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Visual Attention to Photograph and Cartoon Images in Social StoriesTM: A Comparison of Typically Developing Children and Children with ASD

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VISUAL ATTENTION TO PHOTOGRAPHS AND CARTOON IMAGES IN SOCIAL STORIES™: A COMPARISON OF TYPICAL DEVELOPING CHILDREN AND CHILDREN WITH ASD

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ABSTRACT

Autism Spectrum Disorder (ASD) is often accompanied by atypical attention to faces. Some previous studies have suggested that children with ASD demonstrate strengths when processing visual information from cartoons, whereas others have argued that photographic stimuli confer benefits. No previous studies have compared photograph and cartoon images of faces (i.e., Boardmaker [BM] images) in the context of a Social Story™ (Gray, 2010): a common intervention to support behavior and social cognition in children with ASD. In this study, we examined visual attention to static face stimuli in the context of Social Stories™. Participants were 19 typically developing (TD) children and 18 age-matched children with ASD. We addressed two questions: 1) Is there a difference between TD children and children with ASD in how they attend to cartoon and photographic stimuli in the context of a Social Story™? and 2) Do group differences in visual attention to BM and/or photographic stimuli correlate with age and indices of autism severity, executive function, intellectual functioning, and weak central coherence? With regard to question 1 and with one exception, we found no differences between groups when viewing images of faces. The exception involved our cartoon and photograph images that differed in content from the other face images in that they represented a person's full body as well as a range of objects (i.e., it was a more complex scene). For these images an interaction was observed such that the TD and ASD groups were no different in their looking patterns in the BoardMaker condition but they were different in the photograph condition. More specifically, we found that a shift toward more mouth-looking in the photograph condition among children with ASD was negatively associated with attention shifting and verbal IQ and that a shift toward more 'other'-looking (i.e., looking that occurred outside the eye and mouth region of the face) was negatively associated with attention shifting, age, and central coherence. These findings suggest that children with ASD demonstrate typical visual attention patterns to both cartoon and photographic stimuli representing faces but that children with ASD employ an atypical scanning strategy when presented with photographic stimuli representing more complex social scenes. The theoretical and clinical implications of the findings are discussed.

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Chapter 1: Review of the Literature

Despite the oft-cited importance of visual supports to facilitate communication and more appropriate behavior in ASD (Arthur-Kelly, Sigafoos, Green, Mathisen, & Arthur-Kelly, 2008; Simpson, Smith Myles, & Ganz, 2000), very few studies have been conducted to examine the efficacy of different kinds of visual supports that are most commonly used in intervention. The one study that was conducted in this area was done by Gillespie-Smith, Riby, Hancock, and Doherty-Sneddon (2014) who used eye tracking to examine how children with ASD and their typically developing (TD) counterparts attended to picture communication symbols (also known as BoardMaker [BM] images) used in the Picture Exchange Communication System. Results indicated that children with ASD attended to these images in a manner that did not differentiate them from TD children. The authors concluded that children with and without ASD have the same opportunity to encode the information available in the images.

Furthermore, individuals with ASD are generally considered to be better visual learners as they often experience auditory processing problems, encouraging the use of visual supports as an intervention strategy. Visual supports have the potential to support information processing through reducing executive demands, which are a common concern in ASD. Despite their importance, the nature of the visual supports used to facilitate learning in ASD has received minimal attention and little is known about the kinds of stimuli that predict (or potentially hinder) success with intervention. The purpose of this study was to examine the visual attention of TD children and children with ASD in response to two kinds of social static stimuli most often employed as visual supports in the context of intervention. The present study builds on the research of Gillespie-Smith et al. (2014) in two important ways. First, visual attention of TD children and children with ASD to two different kinds of stimuli (BM images vs. photographs) was compared. Second, visual attention to these images was examined when they are incorporated into Social Stories™ (Gray, 2010), which is one of the most widely used interventions in ASD (Arthur-Kelly et al., 2008; Hess, Morrier, Heflin, & Ivey, 2007). This literature review will describe: 1) eye tracking studies on visual attention to social stimuli, 2) potential mechanisms to account for atypical visual attention to faces often observed in ASD, 3) contradictory views on the superiority of cartoon-like versus photographic stimuli for supporting social understanding in ASD, and 4) a brief description of Social Stories™.

1.1 Eye tracking Studies and Visual Attention to Social Stimuli

Eye tracking involves measuring the movement of the eyes and mapping the gaze to the real-world (Feng, 2011). Eye tracking studies usually examine saccades and fixations. A saccade is a ballistic eye movement between fixations, which refer to a period of time when the eyes stabilize on an area of interest. Saccades and fixations are assessed to identify an individual's scan path or gaze pattern. Generally speaking, the analysis of visual attention priorities is important because how we attend to the world influences the knowledge that we have, which, in turn, can impact how we interact with our environment (Freeth, Chapman, Ropar, & Mitchell, 2010). Furthermore, it seems likely that visual attention in ASD is driven by face processing decisions that reflect the underlying social-cognitive deficits in ASD. Although the precise links from gaze to social-cognition are complex and uncertain, what children look at (and what they do not look at) can have profound developmental consequences (Feng, 2011).

In a now classic eye tracking study, Klin et al. (2002) demonstrated atypical social attention in children with ASD while viewing dynamic social scenes from *Who's Afraid of Virginia Wolf?* In comparison to age-, sex-, and IQ-matched TD children, children with ASD evidenced more fixations to mouth, body, and object areas of interest (AOIs) and fewer fixations to the eye region of the face. Klin and colleagues (2002) suggested that decreased fixation time to the eye region of the face was the best predictor of ASD and social competence, within the parameters of their study. Speer, Cook, McMahon, and Clark (2007) found similar results, in which the most significant difference between participants with ASD and the TD comparison group was the duration of fixation on the eye region. This study also revealed that children with ASD "spent marginally more time looking at the body…than did individuals in the comparison group" (p. 274). Similarly, Rice et al. (2012) found children with ASD demonstrated altered social visual engagement with naturalistic social stimuli (e.g., two videos of school-aged children interacting in everyday scenarios) in comparison to age-, gender-, and IQ-matched TD peers. Children with ASD were found to focus more on objects in the scene and less on face regions (i.e., mouth and eyes). Norbury, Brock, Cragg, Einav, Griffiths, and Nation (2009) found consistent results thus lending further support for the notion that children with ASD tend to focus less on eye regions when viewing dynamic social situations. Taken together, these studies suggest that when viewing complex social scenes using dynamic stimuli, children with ASD attend more to objects and less to people (or their faces) compared to their TD peers.

It is crucial to note that when it comes to the question of whether individuals with ASD exhibit excess mouth-looking and diminished eye-looking relative to TD individuals, the evidence is mixed (for review see Guillon et al., 2014). Indeed, several studies have failed to document differences in eye- versus mouth-looking (Anderson, Colombo, & Shaddy, 2006; Bar-Haim, Shulman, Lamy, & Reuveni, 2006) and many have concluded that there is a great deal of similarity in how TD and ASD groups allocate visual attention, such as the proportionally greater attention to the eye region as compared with the mouth (Falkmer, Larsson, Bjällmark, & Falkmer, 2010; Snow et al., 2011). Nevertheless, when differences are observed, it is important to consider what mechanisms may be operating so as to understand the theoretical underpinnings of social attention in ASD that may have implications for clinical practice.

1.2 Potential Mechanisms to Account for Atypical Visual Attention to Faces in ASD

A number of studies have found that children with ASD direct more visual attention to objects within their visual field compared to people (e.g., Riby & Hancock, 2008; Sasson & Touchstone, 2013). The term 'restricted interests' refers to highly circumscribed interests that ultimately impact daily living. Restricted interests are a common feature seen in ASD (Sasson, Turner-Brown, Holtzclaw, Lam, & Bodfish, 2008) and some researchers have proposed that children with ASD evidence less frequent but longer fixations to objects compared to people because of a higher degree of interest in objects (Sasson et al., 2008; Grelotti et al., 2004). If children with ASD orient less to areas containing social information, this may help explain why not only object regions but also mouth and body regions of the visual field are privileged over the high degree of social information given in the eye region of faces (Chawarska, Macari, & Shic, 2013; Klin et al., 2002; Riby & Hancock, 2008; Rice et al., 2012; Speer et al., 2007).

It has also been suggested that differences in the social attention of children with ASD might be due to abnormal top-down processing strategies. Top-down processing is driven by the meaning of the stimulus as well as the learned associations and expectations that have been developed about a stimulus (Neumann, Spezio, Piven, & Adolphs, 2006). Insufficient top-down processing may contribute to difficulties using gaze following as a visual cue (Neumann et al., 2006) and is consistent with the notion that social learning, which is deficient in ASD, is dependent on successful learned experience (Chawarska et al., 2013). Of course, other processes may also be at work. Sasson et al. (2008) argued that it is not an atypical top-down process, but rather an atypical detail-oriented processing style that underlies a preference for objects that is sometimes observed in children with ASD. Sasson and colleagues (2008) maintained "children with autism have a domain-general pattern of visual attention that may represent an exaggeration of a typical attentional process and is related to a tendency to perseverate on images of interest and explore them in a more detail-oriented manner" (p. 31). These conclusions are consistent with the theory of weak central coherence (WCC) (Frith, 1989), which was originally proposed to account not only for many of the deficits of ASD, but also reported strengths. WCC refers to an information processing style that relies on detail- or piecemeal-oriented processing which differs from the normative processing style that is oriented toward holistic or gestalt-processing (Frith, 1989; Frith & Happé, 1994; Happé, Briskman, & Frith, 2001).

The WCC theory has been invoked to explain the face processing differences often observed in children with ASD, but the results have been mixed. Some studies find support for WCC as a causal and explanatory mechanism (e.g., Deruelle, Rondan, &

Gepner, 2006; Kätsyri, Saalasti, Tiippana, Wendt, & Sams, 2008; Kimchi, 1994; Lopez, Donnelly, Hadwin, & Leekam, 2004). Conversely, others have suggested that children with ASD employ a configural (i.e., holistic) processing strategy, arguing that central coherence is intact in children with ASD (Donnelly & Davidoff, 1999; Joseph & Tanaka, 2003). The current state of the evidenced seems to suggest that 1) not all children with ASD adopt a cognitive style of WCC, 2) when it does operate, WCC is not the only factor that can lead to atypical visual attention and, 3) the heterogeneity of ASD almost certainly leads to the contrasting results. As noted by Deruelle et al. (2006):

> On the one hand, autistic profiles may be associated with preserved or even enhanced cognitive abilities. On the other hand, autism is also commonly associated with impaired social and communicative developments, as well as restricted interests or activities. Whether the global/configural dissociation can account for these social impairments is unclear. Other theories focusing for instance on deficits in executive functions or theory of mind, might better account for the atypical social behavior of children with autism. Still, the global/configural dissociation had the advantage of potentially accounting for both deficits and enhanced competencies in autistic children, while other theories only account for deficits (p. 105).

Building on the idea that WCC cannot solely account for the atypical visual attention to faces demonstrated by children with ASD, it is possible that other processes and mechanisms may be operating as well. One possibility is that eye-looking is anxiety-provoking for children with ASD. As noted by Langdell (1978) " 'gaze avoidance' is due to a high level of arousal in the autistic child" (p. 256), indicating that eye contact may be a source of distress for children with ASD. In agreement with Langdell (1978), Riby and Hancock (2008), Chawarska et al. (2013), and Rice et al. (2012) found that children with ASD attend less to eyes and faces in general, suggesting that eye-looking is avoided because of the anxiety it may cause.

Furthering the notion of the likelihood of multiple mechanisms, executive functioning (EF) abilities have also been investigated. EF refers to the cognitive resources required to carry out higher-order functions (e.g., working memory, attention, planning, attention shifting). Recently, a study by Hutchins and Brien (2016) examined how children with ASD visually attend to a speaking-partner during conversation. Specifically, children with ASD participated in two conversations: one about "how people feel" and one about "what people do." Children with ASD were found to look longer at mouths and had fewer fixations to the eyes during the "how people feel" conversation (Hutchins & Brien, 2016, p. 1). These findings suggest that executive functioning is strained when children with ASD engage in social interactions. Furthermore, the stress put on executive functioning during social interactions may account for decreased eye-looking in children with ASD.

There is still much debate on surrounding which mechanisms underlie the atypical looking patterns that are often observed in children with ASD. One goal of this study is to examine whether different patterns of visual attention are associated with constructs such as executive functioning and weak central coherence in an attempt to elucidate causal mechanisms.

1.3 Visual Attention to Static Cartoons and Photographic Social Stimuli

As noted above, children with ASD often benefit from interventions that incorporate visual supports to improve their communicative and behavioral functioning. Visual supports are pictorial and provide concrete support to enhance comprehension and learning for individuals who struggle to communicate (Arthur-Kelly et al., 2008). The transient, temporal, and serial nature of language may contribute to the language comprehension difficulties often experienced by individuals with ASD. Static visual supports, however, are fixed, atemporal, and persist in ways that help children with ASD access information in a more efficient manner. Indeed, the visual pathway may be the preferred sensory modality for many children with ASD and visual supports may facilitate predictability, organization, and communication through tools such as visual schedules and timers (Arthur-Kelly et al., 2008; Dettmer, Simpson, Brenda, & Ganz, 2000).

