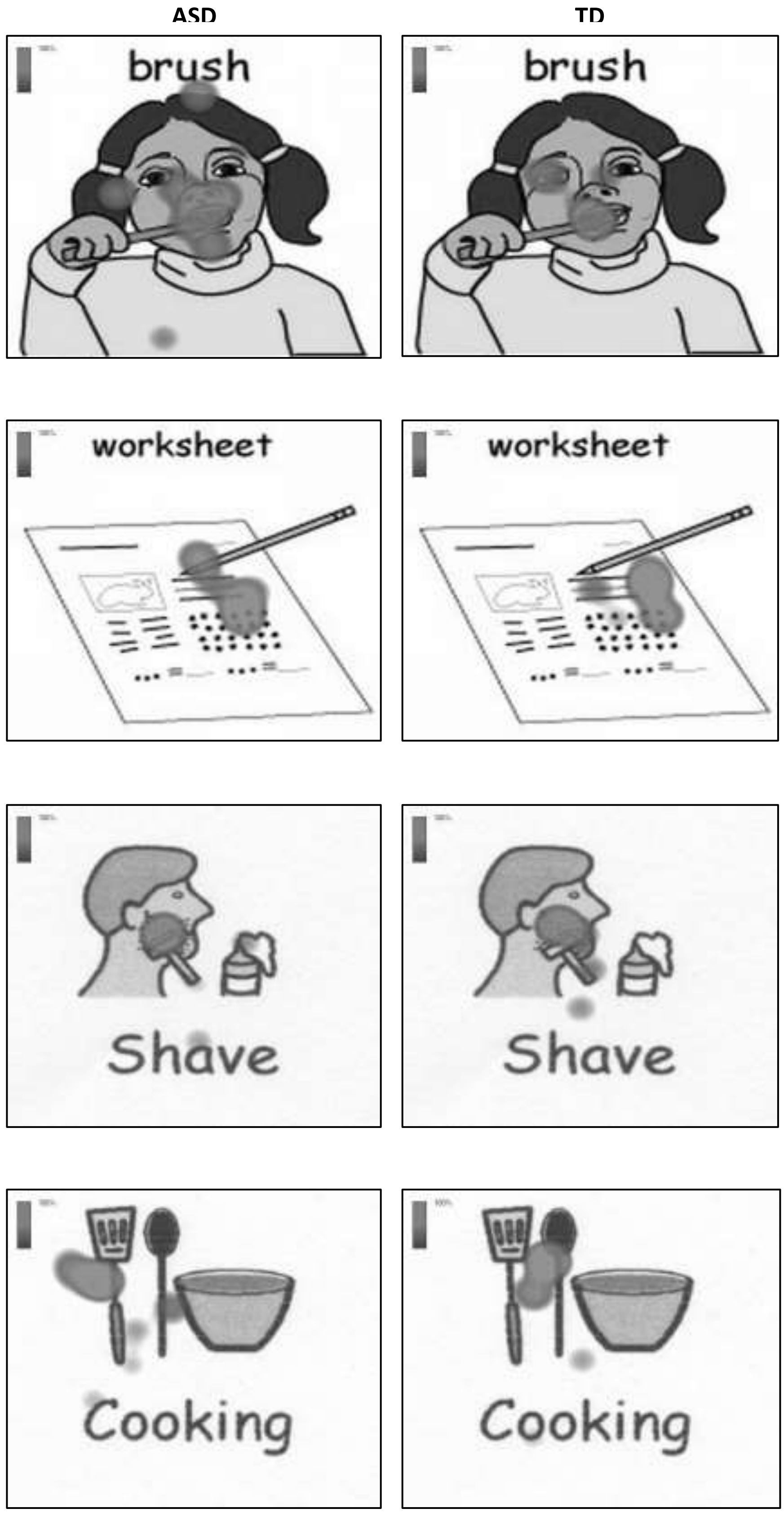
ASD
TD
brush
brush
worksheet
worksheet
Shave
Shave
Cooking
Cooking

Figure 1 Examples of fixation durations by children in the ASD and TD groups while looking at PECS images and BM images showing faces and objects.