When it comes to the debate about what kinds of visual supports are most effective for children with ASD, there is a small but growing body of research that has considered various kinds of stimuli, with many researchers arguing for the superiority of cartoon stimuli over photographic stimuli. For example, children with ASD have been found to process photographs of faces in a local and piecemeal style, whereas TD children process photographic stimuli of faces in configural, gestalt, or holistic manner (Grelotti et al., 2004; Rosset, Rondan, Da Fonseca, Santos, Assouline, & Deruelle, 2007). However, an opposite processing pattern (referred to previously as weak central coherence) is observed when children with ASD and TD children are compared when viewing cartoons (Brosnan, Johnson, Grawmeyer, Chapman, & Benton, 2015; Grelotti et al., 2004; Rosset et al., 2007). These divergent patterns are demonstrated via the inversion effect, in which faces are presented up-side-down. Langdell (1978) demonstrated the inversion effect in his study of ASD and TD children, reporting that older children with ASD were better able to recognize photographs of inverted faces in comparison to controls. Therefore children with ASD may not interpret the face as a social stimulus, but as a “pure pattern” (Landgell, 1978, p. 257) accounting for the processing differences of inverted faces. While TD peers display a prolonged response when presented with inverted faces (which is more typical), children with ASD respond more accurately when faces are upside down (which is more atypical as suggestive of piecemeal processing) (Rosset et al., 2007).

Another explanation for the more typical processing of cartoons among children with ASD may involve the interest and expertise they often have with cartoons (Grelotti et al., 2004). Grelotti et al. (2004) states “experts in a domain, such as dog or bird experts, can categorize objects at the individual level as fast as at the basic level” (p. 380) and found that children with ASD displayed expertise at the individual level for a cartoon of interest (e.g., Digimon) but not for faces. Results of this study suggest that children with ASD are not experts at processing faces, but are experts when processing non-face objects which is related to the motivation underlying their interests.

More effective processing of cartoon stimuli may also be related to the reduced social complexity and social realism of cartoons relative to photographic representations of faces. That is, photographic images contain subtle social information that requires accurate interpretation, which is challenging for many individuals with ASD (Brosnan et al., 2015; Riby & Hancock, 2008). This interpretation is in line with the conclusions of Gillespie-Smith et al. (2014) who argued that “social complexity increases atypical gaze behavior” in ASD (p. 468). Furthermore, Downs and Smith (2004) found that children with ASD performed significantly worse than TD peers when recognizing emotions from photographs; however, they did not differ in other emotional recognition tasks (i.e., drawings of emotions, belief-based emotion, desire-based emotion, and situation-based emotion). In a related vein, cartoon stimuli are also less complex relative to photographic stimuli with regard to physical complexity (e.g., color, shading, contours, contrasting edges). Angermeier, Schlosser, Luiselli, Harrington, and Carter (2007) addressed whether more simplistic images would be more beneficial within the context of PECs. Angermeier et al. (2007) concluded that more simplistic images would be beneficial in therapy and increase the likelihood generalization will occur since they would not lock a child with ASD into a specific symbol-referent relationship (as discussed more fully below, Hartley and Allen [2015] take the opposing view and argue for the value of the literal accuracy of photographs).

Additional support for the use of cartoon-like stimuli comes from decades of research documenting the effectiveness of an intervention designed to facilitate the communication of children with ASD with the most limited verbal abilities, i.e., the Picture Exchange Communication System (PECS). Generally speaking, PECS has been a beneficial therapy tool for children with ASD (Angermeier et al., 2007; Ganz & Simpson, 2004; Ganz et al., 2008; Gillespie-Smith et al., 2014; Hartley & Allen, 2013). An increase in overall communication (Angermeier et al., 2007; Ganz & Simpson, 2004) and an increase in generalization of skills (Ganz, Sigafoos, Simpson, & Cook, 2008; Hartley & Allen, 2013) have been found when PECS is used for children with ASD.

Of course, there are also researchers who argue that photographic stimuli are better suited to facilitate communication and training of persons with ASD. For example, it has been reported that children with ASD may not benefit from cartoon images because they have a hard time understanding that cartoons serve as representations of real objects. As Hartley and Allen (2013) argued “children with autism may fail to treat pictures as symbols for several reasons” and “this achievement has been linked to language development and the ability to understand referential intentions” (p. 16).

Considering that pictures represent real objects (Hartley & Allen, 2013), they can be considered to be literally accurate, which may facilitate the ability of individuals with ASD to correctly access an image's meaning. In a recent study comparing TD children and children with ASD, Hartley and Allen (2015) tested the ability of participants to "contextualize" (p. 570) the symbolic information communicated by pictures, black and white line-drawings, and abstract color picture drawings. These stimuli were created and chosen based on their literal accuracy, where pictures were most literally accurate and abstract pictures were the least literally accurate. Participants were shown a picture of where a toy was hidden and asked to find it in the therapy room. After finding the toy, the child was asked to identify the picture shown in isolation. Results showed that children with ASD and TD children were able to recall objects using all picture types but the most realistic representations (i.e., those with high literal accuracy) significantly benefited performance in both groups. Authors concluded that children with ASD could "contextualize mental representations of pictures and use them to adaptively guide their behavior" (p. 576), highlighting that children with ASD were able to understand that pictures have a referential purpose. Furthermore, receptive language ability, in both TD children and children with ASD, was associated with better performance. In summary, the findings of this study suggest that color pictures with high literal accuracy will be beneficial when using picture-based communication interventions for children with ASD.

Another study by Hartley and Allen (2014a) addressed whether children with ASD could generalize labels from color photographs to actual objects based on sameness of color, shape, or both. Results demonstrated that children with ASD were more likely to sort objects based on color rather than shape, indicating difficulty understanding that symbolic word-picture-object relations are constrained by shape. Findings suggested that children with ASD created “mental representations that are characterized by multiple, equally-weighted, perceptual details (e.g., shape and color) that serve as independent bases for label extension” (p. 2070). This study incorporated a linguistic component (e.g., labels), adding another layer of complexity for children to sort through, which may have influenced the ability of children with ASD to access all features of the photograph. The results of Hartley and Allen (2014b) and Hartley and Allen (2015) suggest children are able to understand the referential nature of photographs. However, incorporating a linguistic component, as used in Hartley and Allen (2014a), may hinder the ability of a child with ASD to generalize labels of photographs to objects.

Hartley and Allen (2013) also examined whether object resemblance (i.e., literal accuracy) or representational intent (i.e., which requires an understanding of what the artist intended to represent) could be used as cues for children with ASD when mapping picture-object relations. This study demonstrated that children with ASD matched pictures to objects based on resemblance, whereas TD children were more likely to use representational intent. The authors argued that “resemblance-based comprehension of abstract pictures is caused by an inability to reflect on the intentions of others” (p. 55) and that this finding is consistent with the perspective-taking deficits known to occur in ASD.

More recently, a study by Saitovitch et al. (2013) found that children with ASD exhibited looking patterns that paralleled their TD peers. Saitovitch and colleagues (2013) compared dynamic human, dynamic cartoon, static human, and static cartoon images and found children with ASD demonstrated decreased eye looking in the static photograph condition as well as for the dynamic stimuli. Specifically, this study found that children with ASD had significantly fewer fixations to the face region and eyes in the dynamic human stimuli and in the picture with human actors. Also, children with ASD had significantly more fixations to non-social backgrounds in the human dynamic and in the dynamic cartoon stimuli. Saitovitch et al. (2013) concluded that gaze abnormalities in children with ASD are better detected when using dynamic stimuli and these gaze abnormalities are dependent on the type of stimuli used. It was also concluded that stimuli that are more ecological and contain human characters, can help discern more specific details such as eye-looking, of abnormal gaze patterns.

Taken together, it can be seen that there is conflicting evidence surrounding visual attention to static cartoon and photographic social stimuli in ASD. Understanding the types of stimuli children with ASD respond best to can guide future intervention strategies when determining appropriate visual supports. This study utilized photographs and BM images in the context of the same Social Story™ to further investigate if children with ASD will attend to BM images and photographs in a different manner.

1.4 Social Stories™

Social Stories™ are a popular intervention designed to teach children with ASD about social situations (Gray, 2010; Gray & Garand 1993) and they usually (but not always) incorporate visual supports as an important component of the activity. A Social Story™ is an individualized story written from the perspective of the child, with the aim of enhancing social understanding. Social Stories™ are short stories that have an introduction, a body, and a conclusion and are usually written to explain what happens during a challenging situation. An effective Social Story™ is one that considers what a child may hear, see, and feel in the targeted situation, highlighting the child's perspective as a critical component (Hutchins & Prelock, 2012). The visual supports used in interventions like Social Stories™ typically make use of 'BoardMaker' (BM; AKA picture communication symbols or 'Johnson Meyer' symbols; Gillespie-Smith et al., 2014). BM images are cartoon-like images designed to convey a wide range of information that is important for everyday functioning and communication (Gillespie-Smith et al., 2014).

The purpose of a Social Story™ is to explain the who, what, when, where, and why surrounding an event, with the assumption that enhanced social understanding will be accompanied by more appropriate social behaviors. Research has also shown remediation of communicative deficits (e.g., echolalia, interruptions) in children with ASD when a Social Story™ is used (Hutchins & Prelock, 2012). However, due to the heterogeneity of ASD, it is important to note that Social Stories™ as an intervention technique vary in regards to their effectiveness. Social Stories™ can yield "positive outcomes for some individuals or behaviors but not for others" (Hutchins & Prelock, 2012, p. 157). Therefore, it is important to identify the effectiveness of using a Social Story ™ as an intervention strategy for each individual. Despite the variability of Social Story™ effectiveness, it is still a widely popular intervention (Hess et al., 2007) used to address theory of mind, communicative, and behavioral deficits seen in children with ASD (Hutchins & Prelock, 2012).

Furthermore, Social Stories™ are evidence-based intervention strategies and have been identified as one of 11 established treatments for ASD by the National Standards Project (National Autism Center, 2009; 2015). As noted by Hutchins (2012), studies surrounding the efficacy of Social Stories™ have been minimal; however, there have been a large number of studies regarding Social Story™ effectiveness. For example, the systemic review done by Karkhaneh and colleagues (2010) conducted a qualitative analysis on the Social Story™ literature to assess its effectiveness. Results revealed that Social Stories™ yielded statistically significant benefits related to social interaction, but highlighted the need for information regarding the effectiveness of intervention in less controlled settings, frequency of intervention, and maintenance (Karkhaneh et al., 2010). In agreement with Karkhaneh et al. (2010), Reynhout and Carter (2009) found that teachers felt Social Stories™ were an effective intervention technique. With regard to quantitative measures, researchers (Ali & Fredrickson, 2006; Kokina & Kern, 2010; Test, Richter, Knight, & Spooner, 2010) have concurred that the use of Social Stories™ as an intervention strategy can be beneficial. However, these researchers also highlight the weaknesses (e.g., maintenance, generalizability, small sample sizes, confounding factors such as the use of additional supports) of Social Story™ intervention. Although there are methodological weaknesses in some reports of Social Story™ intervention, overall it is considered an established intervention for children with ASD.

1.5 Statement of the Problem

The literature review suggests that children with ASD demonstrate strengths when processing visual information from cartoons. It is suggested that cartoons are effective for intervention due to their decreased ecological-validity (i.e., BM) indicating that there is less social information to be interpreted. Although photographs may be more complex to process, additional research surrounding the effectiveness of highly ecologically-valid images for intervention purposes is needed.

There is also debate in the research surrounding how children with ASD attend to static visual social scenes. Eye tracking studies have revealed a mouth over eyes preference, but there is controversial evidence as to why this is observed. The following study focuses on the disparity in the literature by analyzing how children with ASD and TD peers attend to static visual social scenes and how these fixations differ between cartoons and photographs. The goal of this research is to build on the study done by Gillespie-Smith et al. (2014), using photographs and BM images in the context of a Social Story™. As noted by Riby and Hancock (2008) "comparing cartoon images versus photographs… may be particularly important when associating visual fixation patterns with social cognition and understanding" (p. 2856). Therefore, the following questions were addressed within the study:

1. Is there a difference between TD children and children with ASD in how they attend to cartoon and photographic stimuli in the context of a Social Story™?
2. Do group differences in social attention to BM and/or photographic stimuli correlate with age and indices of autism severity, executive function, intellectual functioning, and weak central coherence?

Chapter 2: Method

2.1 Participants

Participants are 19 typically developing children (15 males, 4 females) ages 6 years, 3 months to 12 years, 11 months (*M* = 8 years, 8 months, *SD* =2.23) and 18 children (15 males, 3 female) ages 6 years, 1 month to 11 years, 9 months (*M* = 9 years, 3 months, *SD* = 1.55) diagnosed with ASD. These participants were from a larger study in which participants participated in six eye tracking studies. The order in which participants participated in each individual study was counterbalanced. All typically developing children were identified on the basis of parental report. More specifically, parents responded to a questionnaire designed to screen for a variety of conditions. Parents were asked to report whether their child had ever received a diagnosis or were ever concerned about the presence of a developmental delay (including ASD), learning impairment, speech and language impairment, and uncorrected visual or hearing impairment.

On the basis of parental report, four children had a diagnosis of autism, six had a diagnosis of Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), and eight had a diagnosis of Asperger Syndrome (American Psychiatric Association, 2000). All children had been diagnosed by a psychologist or developmental pediatrician. Six children in the ASD group also had a concomitant diagnosis of Attention-Deficit Hyperactivity Disorder or Attention-Deficit Disorder. One child in the ASD group was functionally nonverbal (characterized by parental report as having "limited speech") but was able to attend to stimuli making collection of the eye tracking data possible. All 17 remaining children were verbal and could use language functionally and flexibly.

2.2 Measures

Measures for autism severity, executive function, and central coherence were employed to examine whether they predicted atypical visual attention. Data for general and subscale intelligence were also collected. These data were included in the predictor analyses but also used to evaluate whether our ASD and TD groups were distribution matched on general intelligence.

2.2.1 Behavior Rating Inventory of Executive Function. The *Behavior Rating*

Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) is a parent and/or teacher informant measure designed to assess executive function behaviors in individuals ages 5 through 18. The test is composed of 86 items divided into eight categories: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor. Scores are reported for each of the categories as well as an overall behavioral index, a metacognition index, and a global executive composite. The BRIEF has been evaluated for reliability (internal consistency, test-retest, and interrater) and validity (convergent and divergent) and has demonstrated adequate psychometric properties (Schraw, 2003).

2.2.2 The Gilliam Autism Rating Scale-2. The *Gilliam Autism Rating Scale, second edition* (GARS-2; Gilliam, 2006) is a norm-referenced rating scale based on the definitions of autism adopted by the Autism Society of America and the DSM-IV. The GARS-2 is typically used as a screening tool with children between the ages of 3 and 22 who show signs indicative of ASD. There are 42 items separated into three subscales: communication, social interaction, and stereotyped behaviors. This scale assesses behaviors using objective frequency-based ratings by individuals familiar with the individual and takes approximately 5-10 minutes to complete. The combined scores on these subscales yield an autism index (AI) score (with a mean of 100 and *SD* of 15), which provides a total score assessing the probability of autism and the degree of severity. Statistically significant validity and reliability (internal consistency, test-retest, and interrater reliability) were reported for each of the test domains and the AI (Lopez-Wagner, Hoffman, Sweeney, & Hodge, 2008).

2.2.3 The Group Embedded Figures Task. The *Group Embedded Figures Task*

(GEFT; Oltman, Raskin, Witkin, & Karp, 2002) is perceptual functioning test designed to measure detail-oriented (i.e., part) processing abilities by detecting embedding simple figures in more complex figures. The GEFT contains 24 items and is composed of three sections (i.e., First Section, Second Section, Third Section), with increasing difficulty for each item. Further, this test is broken down into two Embedded Figures Tests (EFT)- Form A and Form B. Form A consists of the first 12-items of the test and Form B is comprised of the second set of 12-items. For the purpose of our study, only Form A was administered. Additionally, Form A has a 3-minite time limit in which it must be completed. The GEFT test booklet also includes a "Simple Forms" page, to which the examinee can refer throughout the test. The EFT demonstrates adequate reliability and validity.

2.2.4 The Wechsler Abbreviated Scale of Intelligence. The *Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler, 1999) is a brief norm-referenced IQ test for individuals between the ages of 6 and 89. The WASI is composed of four subtests: vocabulary, similarities, block design and matrix reasoning, yielding a verbal IQ score, a performance IQ score, and a full IQ score. The WASI has been evaluated for reliability (internal consistency, test-retest) and validity, and has demonstrated good psychometric properties (Lindskog & Smith, 2010).

2.3 Apparatus

Eye movements were recorded using the Mirametrix S2 Eye Tracker System to record X and Y coordinates of eye position. The screen-capture system promoted more natural behavior since it did not place restraints on participants such as a helmet, head-mounted sensor, or glasses. The system utilized a sampling rate of 60 Hz yielding an accuracy of .5-1 degree of the visual angle. Eye blinks and off screen gazes were identified by loss of corneal reflection and were excluded from the data. Participants were seated at a desk in front of a 22-inch computer monitor (1680 X 1050 pixels resolution) located approximately two feet away. The eye tracker was positioned just below the computer screen. Presentation of the stimuli was captured using Viewer software in Mirametrix and the resulting data was managed by conducting analyses of CSV (Comma Separated Values) files. Fixation calculation parameters for gaze were set at 20 pixels (for the maximum distance in pixels that a point may vary from the average fixation point and still be considered a fixation) and 2 samples (minimum number of samples to be considered a fixation) with 3 degrees of visual angle. Participants' gazes were calibrated quantitatively in the following manner:

> The user is required to look at these coordinates, in such a manner that the system associates to each of these a specific relative position of both the flint and pupil centers. Once these nine points are successfully recorded (about 15 seconds), the system is able to track the point-of-regard in every position of the screen, by means of computer vision techniques and trigonometric calculations. The mirametrix S2 device specifies that there will never be a drift over 0.3 degrees. Furthermore the device takes less than 16ms to reacquire the eyes image in case of need. Following the official device' specifications, its accuracy is in the range of 0.5-1 degrees of visual angle, meaning that with the user staying at 50 cm from the device, the error in the screen is going to be in the range of 0.44 cm to 0.87 cm approximately (Barral, 2013, p. 17).

2.4 Image Types

Two image types were examined: BoardMaker™ images and photographs. Each set of images types are presented in the Appendix along with the Social Story™ in which they were embedded. Because this study was interested in how children visually attended to two types of visual supports, the text of the Social Story™ did not appear on screen.

Rather, as each slide was presented, audio was played to give the content of the Social Story™. The Social Story™ that was developed for this study was designed to be as simple and short as possible while including the major components of a Social Story™ which include an introduction, a body, and a conclusion. The Social Story was typical in that it described a challenging situation that made reference to what people do, what people feel, and why people feel the way they do. It is also typical in the sense that it offered strategies to support more effective behaviors. The Social Story™ was atypical in that it was not written from the perspective of the audience which was not possible in this study. As such, the Social Story™ was essentially a narrative about a 3rd person.

The Social Story™ consisted of nine pages: seven images depicted people's faces (slides 1, 3, 4, 6, 7, 8, 9), one image (slide 5) depicted an action (i.e., pinching), one image depicted objects only (slide 2), and one image depicted both people and objects (slide 7). The specific BoardMaker images were first identified on the basis that they appeared in the first group of images following a BoardMaker search (e.g., when searching for images of "wake up", a group of images is retrieved from BoardMaker™) and were therefore assumed to be relatively high frequency choices among professionals. The particular images were then selected from the larger set based on their ability to be easily replicated via photograph. Using this procedure yielded a mix of visual supports that (in line with our clinical experience) is typical in the context of Social Stories™. On the other hand, it did carry an empirical disadvantage in that while the photograph Social Story™ was consistent in its depictions of characters (i.e., Brynn and her mother are always presented as the same two persons), the BoardMaker™ Social Story was not (i.e., the graphic representations of persons in not consistent). On the basis of informal clinician report and the experience of these authors' experiences, BoardMaker™ images are often chosen based on the first images that appear after a BoardMaker™ search. Therefore, this decision was made in order to make the Social Story™ as ecologically valid (i.e., creating the Social Story™ in the same way it would be created during intervention).

2.5 Procedure

Participants with ASD were recruited via informal contacts as well as notices to local support agencies for families with children with ASD. Additionally, six participants with ASD were recruited through an ad placed in the local newspaper. Participants with typical development were recruited via fliers and informal contacts. Parents received $25.00 compensation for participation in the study. Upon arrival to the laboratory, informed consent was obtained from a parent. The children were seated in front of the computer screen for the Social Story™. The children were given the instruction "find your sweet spot" if they were looking at the computer screen but their eyes were not picked up by the eye tracker. Participants' eye gazes were calibrated using quantitative measures (described above) as well as visual confirmation (i.e., they were asked to look at particular objects on the screen and it was noted where their eyes were fixating on the computer screen). Visual confirmation checks were informal and used as necessary.

Each child viewed both stories and the instructions for each were identical. The child was asked to "get ready to watch so I can tell you a story". The story order (BM or photographic images) was counterbalanced so that each order was as equally represented as possible. This study was part of a larger series of eye tracking studies using different sets of stimuli. Each set of stimuli was also presented in a counterbalanced order so that each order was as equally represented as possible.

After the gathering of the eye tracking data, the GEFT and the WASI were administered to the child (in that order). During this time, parents were asked to complete the BRIEF and the GARS-2. The completion of all data collection procedures took between two to three hours.

2.6 Dependent Variables

For the seven slides that depicted people's faces, the areas of interest (AOIs) were chosen based on the upper and lower regions of the face, as well as 'other' AOIs. The upper region included the eyes and brows and extended to the temple area of the face. The lower region included the mouth. All 'other' AOIs included all other areas of the screen. For the slide depicting action (i.e., slide 5 was an image of pinching), there were two AOIs: one for the action (the fingers involved in the pinching event) and one for "other" (everything outside the pinching AOI). Data were collected for the number of fixations and the total fixation time for each AOI in each condition.

2.7 Data Analytic Plan

Data for all eye tracking dependent variables were submitted to a series of mixed model 2 (group: typically developing vs. ASD) X 2 (stimulus type: BoardMaker vs. photographs) Analyses of Variance (ANOVAs) with repeated measures on stimulus type. To explore correlates of looking patterns, differences in looking data between the two conditions were calculated for any previous ANOVA comparisons with a significant interaction effect. Specifically, differences between conditions (i.e., change scores) were calculated and correlated with variables of interest (i.e., executive function [EF], IQ, autism severity, weak central coherence, age) to determine which variables predicted shifts in visual attention across conditions.

Evaluation of this data set (which has been analyzed for previously collected eye tracking data) suggests that the current sample size is sufficient to detect effects, although perhaps not small effects. For this reason and given the exploratory nature of this study, an alpha of .10 was adopted for all analyses.

Chapter 3: Results

3.1 Participants Characteristics

Data for matching variables were submitted to a series of independent samples t-test. No differences were found for the variables of the child age or gender ($p > .45$ for each). Differences were observed for the WASI-2 verbal section ($p = .003$) and for the WASI-2 full scale ($p = .02$). It should be noted that these differences appear to be due to *over*-performance by the TD group as they were generally 1 SD above the mean (WASI-2 verbal section $M = 116.00$; $SD = 16.42$; WASI-2 full scale $M = 112.84$; $SD = 14.90$). The average scores for the ASD group were within the normal range for the verbal section ($M = 94.89$; $SD = 23.75$), and also were for the WASI-2 full scale ($M = 98.44$; $SD = 20.66$). All participants with ASD completed the GARS-2 as well ($M = 87.11$; $SD = 16.23$), indicating that our sample typically fell within the range of mild autism severity and considered high-functioning.

Boneferroni tests to correct for family-wise error were not conducted for these data. Given the large number of comparisons and exploratory nature of this research, it is important to protect against the likelihood of multiple Type II errors (O'Keefe, 2003a,b).

3.2 Research Question 1

Research question 1 sought to answer: “Is there a difference between TD children and children with ASD in how they attend to cartoon and photographic stimuli in the context of a Social Story™?” Number of fixations and fixation time for each AOI (e.g., mouth, eye, and ‘other’ regions meaning those that were not mouth or eye AOIs) on every slide were analyzed for each dependent variable. To investigate whether differences existed for each AOI for each stimulus, data were submitted to a series of 2 (group: TD, ASD) x 2 (stimulus: BM, photographs) mixed model ANOVAs with repeated measures on stimulus.

A main effect of stimulus was found for the “Brynn” slide for the number of fixations to the eye AOI, F (1, 35) = 9.63, $p < .01$, such that there were significantly more fixations to the eye AOI in the picture condition (M = 9.94; SD = 1.22) compared to the BM condition (M = 6.02; SD = .86). A main effect of stimulus was found for the “Brynn” slide for fixation time to the eye AOI, F(1, 35) = 20.73, $p < .001$, such that there was significantly longer fixation time in the picture condition (M = 1.56; SD = .16) compared to the BM condition (M = .93; SD = .14). A main effect of stimulus was also found for the “Brynn” slide for number of fixations to the ‘other’ AOI, F(1, 35) = 8.02, $p < .001$, such that there were significantly more fixations to the ‘other’ AOI in the BM condition (M = 7.77; SD = .90) compared to the picture condition (M = 5.32; SD = .81). Finally, a main effect of stimulus was found for the “Brynn” slide for fixation time to the ‘other’ AOI, F(1, 35) = 9.63, $p < .01$, such that there was significantly longer fixation time in the BM condition (M = 3.6; SD = .17) compared to the picture condition (M = 3.0; SD = .18). No other significant effects were found for the “Brynn” slide.

A main effect of group was found for the "Wakeup" slide for fixation time to the mouth AOI, F (1, 35) = 3.09, $p < .10$, such that the TD group looked significantly longer at the mouth AOI (M = .29; SD = .06) compared to the ASD group (M = .15; SD = .06). A main effect of stimulus was also found for the "Wakeup" slide for fixation time to the mouth AOI, F (1, 35) = 3.04, $p < .10$, such that there were significantly more fixations to the mouth AOI in the BM condition (M = .29; SD = .07) compared to the picture condition (M = .14; SD = .36). No other effects for the "Wakeup" slide were significant.

A main effect of stimulus was found for the "Angry" slide for number of fixations to the eye AOI, F (1, 35) = 7.91 $p < .01$, such that there were significantly more fixations in the BM condition (M = 9.77; SD = 1.25) compared to the picture condition (M = 6.69; SD = 1.05). A main effect of stimulus was found for the "Angry" slide for number of fixations to the 'other' AOI, F (1, 35) = 3.23, $p < .10$, such that there were significantly more fixations to the 'other' AOI in the picture condition (M = 7.08; SD = .93) compared to the BM condition (M = 5.34; SD = .77). No other effects for the "Angry" slide were significant.