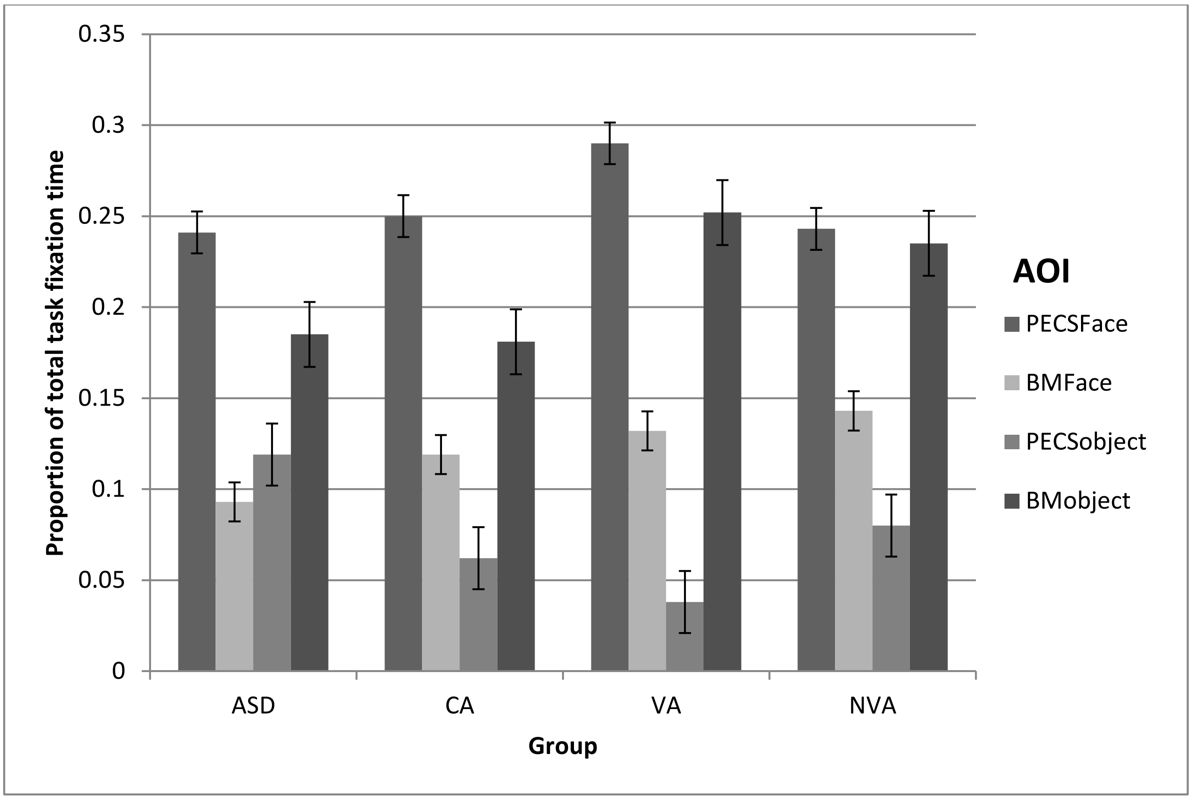

Figure 2 How attention was allocated to the face and object AOIs in PECS and BM images across groups.

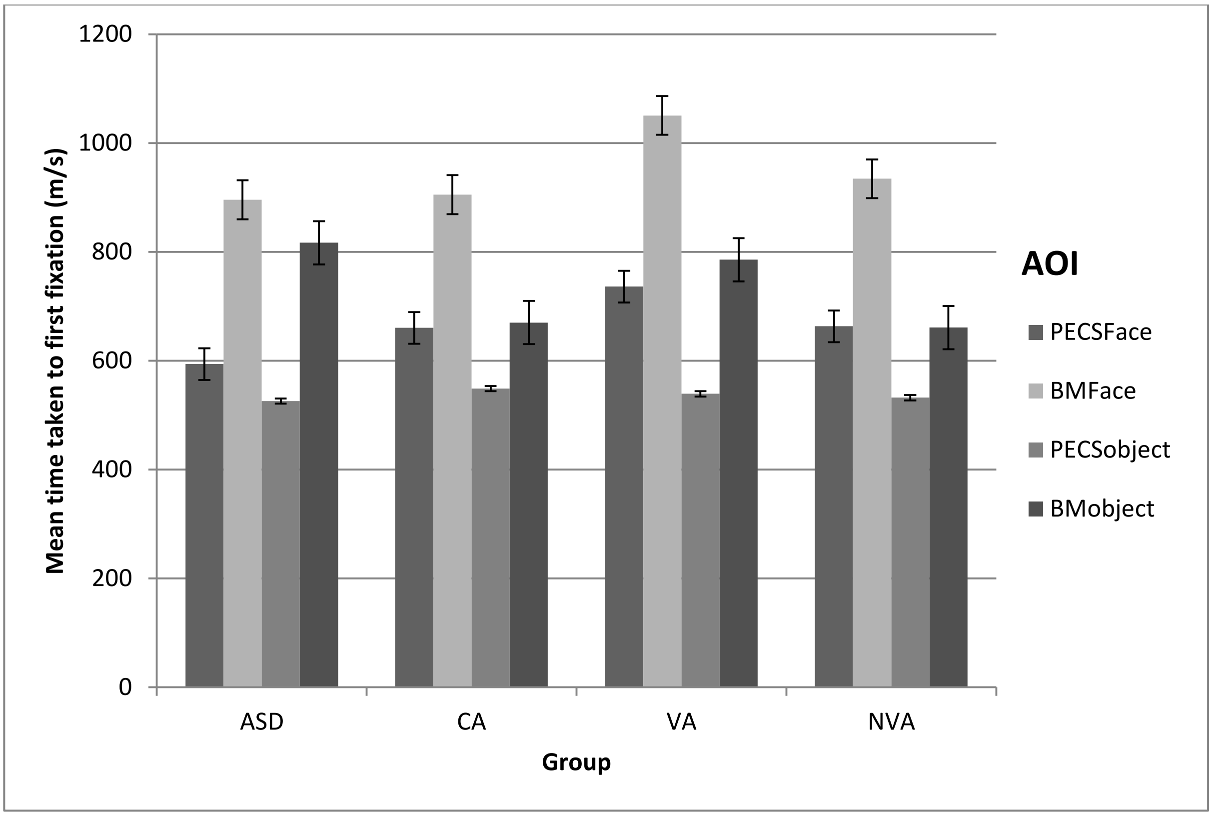

Figure 3 Mean time taken to fixate on face and object AOIs in Picture Exchange Communication (PECS) and Boardmaker (BM) images across groups.