A main effect of stimulus was found for the "Sad" slide for number of fixations to the eye AOI, F (1, 35) = 3.72, $p < .10$, such that there were significantly more fixations in the BM condition (M = 11.18; SD = 1.43) compared to the picture condition (M = 8.67; SD = 1.10). A main effect of stimulus was found for the "Sad" slide for number of fixations to the mouth AOI, F (1, 35) = 6.53, $p < .05$, such that there were significantly more fixations in the picture condition (M = 2.74; SD = .46) compared to the BM condition (M = 1.60; SD = .38). Finally, a main effect of stimulus was found for the "Sad" slide for number of fixations to the 'other' AOI, F (1, 35) = 3.72, $p < .10$, such that there were significantly more fixations in the picture condition (*M* = 5.13; *SD* = .58) compared to the BM condition (*M* = 3.65; *SD* = .52). No other effects for the "Sad" slide were significant.

For the "Play" slide, a significant interaction was observed, F (1, 35) = 3.29, $p < .1$, such that the number of fixations to the eye AOI was not significantly different for the TD group across BM (*M* = 1.47; *SD* = .59) and picture conditions (*M* = 2.00; *SD* = .61). However, the number of fixations for the ASD group was significantly higher in the BM condition (*M* = 2.33; *SD* = .61) compared to the picture condition (*M* = .67; *SD* = .63). No other significant effects were found for the "Play" slide.

A main effect of stimulus was found for the "Remember" slide for number of fixations to the eye AOI, F (1, 35) = 8.11, $p < .01$, such that there were significantly more fixations in the BM condition (*M* = 9.70; *SD* = 1.17) compared to the picture condition (*M* = 7.28; *SD* = .85). A main effect for stimulus was found for the "Remember" slide for number of fixations to the mouth AOI, F (1, 35) = 3.48, $p < .10$, such that there were significantly more fixations in the picture condition (*M* = 2.57; *SD* = .45) compared to the BM condition (*M* = .74; *SD* = .19). A main effect for stimulus was found for the "Remember" slide for fixation time to the mouth AOI, $F(1, 35) = 4.10$, $p < .10$, such that there was significantly longer fixation time in the picture condition (*M* = .36; *SD* = .14) compared to the BM condition (*M* = .07; *SD* = .02). A main effect for stimulus was found for the "Remember" slide for fixation time to the 'other' AOI, F (1, 35) = 4.20, $p < .05$, such that there was significantly longer fixation time in the BM condition (*M* = 3.50; *SD* = .19) compared to the picture condition (*M* = 3.17; *SD* = .20). No other effects for the "Remember" slide were significant.

A main effect of stimulus was found for the “Happy” slide for number of fixations to the eye AOI, F (1, 35) = 4.45, $p < .05$, such that there were significantly more fixations in the picture condition (M = 8.34; SD = .78) compared to the BM condition (M = 6.91; SD = .86). A main effect for stimulus was found for the “Happy” slide for fixation time to the eye AOI, F (1, 35)=17.19, $p < .001$, such that there was significantly longer fixation time in the picture condition (M = 1.88; SD = .20) compared to the BM condition (M = 1.15; SD = .14). A main effect of stimulus was found for the “Happy” slide for number of fixations to the mouth AOI, F (1, 35) =5.06, $p < .05$, such that there were significantly more fixations in the picture condition (M = 3.41; SD = .81) compared to the BM condition (M = 1.85; SD = .37). A main effect of stimulus was found for the “Happy” slide for fixation time to the mouth AOI, F (1, 35) = 8.52, $p < .01$, such that there was significantly longer fixation time in the picture condition (M = .53; SD = .10) compared to the BM condition (M = .25; SD = .05). A main effect of stimulus was found for the “Happy” slide for number of fixations to the ‘other’ AOI, F (1, 35) = 17.58, $p < .001$, such that there were significantly more fixations in the BM condition (M = 8.67; SD = .99) compared to the picture condition (M = 4.50; SD = .66). Finally, a main effect for stimulus was found for the “Happy” slide for fixation time to the ‘other’ AOI, F (1, 35)=30.41, $p < .001$, such that there was significantly longer fixation in the BM condition (M = 3.6; SD = .15) compared to the picture condition (M = 2.58; SD = .23). No other significant effects found for the “Happy” slide were observed. All the data reported above are provided in Table 1 along with Eta squared effect size estimates for all inferential comparisons. The mean number of fixations and mean fixation time by group and stimulus condition are also presented in Figures 1-15 where asterisks denote a significant effect.

In summary, this finding suggests that children with ASD and their TD peers demonstrate similar visual attention patterns with simple visual static social stimuli. However, main effects for stimulus varied across slides. Some slides evidenced more eye-looking and other slides showed more mouth-looking, but the effects were unique to each slide and not more generally predicted by stimulus type (BM vs. photographs). These results suggest visual attention to static social stimuli in children with ASD and their TD peers is likely driven by information-seeking vis-à-vis emotion recognition. Furthermore, group effects were only found for the "Play" slide, in which the ASD group looked less at the eye AOI in the photograph Social Story™ in comparison to TD peers. One possible explanation for this finding is the complexity of the "Play" scene as it incorporated objects (e.g., toys) that may have been of interest to participants in the ASD group.

3.3 Research Question 2

Research question 2 was: Do group differences in social attention to BM and/or photographic stimuli correlate with age, autism severity, EF, intellectual functioning, or weak central coherence in children with ASD? Differences in looking data between the two conditions were calculated for stimuli that evidenced a significant interaction effect. Differences between conditions (i.e., change scores) were then correlated with variables of interest (i.e., age, EF, IQ, autism severity, weak central coherence) to determine which variables predicted shifts in visual attention across conditions.

Only the "Play" slide was found to have a significant interaction and between-groups effect, such that the ASD group looked less at the eye AOI in the photograph Social Story™ in comparison to TD peers. Change scores were calculated for the number of fixations and fixation time for each AOI (e.g., mouth, eye, and 'other') by subtracting photograph stimulus looking data from the BM stimulus looking data. These six change scores were then correlated with our variables of interest. Five significant correlations ($p < .10$) were observed.

Age was positively correlated with change scores for the number of fixations to the "other" AOI ($r = .73$, $p < .001$): as the number of fixations to the 'other' AOI increased from the BM to the photograph condition, age decreased. Age was also correlated with change scores for fixation time to the mouth AOI ($r = .43$, $p = .07$): as fixation time to the mouth AOI increased from the BM to the photograph condition, age decreased.

The Shifting Attention subscale of the BRIEF was positively correlated with the number of fixations to the mouth AOI ($r = .41$, $p = .09$) and number of fixations to the 'other' AOI ($r = .63$, $p < .05$): as the number of fixations to the mouth and 'other' AOIs increased from the BM condition to the photograph condition, scores for attention shifting decreased.

The WASI-2 Verbal subscale was negatively correlated with the change score for number of fixations to the mouth AOI ($r = -.39$, $p < .11$): as the number of fixations to the mouth AOI increased from the BM to the photograph condition, verbal IQ decreased.

Finally, data for the Embedded Figures Task was positively correlated with the change score for number of fixations to the 'other' AOI ($r = .41$, $p < .09$). Therefore, as the number of fixations to the 'other' AOI increased from the BM to the photograph condition, central coherence decreased. A qualitative exemplar (heat map) demonstrating the nature of visual attention to the Play slide among children with ASD is presented in Figure 16.

In summary, results for the "Play" slide highlighted that condition (BM vs. photograph) did not affect the visual attention of TD children to the various AOIs. By contrast, children with ASD looked more at the mouth and 'other' AOIs in the photograph condition relative to the BM condition: this shift towards more mouth-looking in the photograph condition was negatively associated with attention shifting and verbal IQ and the shift toward more 'other'-looking was negatively associated with attention shifting, age, and central coherence.

Chapter Four: Discussion

Social Stories™ are considered an established, evidence-based intervention for children with ASD (National Professional Development Center, 2014). One reason they are believed to be effective is that they typically incorporate the use of visual supports. Research surrounding Social Story™ interventions has not addressed which types of visual support may be most effective for children with ASD. The present study begins to address this gap in the literature by examining how TD children and children with ASD attended to two popular visual supports: BM images and photographs.

4.1 Research Question 1

The first research question was: Is there a difference in how TD children and children with ASD attend to cartoon and photographic stimuli in the context of a Social Story™? For all but one slide, we found no group effects, suggesting that the visual attention of TD children and children with ASD was similar. This finding is in alignment with Gillespie-Smith et al. (2014), who found that children with ASD demonstrated visual attention to objects and faces similar to their TD peers when viewing BM and PECS images. On the other hand, our finding lies in contrast to the results of Klin et al. (2002) who reported that children with ASD demonstrated atypical visual attention to social stimuli when comparison to TD children. It is important to note, however, that Klin et al. (2002) employed dynamic stimuli (videos) with content focusing on a range of complex emotions across characters engaged in interaction. As noted in this paper's introduction, differences between individuals with ASD and those who are TD may be more likely to occur with dynamic stimuli (Klin et al., 2002; Norbury et al., 2009; Rice et al., 2012; Speer et al., 2007).

If our interpretation of the data are correct and the similar patterns of visual attention to static faces reflect similar face processing strategies in TD and ASD groups, it is worthwhile to examine the looking data in light of the quality of our main effects of stimulus. Notably, the main effects for stimulus were not monolithic. That is, some slides showed more eye-looking and other slides showed more mouth-looking, but the effects were unique to each slide and not more generally predicted by stimulus type (BM vs. photographs). This finding is supported by the research done by Saitovitch et al. (2013), who found children with ASD demonstrated more abnormal visual allocation patterns when viewing dynamic human stimuli in comparison to dynamic cartoon stimuli and static cartoon stimuli. Taken together, these findings suggest that cartoon images may be most beneficial for children with ASD as these images potentially have fewer cognitive demands, are less social, and more simplistic. Therefore, it an be proposed that children with ASD may have a better ability to access, learn, and generalize information when visual supports are comprised of a cartoon (e.g., BM) image.

For this reason, we imagine that visual attention to static social stimuli in children with ASD and their TD peers is likely driven by information-seeking vis-à-vis emotion recognition. That is, depending on the specific features of a visual stimulus, emotions and social information can be located in different AOIs. It is possible that TD children and children with ASD are demonstrating selective visual attention to static social stimuli, attending to the most relevant emotion information. For example, for the "Brynn" slide, it was found that both groups demonstrated more fixations and longer fixation times to the eye AOI in the photograph condition. When looking at this slide (see Appendix A, Slide 1) the eye AOI in the BM condition is merely a pair of dots, whereas the eye AOI in the photograph is a pair of real eyes. Arguably, a photograph of real eyes provides more emotion-information than do a pair of dots. Findings from the "Angry" slide (refer to Appendix A, Slide 4) further reinforce this interpretation for which both groups demonstrated an increased number of fixations to the eye AOI in the BM condition. When comparing the two slides, the eye AOI of the BM slide contains more obvious (and possibly exaggerated) 'angry' information than the eye AOI for the photograph condition. In a final example, both groups demonstrated an increased number of fixations and fixation time to the mouth AOI in the photograph condition for the "Happy" slide (Appendix A, Slide 9). It can be argued that the mouth AOI in the photograph condition contains a higher amount of noticeable "happy" information in comparison to the BM condition. These examples suggest that stimulus type (BM vs. photographs) is not a primary driver of visual attention to various face AOIs, but rather that information search is strategic and dependent on the particularities of each stimulus. Indeed, it appears as though TD children and children with ASD are directing their eyes to 'go where the emotion information is'. This could be further investigated by conducting emotion recognition tasks to explicitly examine this interpretation.

One significant interaction was observed for the "Play" slide in that ASD group looked less at the eye AOI in the photograph Social Story™ in comparison to TD peers. A possible explanation for this finding is the complexity of the "Play" scene as it incorporated objects (e.g., toys) that may have been of interest to participants in the ASD group. It is possible that children with ASD demonstrated more fixations to the 'other' regions due to the presence of these objects of interest (Grelotti et al., 2004; Sasson et al., 2008). Therefore, objects of interest may potentially distract children with ASD, accounting for the increased number of fixations to the 'other' AOI and decreased ability to shift attention in the picture condition. As noted by Sasson et al. (2008), "visual perseveration and detail orientation may therefore act as a mechanism for reduced visual exploration in autism and suggests that salient items may disproportionally 'capture' or 'trap' attention in ASD" (p. 38). Support for this explanation is also documented the study done by Sasson and Touchstone (2013), who found that visual attention to static social stimuli is potentially controlled by non-social stimuli. Specifically, visual attention to social information is governed by the clarity of the present non-social stimuli in children with ASD. Furthermore, when children with ASD viewed images of a human face that appeared alongside an object that was not of personal interest to them, they demonstrated a visual attention pattern that was similar to their TD peers. However, it should be noted that our study did not account for the specific interests of each individual participant. To further investigate the influence of objects of interest within a complex static social scene, future research should incorporate high interest objects of individual participants into the stimuli presented.

4.2 Research Question 2

Research Question 2 was: Do differences in social attention to BM and/or photographic stimuli correlate with indices of age, autism severity, executive function, intellectual functioning, or weak central coherence? Only the “Play” slide yielded a significant interaction effect and so only data for this slide were examined for these analyses. Recall, the results for the “Play” slide showed that condition (BM vs. photograph) did not affect the visual attention of TD children to the various AOIs. By contrast, children with ASD looked more at the mouth and ‘other’ AOIs in the photograph condition relative to the BM condition. This shift towards more mouth-looking in the photograph condition was negatively associated with attention shifting and verbal IQ and the shift toward more ‘other’-looking was negatively associated with attention shifting, age, and central coherence.

With regard to the first finding (i.e., the ASD group demonstrated increased mouth-looking in the photograph condition compared to the BM condition which was predicted by decreased attention shifting and lower verbal IQ), our result aligns with some previous studies (Elsabbagh et al., 2014; Hutchins & Brien, 2016; Speer et al., 2007) but conflicts with others (Chawarska et al., 2013; Jones & Klin, 2008; Klin et al., 2002) reporting that children with ASD with higher verbal intelligence actually demonstrate increased mouth-looking while viewing social scenes. This is presumably because they find the mouth region of the face to yield more useful social information (Klin et al., 2002). Yet, this interpretation seems counterintuitive and difficult to square with the notion that social competence is, to some degree, contingent on the ability to use information from the eye region of the face. Indeed, eye-information seems essential for emotion recognition, following eye-gaze, establishing joint attention, and reading intentions, all of which are hallmark impairments of ASD.

An alternative interpretation in support of our finding for both verbal IQ and attention shifting is that mouth-looking is a result of resource allocation as it requires less executive resources (precisely because it yields less social information; Hutchins & Brien, 2016) than eye-looking. As a result "simpler, more efficient strategies may be used by those with autism as the complexity of information increases, while [TD individuals] may be able to decode the complexity and make use of the increasing information" (Rutherford & Towns, 2008, p.1390). This interpretation suggests more effortful and/or less efficient information processing due to higher cognitive load associated with the viewing of complex (but not simpler) scenes (Buchan, Pare, & Munhall, 2008; Mills, Hollingworth, Van der Stigchel, Hoffman, & Dodd, 2011; Pollatsek, Rayner, & Bolata, 1986). This interpretation is consistent with previous research suggesting that social impairment and atypical visual attention are positively correlated in ASD (Elsabbagh et al., 2014; Speer et al., 2007) and support the notion that the ability to access and make use of eye information is relevant to optimal social, language, and cognitive developmental outcomes in ASD.

Of course, it is important to recognize that these discrepant findings are potentially explained by the stimuli used. Klin et al. (2002) and Rice et al. (2012) utilized dynamic visual stimuli, whereas the present study and others (Chawarska et al., 2013; Hutchins & Brien, 2016; Jones & Klin, 2008;) used static social stimuli. This suggestion is supported by Speer at al. (2007) who found differences between children with ASD and TD peers during dynamic viewing tasks but not during static visual tasks.

With regard to the second finding (i.e., in the photograph condition increased 'other'-looking was negatively correlated with age, attention shifting and central coherence), our interpretation for the shifting attention data are similar to that described immediately above (i.e., it is likely a response to increased executive demands) but the finding for age and central coherence require further scrutiny. The result relating to age is supported by previous literature suggesting that younger children with ASD demonstrate decreased looking time and fewer fixations to the eye region of the face (Chawarska et al., 2013; Hutchins & Brien, 2016; Langdell, 1977). As Hutchins and Brien (2016) argued, as children with ASD get older, "they tended to *not* shift attention away from the eyes during the emotion conversation to the degree that the younger children do" and that the "tendency toward more typical visual attention with age suggests that the eyes provide useful social information to persons with ASD during interaction" (p. 8).

Finally, our measure of central coherence negatively correlated with number of fixations to the 'other' AOI in the photograph condition. Accordingly, as the number of fixations to the 'other' AOI increased from the BM to the photograph condition, central coherence decreased. These results are consistent with the WCC hypothesis (Frith, 1989), suggesting a detail-oriented style of information processing in ASD. One explanation to account for why this effect was only observed for the "Play" slide may be due to the complexity of the scene. As there are more objects to navigate within the "Play" slide image in comparison to the other slides, it is may be that a piecemeal-oriented processing style will be pronounced. Therefore, an detectable effect of WCC may be more likely with complex static social scenes. Of course it is important to note that the WCC hypothesis is controversial owing primarily to the great heterogeneity observed in information processing in persons with ASD. The controversy might be resolved if one adopts a weaker form of the WCC hypothesis and concludes that WCC is merely a tendency among some individuals with ASD, as opposed to a more rigid cognitive style adopted by all.

4.3 Clinical Implications

Results of this study have implications for how intervention is provided for students with ASD. As previously highlighted, the extant research has mixed evidence for abnormal looking patterns when viewing social stimuli. Specifically, evidence from eye tracking studies for dynamic social stimuli generally suggests that there are atypical visual allocation patterns observed in individuals with ASD. However, evidence for atypicality when viewing static social stimuli, which was the focus of the current study, is conflicting and limited.

One implication our general group data is that for many children with ASD, the choice of photograph or BM stimuli may not determine looking behavior. As there was not one stimulus within simple static social scenes that resulted in atypical looking, this suggests that stimulus type is not as significant as we expected. Rather, it was observed that complexity of the image was a moderator of atypical looking. Therefore, the decision of which type of visual static social stimuli used in visual supports (e.g., Social Stories™) should be driven by children's ability to draw meaning from the images. Therefore, clinicians might probe comprehension of the images to ensure that facial expressions are being interpreted accurately, regardless of whether they are photograph or BM. This would allow clinicians to understand the type of stimulus that is beneficial for each child and promote understanding and accessibility of the stimuli for children with ASD.

It should also be considered that abnormal looking patterns were only observed for children with ASD during the “Play” slide, which can be considered a complex social scene. Evidence has suggested that abnormal looking trends are observed in children with ASD when the cognitive load is increased (Angermeier et al., 2007; Brosnan et al., 2015; Riby & Hancock, 2008). Therefore, individuals providing therapy should consider the complexity of static social stimuli that are utilized in a Social Story™. Specifically, using a Social Story™ with BM images may be more beneficial for complex static social stimuli, as this study evidenced more typical visual allocation strategies of children with ASD in comparison to the complex static social stimuli within the photograph Social Story™. It is also possible that the types of images differed widely in a way that varied by slide and served as confounding variable within our study.

4.4 Limitations and Directions for Future Research

Data obtained from this study is limited by a relatively small sample size. A sample size of 25, as suggested by the literature, is determined to be sufficient to detect effects in visual attention in ASD. Our sample size was adequate to identify several main effects for stimulus and group at the .05 and .01 levels. However, effects important to our current interpretation of the data were found when an alpha of .10 was used. This suggests that this study may have been underpowered.

The ASD and TD groups were not matched on IQ. However, it is important to note that the ASD group had a mean IQ within the normal range and the TD group had a mean IQ roughly one standard deviation above the mean. ASD and TD groups were not matched on IQ because this could have impacted effects associated with the diagnosis of ASD as IQ is “phenotypically linked with ASD” (Harms et al., 2010, p. 292).

Another limitation of this study involves its design. The data obtained from this study were collected at one-point in time. A longitudinal study design would be beneficial to address the limitations of this cross-sectional design. Examining visual attention to social static stimuli over time would provide information on potential affects of maturation. As our study found that younger age was associated with more ‘other’-looking, examining visual attention over time would provide more insight on patterns associated with increased age.

Another limitation of this current study is that some of our participants had concomitant disorders. Parental report indicated that six participants with ASD also had a diagnosis of ADHD or ADD. These participants were included in the study due to the small sample size despite any coexistent disorders. The present study was unable to account for any impact, if any, the concomitant disorders or medications had on the study’s results. There is a high comorbidity rate between ADHD and ADD with ASD. This could be addressed through the use of additional screening measures or a potentially more stringent set of inclusion criteria. It should be noted that one participant with ASD was functionally non-verbal. This participant’s data were analyzed with the other participants’ data, as his verbal ability did not interfere with the eye-tracking technology. All other participants were verbal and able to flexibly use language.

It is important to note that comprehension of facial expressions was not assessed across stimulus type and should therefore be a direction for future research. This is a substantive concern, as looking behavior cannot directly reveal underlying cognitive processes. In future research, it will be important to disentangle looking behavior and emotion recognition to determine whether the similar scan patterns of TD children and children with ASD are accompanied by similar levels of facial expression comprehension. After all, just because TD children and children with ASD may show similar visual attention to static face stimuli, it does not necessarily follow that they find both BM and photographic stimuli equally comprehensible and meaningful.

Future research should examine the potential differences between simplistic (consisting only of faces or people) and complex (consisting of faces and objects) static social stimuli. A task designed to address changes in visual attention across simple and complex scenes would be important to determine whether individuals with ASD and their TD peers have similar looking patterns when viewing BM and photograph images. This is important because it may be that the content of visual stimuli interacts with stimulus type, which would lead to specific recommendations for practice.

Another limitation of this study is that our stimuli across conditions were not perfectly equivalent. As mentioned earlier, slides such as the “Sad” and “Angry” slides in the photograph contained more details (e.g., shirt, hair, earrings) than the BM condition. Therefore, this could account for the visual allocation patterns observed for ‘other’ AOIs in these slides. It is possible that these extra details were distracting for both groups and impacted the findings of this research. It will be beneficial for future research to replicate this study with parallel stimuli.

Conclusively, this study has clinical implication for children with ASD. As evidenced by this study, simplistic visual static social stimuli may be most beneficial to use within the context of Social Stories™ for children with ASD. Findings suggest that children with ASD exhibit typical visual allocation patterns that parallel their TD peers when simplistic images are used. However, when complex visual static social stimuli are used, children with ASD demonstrate more atypical visual allocation patterns. Specifically, children with ASD demonstrated increased mouth and “other” looking in the photograph condition when compared to the BM condition. Therefore, BM images may be more beneficial to use when complex social scenes are incorporated into a Social Story™. As our study was only able to identify what they eyes were doing utilizing eye-tracking technology, it will be important for future studies to investigate neurological underpinnings to provide information about the brain activity of children with ASD during visual attention to static social stimuli tasks.

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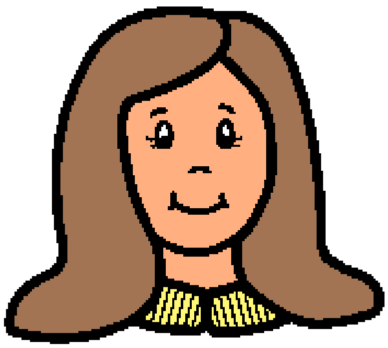
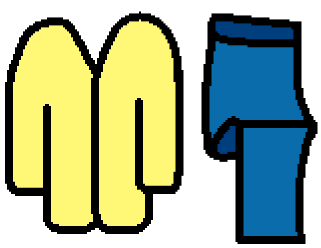
Appendix: Social Story™ for "Getting Dressed in the Morning". All text appearing here does not appear in the experiment but instead is presented as audio that accompanies each image.

BoardMaker images | Photographic images

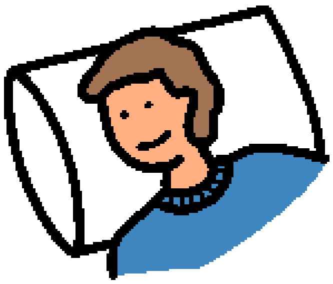
Slide 1: "My name is Brynn."



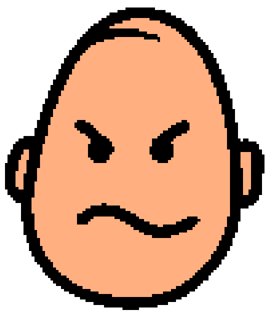
Slide 2: "Usually, before I go to bed, my mom helps me pick out my clothes for the next day."

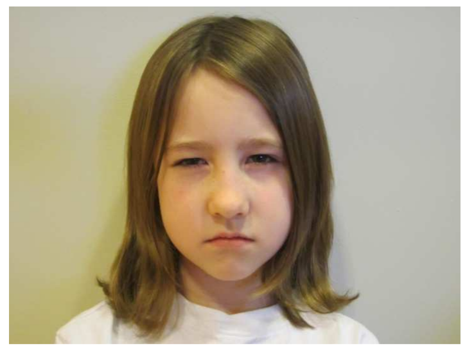


Slide 3: "When I wake up the next morning, I have the clothes I need to get dressed."

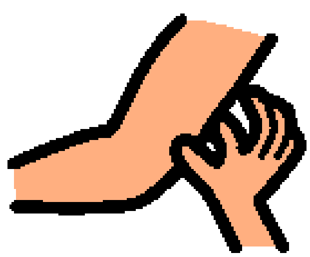


Slide 4: “Sometimes I don’t want to get dressed in the morning and I get very angry.”

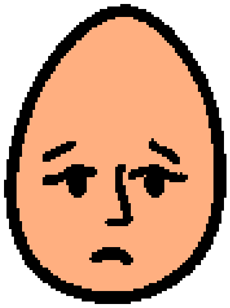


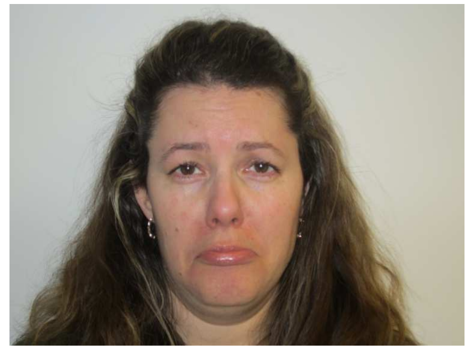


Slide 5: “Sometimes I pinch my mom!”

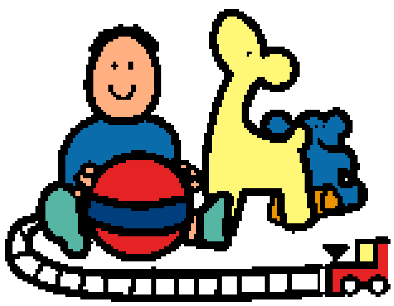


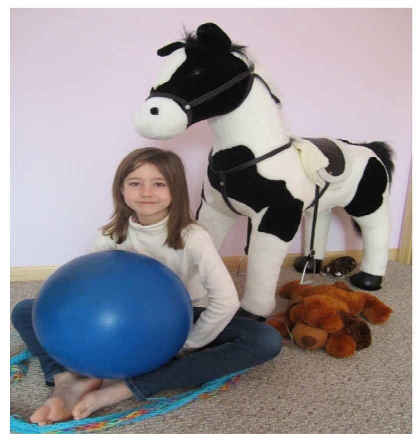
Slide 6: “This makes my mom feel sad because she is trying to help me get ready for the day.”



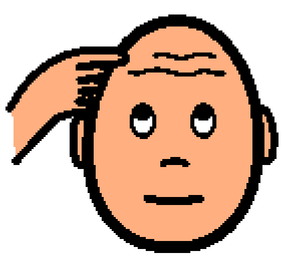


Slide 7: “When I get dressed without getting angry, I might have time to do something that I like.”

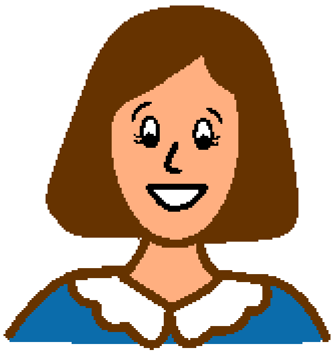




Slide 8: “I will try to remember to get dressed without getting angry.”



Slide 9: “This makes my mom very happy!”



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“The End”

Table 1: Data for number of fixations and fixation time (seconds) for mouth, eyes, and other AOIs across both Social Stories™. Data from series of 2 (group: TD; ASD) x 2 (stimulus: BM; photographs) mixed model ANOVAs with repeated measures on stimulus, for research question one.

	GROUP M (SD)							
BRYNN SLIDE	TD		ASD			F	*p*	η^2
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	6.47	10.11	5.56	9.78	Group:	.135	.716	.004
	(1.2)	(1.71)	(1.23)	(1.75)	Context:	9.63	.004***	.216
					G X C:	.054	.817	.002
Mouth AOI	3.16	2.68	2.67	2.78	Group:	.044	.836	.001
	(.778)	(.691)	(.799)	(.71)	Context:	.157	.694	.004
					G X C:	.409	.527	.012
'Other' AOI	7.37	4.39	8.17	6.28	Group:	.849	.363	.024
	(1.25)	(1.12)	(1.28)	(1.16)	Context:	8.02	.008***	.186
					G X C:	.414	.524	.012
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	1.04	1.83	.819	1.36	Group:	1.76	.194	.048
	(.193)	(.225)	(.199)	(.231)	Context:	20.73	<.001***	.372
					G X C:	.757	.390	.021
Mouth AOI	56	.448	.426	.456	Group:	1.54	.697	.004
	(.136)	(.13)	(.14)	(.133)	Context:	1.56	.695	.004
					G X C:	.475	.495	.013
'Other' AOI	3.4	2.72	3.76	3.18	Group:	1.72	.198	.047
	(.233)	(.254)	(.239)	(.261)	Context:	16.12	<.001***	.315
					G X C:	.127	.724	.004

WAKE UP SLIDE	GROUP M (SD)					F	p	η^2
	TD		ASD					
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	5.32	5.00	3.39	4.11	Group:	1.10	.301	.031
	(1.10)	(1.03)	(1.13)	(1.06)	Context:	.079	.780	.002
					G X C:	.516	.477	.015
Mouth AOI	2.00	1.37	1.33	1.11	Group:	.815	.373	.023
	(.469)	(.488)	(.481)	(.501)	Context:	.875	.356	.024
					G X C:	.201	.657	.006
'Other' AOI	9.16	8.47	10.89	9.17	Group:	.563	.458	.016
	(1.33)	(1.37)	(1.36)	(1.41)	Context:	1.29	.264	.036
					G X C:	.240	.627	.007
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	725	.999	.652	.737	Group:	.686	.413	.019
	(.154)	(.204)	(.158)	(.210)	Context:	1.21	.279	.033
					G X C:	.338	.565	.010
Mouth AOI	.356	.217	.228	.069	Group:	3.04	.090*	.080
	(.102)	(.05)	(.105)	(.051)	Context:	3.09	.087*	.081
					G X C:	.013	.911	<.001
'Other' AOI	3.92	.378	4.12	4.19	Group:	1.75	.194	.048
	(.185)	(.204)	(.91)	(.209)	Context:	.038	.846	.001
					G X C:	.438	.512	.012

ANGRY SLIDE	GROUP M (SD) TD		ASD			F	p	η^2
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	8.47	7.21	11.06	6.17	Group:	.143	.707	.004
	1.75)	(1.46)	(1.79)	(1.5)	Context:	7.91	.008	.184
					G X C:	2.75	.106	.073
Mouth AOI	2.21	1.84	2.00	2.44	Group:	.059	.809	.002
	(.571)	(.724)	(.587)	(.744)	Context:	.006	.937	<.001
					G X C:	.730	.399	.020
'Other' AOI	4.79	6.32	5.94	7.83	Group:	.887	.353	.025
	(1.08)	(1.3)	(1.1)	(1.33)	Context:	3.23	.081*	.084
					G X C:	.036	.850	.001
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	1.65	1.5	1.42	1.24	Group:	.575	.453	.016
	(.24)	(.273)	(.248)	(.281)	Context:	.911	.346	.025
					G X C:	.006	.940	<.001
Mouth AOI	.402	.453	.259	.234	Group:	2.05	.161	.055
	(.092)	(.111)	(.095)	(.114)	Context:	.028	.868	.001
					G X C:	.264	.611	.007
'Other' AOI	2.94	3.05	3.32	3.53	Group:	1.48	.234	.040
	(2.47)	(3.09)	(2.53)	(3.18)	Context:	.664	.421	.019
					G X C:	.073	.789	.002

SAD SLIDE	GROUP M (SD)					F	*p*	η^2
	TD		ASD					
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	10.47	9.95	11.89	7.39	Group:	.068	.796	.002
	(1.99)	(1.54)	(2.05)	(1.58)	Context:	3.72	.062*	.096
					G X C:	2.33	.136	.062
Mouth AOI	1.47	2.26	1.72	3.22	Group:	.708	.406	.020
	(.535)	(.640)	(.55)	(.658)	Context:	6.53	.015**	.157
					G X C:	.629	.433	.018
‘Other’ AOI	3.68	5.21	3.61	5.06	Group:	.021	.885	.001
	(.72)	(.808)	(.739)	(.83)	Context:	3.72	.062*	.096
					G X C:	.003	.958	<.001
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	1.65	1.94	1.35	1.5	Group:	1.67	.205	.045
	(.22)	(.289)	(.226)	(.297)	Context:	.952	.336	.026
					G X C:	.088	.768	.003
Mouth AOI	.189	.332	.302	. 417	Group:	1.10	.301	.031
	(.094)	(.082)	(.096)	(.084)	Context:	2.33	.136	.062
					G X C:	.027	.870	.001
‘Other’ AOI	3.16	2.73	3.35	3.08	Group:	.853	.362	.024
	(.222)	(.303)	(.229)	(.311)	Context:	2.13	.153	.057
					G X C:	.116	.735	.003

PLAY SLIDE	GROUP M (SD)							
	TD		ASD			F	p	η^2
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	1.47	2.00	2.33	.667	Group:	.15	.701	.004
	(.589)	(.611)	(.605)	(.627)	Context:	.89	.352	.025
					G X C:	3.29	.078*	.086
Mouth AOI	1.90	1.58	1.83	.833	Group:	.827	.369	.023
	(.503)	(.362)	(.517)	(.372)	Context:	2.19	.148	.059
					G X C:	.591	.447	.017
'Other' AOI	11.53	12.58	13.00	10.78	Group:	.006	.941	<.001
	(1.74)	(1.9)	(1.79)	(1.95)	Context:	.171	.682	.005
					G X C:	1.34	.254	.037
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	.200	.425	.349	.120	Group:	.283	.598	.008
	(.089)	(.19)	(.092)	(.195)	Context:	.000	.991	<.001
					G X C:	2.14	.152	.058
Mouth AOI	.408	.271	.216	.211	Group:	1.05	.312	.029
	(.119)	(.105)	(.122)	(.108)	Context:	.459	.502	.013
					G X C:	.397	.533	.011
'Other' AOI	4.39	4.30	4.44	4.67	Group:	.929	.342	.026
	(.147)	(.228)	(.151)	(.234)	Context:	.171	.681	.005
					G X C:	.838	.366	.023

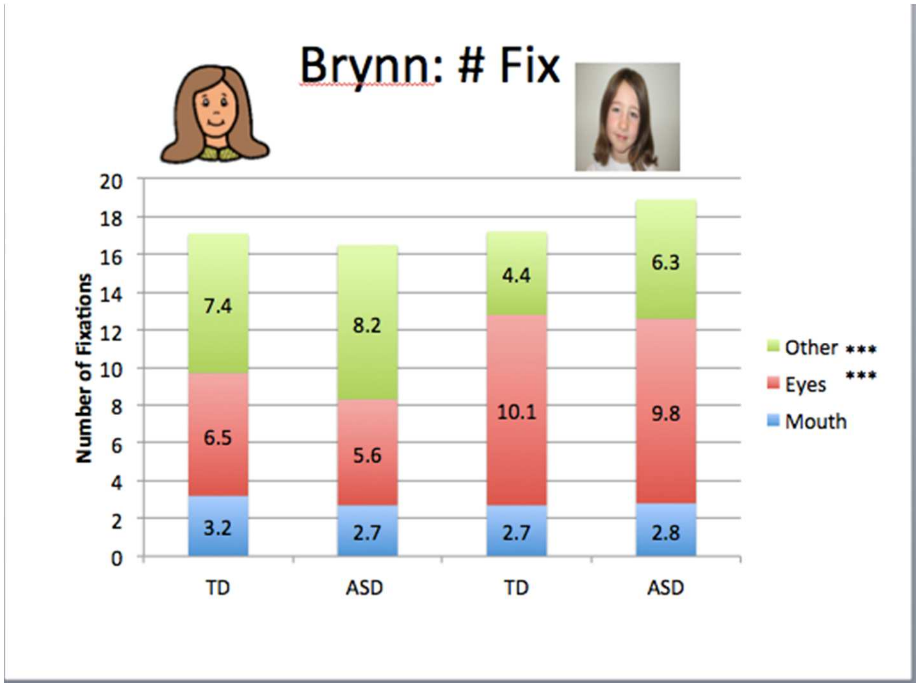
REMEMBER SLIDE	GROUP M (SD)							
	TD		ASD			F	*p*	η^2
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	9.74	8.05	9.67	6.50	Group:	.193	.633	.005
	(1.63)	(1.18)	(1.67)	(1.21)	Context:	8.11	.007***	.188
					G X C:	.757	3.90	.021
Mouth AOI	.263	1.47	1.22	1.67	Group:	1.81	.285	.033
	(.265)	(.629)	(.273)	(.646)	Context:	3.47	.071*	.090
					G X C:	.743	.395	.021
‘Other’ AOI	5.21	5.63	5.56	6.89	Group:	351	.558	.010
	(.922)	(1.25)	(.948)	(1.28)	Context:	1.21	.280	.033
					G X C:	.326	.572	.009
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	1.37	1.59	1.47	1.35	Group:	.053	.820	.002
	(.251)	(.243)	(.258)	(.25)	Context:	.073	.789	.002
					G X C:	.842	.365	.023
Mouth AOI	.029	.210	.115	.504	Group:	1.89	.178	.051
	(.032)	(.192)	(.033)	(.197)	Context:	4.10	.051*	.105
					G X C:	.550	.463	.015
‘Other’ AOI	3.60	3.20	3.42	3.14	Group:	.116	.736	.003
	(.259)	(.281)	(.266)	(.289)	Context:	4.20	.048**	.107
					G X C:	.143	.708	.004

	GROUP M (SD)							
HAPPY SLIDE	TD		ASD			F	*p*	η^2
Number Fixations	BM	PHOTO	BM	PHOTO				
EYE AOI	6.42	7.16	7.39	9.50	Group:	1.23	.274	.034
	(1.19)	(1.09)	(1.23)	(1.12)	Context:	4.45	.042**	.113
					G X C:	1.04	.316	.029
Mouth AOI	2.37	3.26	1.33	3.56	Group:	.126	.724	.004
	(.518)	(1.12)	(.532)	(1.15)	Context:	5.06	.031**	.126
					G X C:	.918	.345	.026
'Other' AOI	8.79	4.16	8.56	4.83	Group:	.027	.871	.001
	(1.38)	(.915)	(1.42)	(.94)	Context:	17.58	<.001***	.334
					G X C:	.208	.651	.006
Fixation Time	BM	PHOTO	BM	PHOTO				
EYE AOI	1.04	1.95	1.26	1.81	Group:	.018	.895	.001
	(.197)	(.284)	(.203)	(.292)	Context:	17.19	<.001***	.329
					G X C:	1.01	.321	.028
Mouth AOI	.346	.604	.144	.466	Group:	1.67	.205	.046
	(.076)	(.143)	(.078)	(.147)	Context:	8.52	.006***	.196
					G X C:	.103	.750	.003
'Other' AOI	3.61	2.45	3.60	2.72	Group:	.146	.705	.004
	(.213)	(.316)	(.219)	(.324)	Context:	30.41	<.001***	.465
					G X C:	.619	.437	.017

* p < .10, ** p < .05, *** p < .01

Figures 1-15: Number of fixations and fixation time (seconds) for mouth, eyes, and other AOIs across both Social Stories™. Data from series of 2 (group: TD; ASD) x 2 (stimulus: BM; photographs) mixed model ANOVAs with repeated measures on stimulus, for research question one.

Figure 1: Number Fixations for "Brynn" SlidE



FigureTwo: Fixation Time for "Brynn" Slide

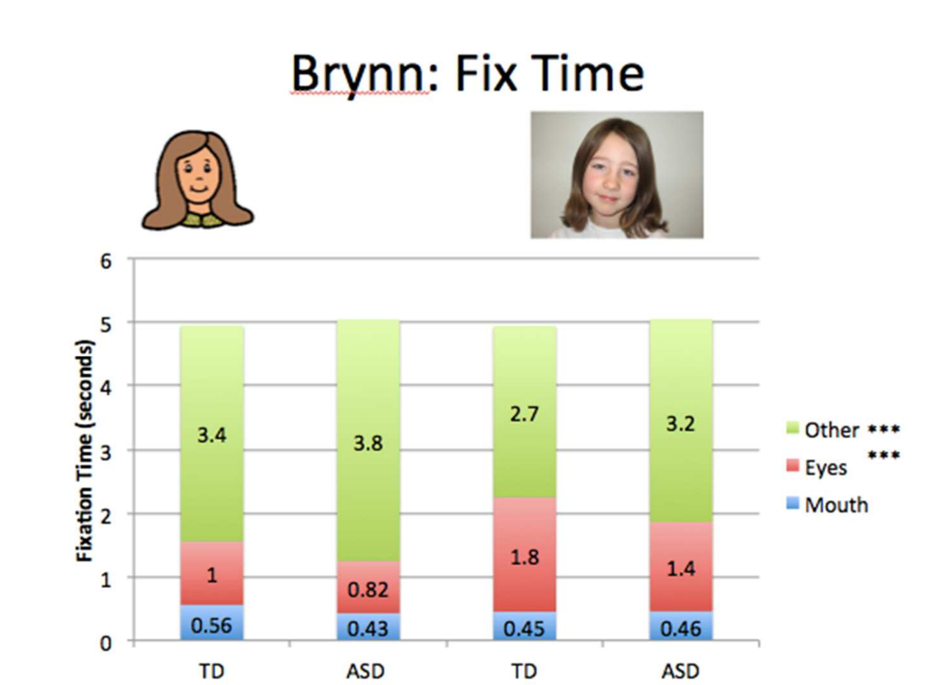


Figure Three: Number Fixations for "Wake Up" Slide

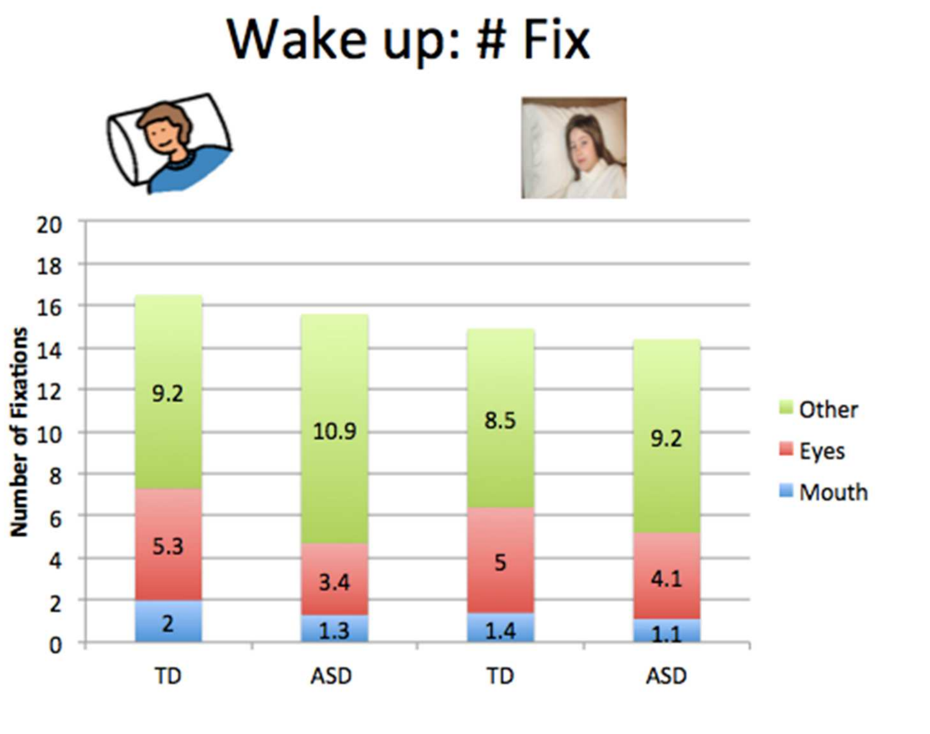


Figure Four: Fixation Time (seconds) for "Wake Up" Slide

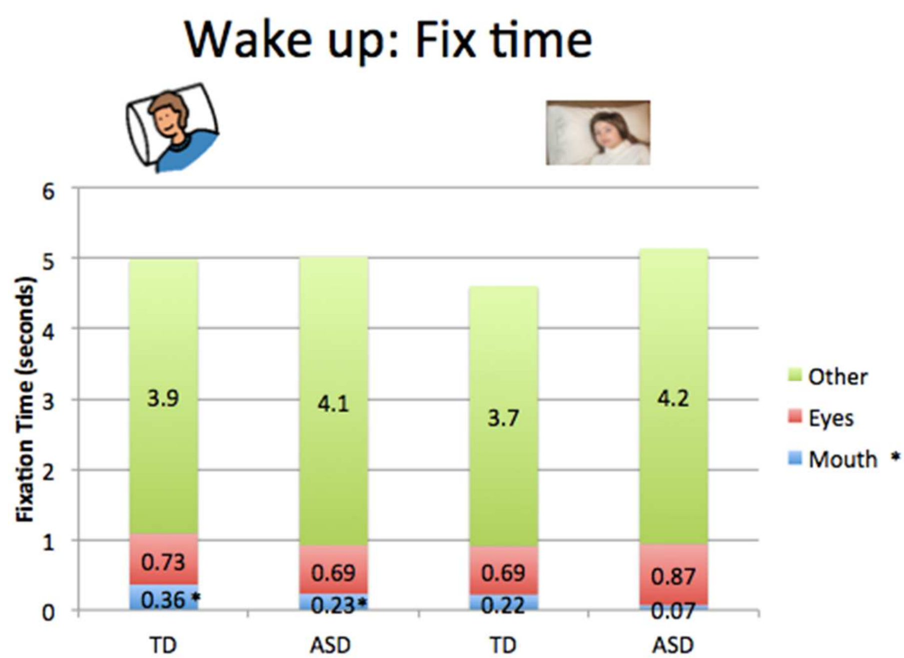


Figure Five: Number Fixations for "Angry" Slide

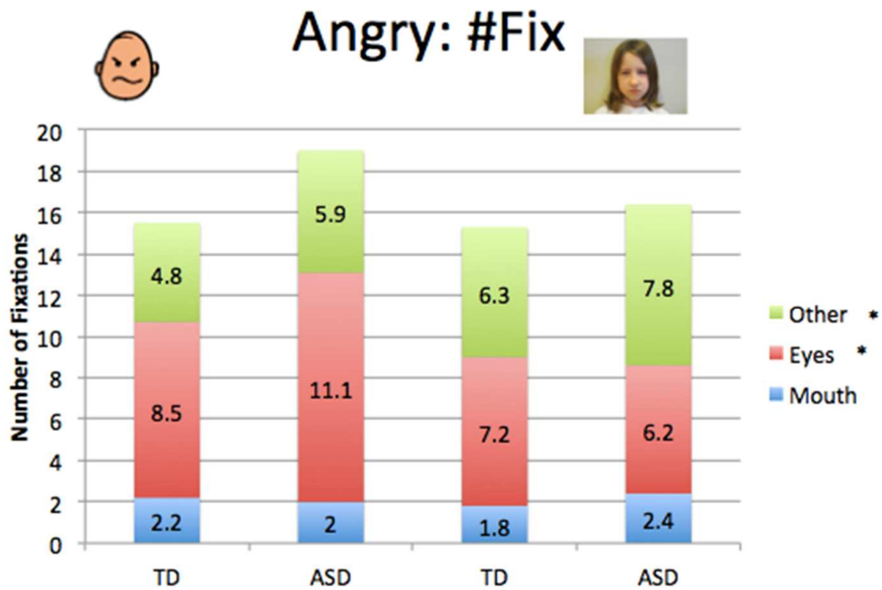


Figure Six: Fixation Time (seconds) for "Angry" Slide

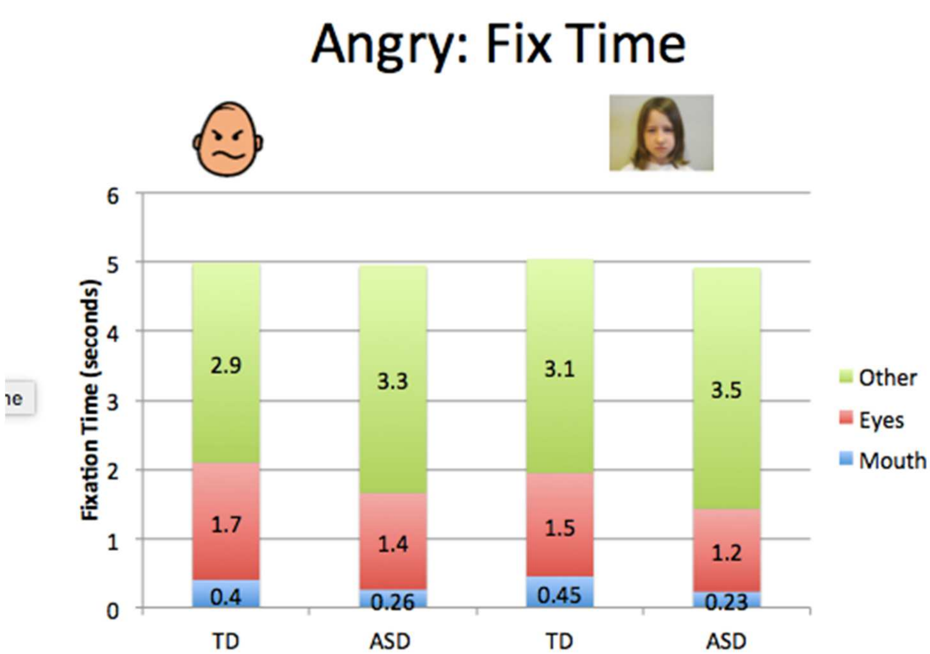


Figure Seven: Number Fixations for “Sad” Slide

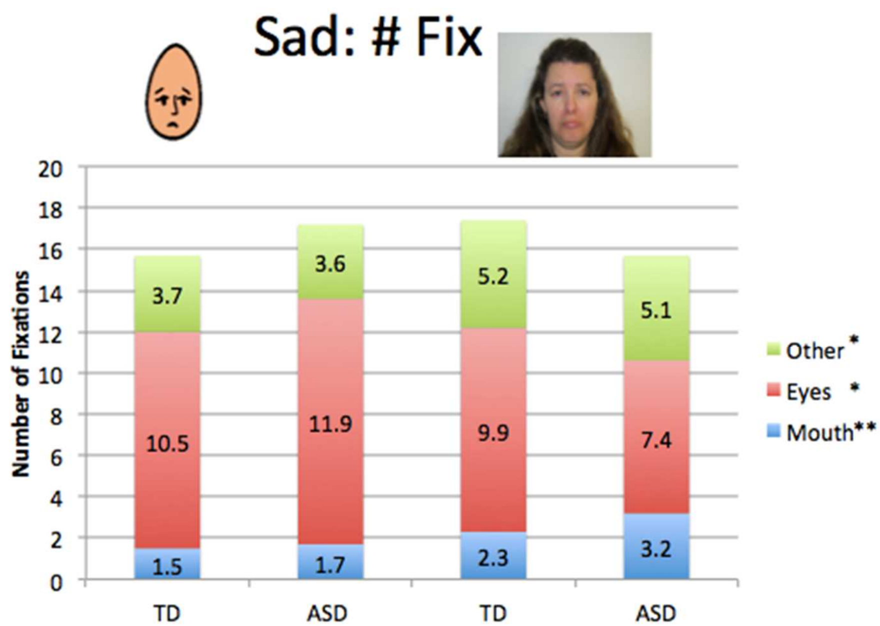


Figure Eight: Fixation Time (seconds) for “Sad” Slide

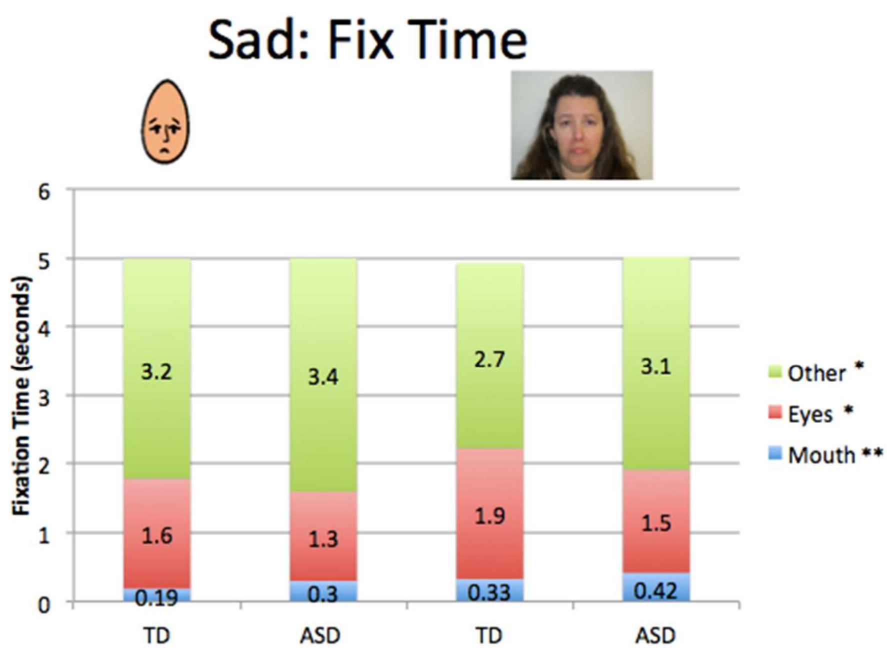


Figure Nine: Number Fixations for "Play" Slide

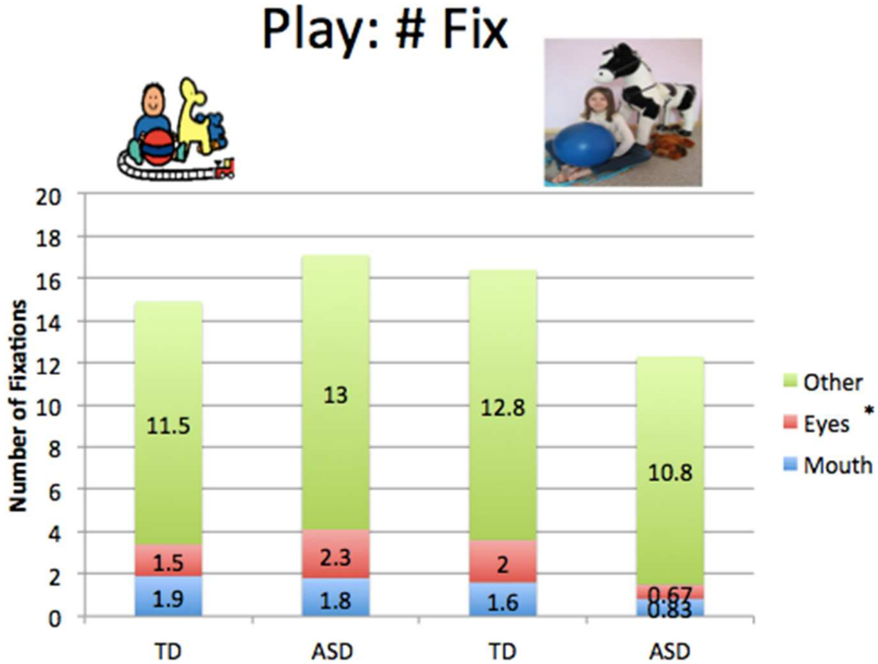


Figure 10: Fixation Time (seconds) for "Play" Slide

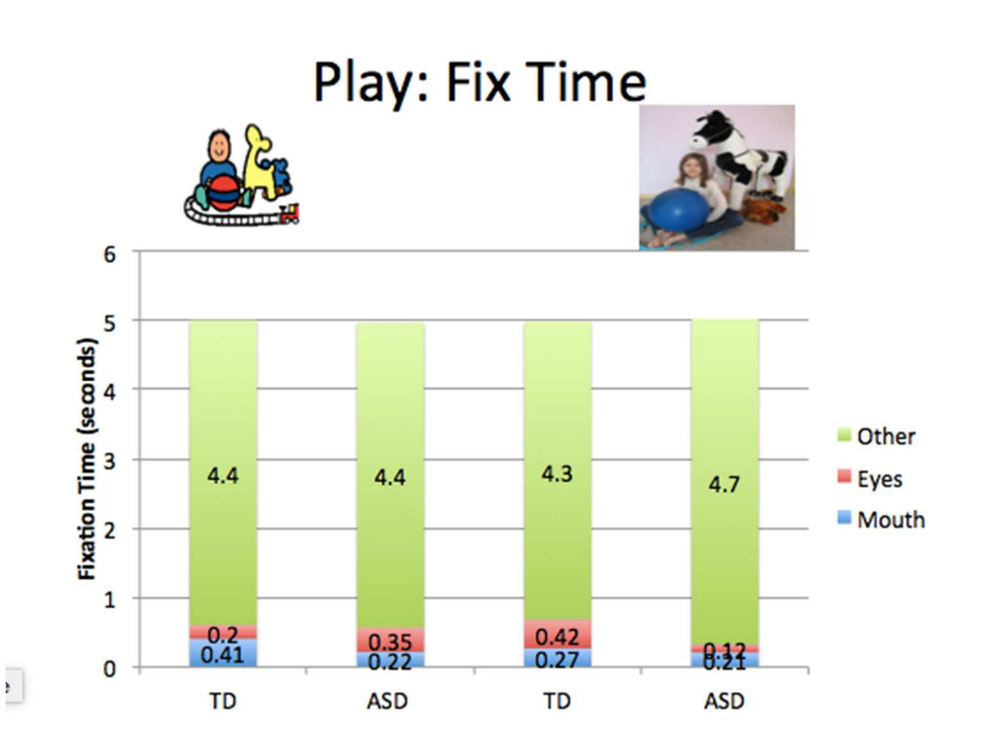


Figure 11: Significant Interaction for Number of Fixations to Eye AOI for "Play" Slide

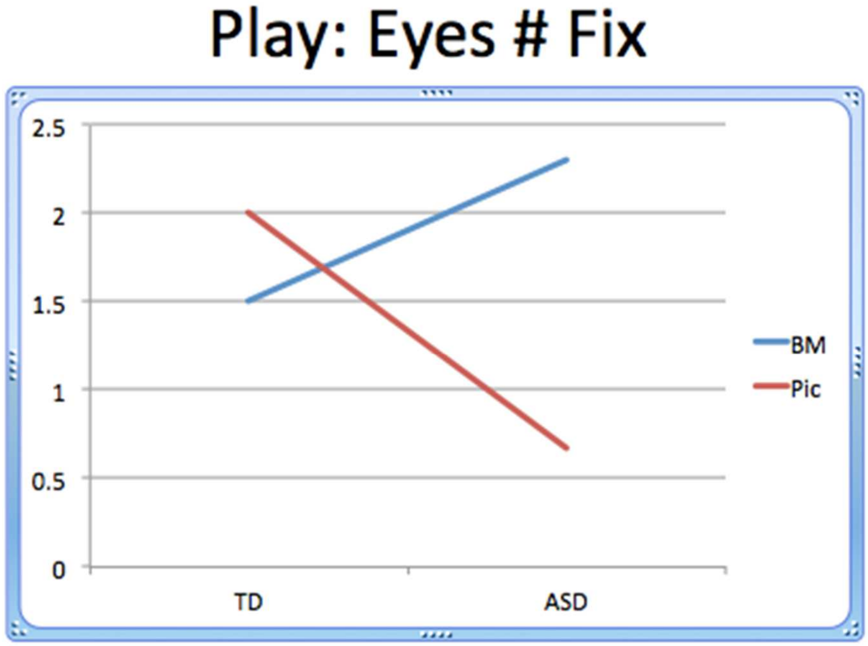


Figure 12: Number Fixations for "Remember" Slide

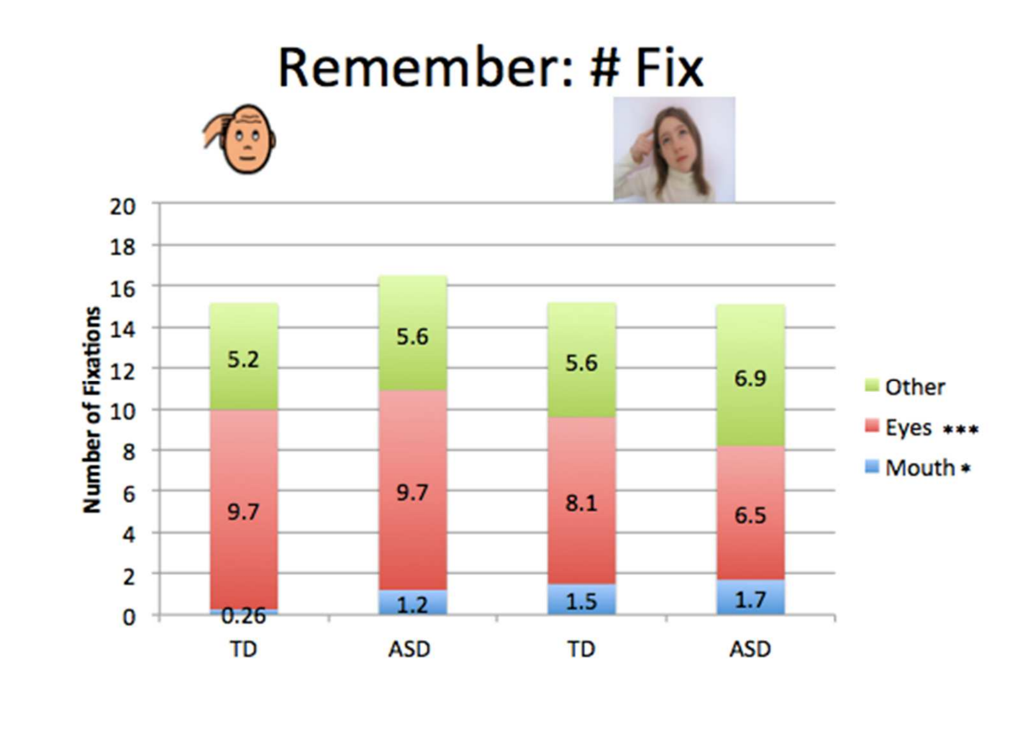


Figure 13: Fixation Time (seconds) for "Remember" Slide

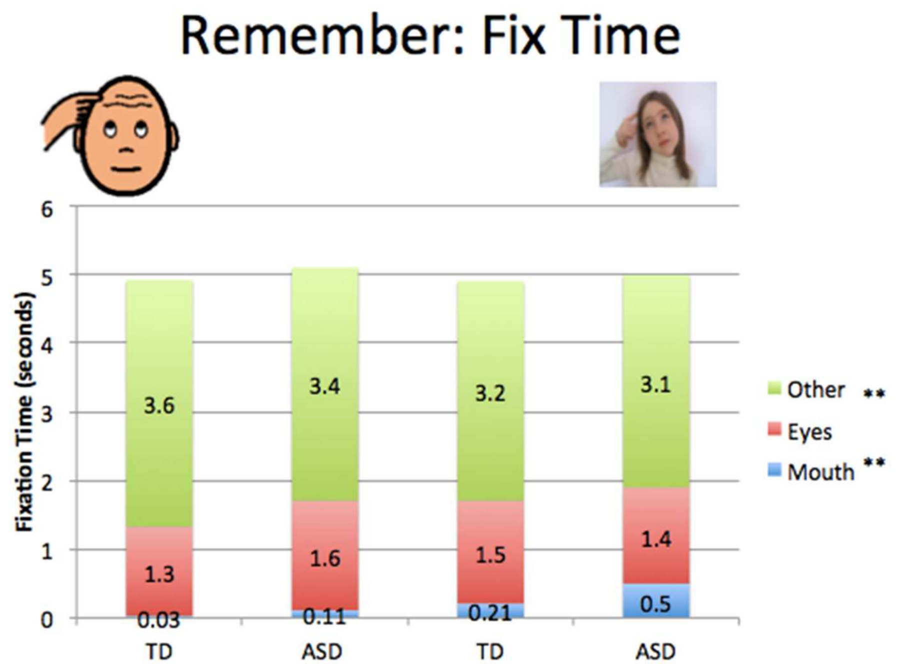


Figure 14: Fixation Time (seconds) for "Happy" Slide

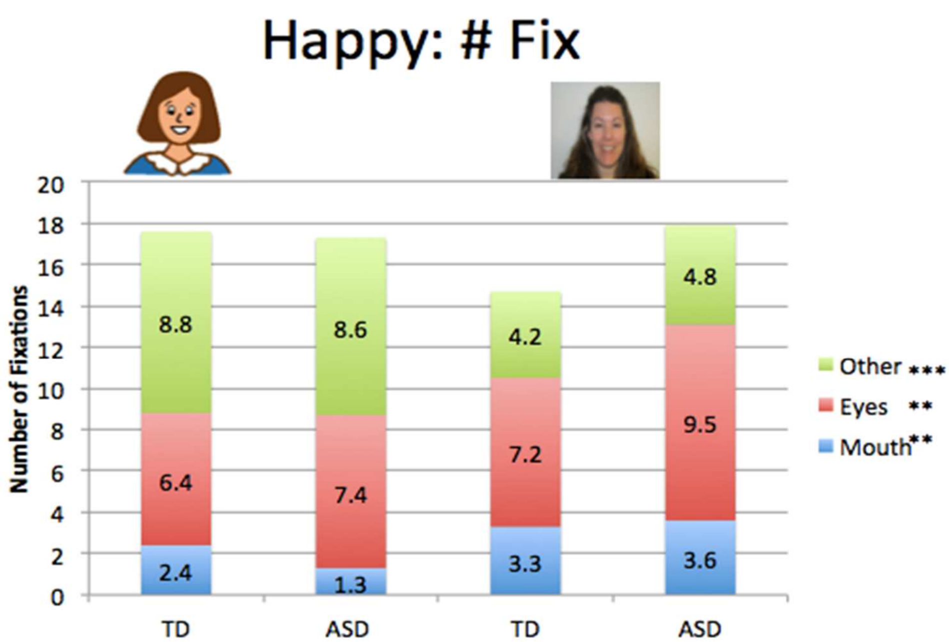


Figure 15: Number of Fixations for "Happy" Slide

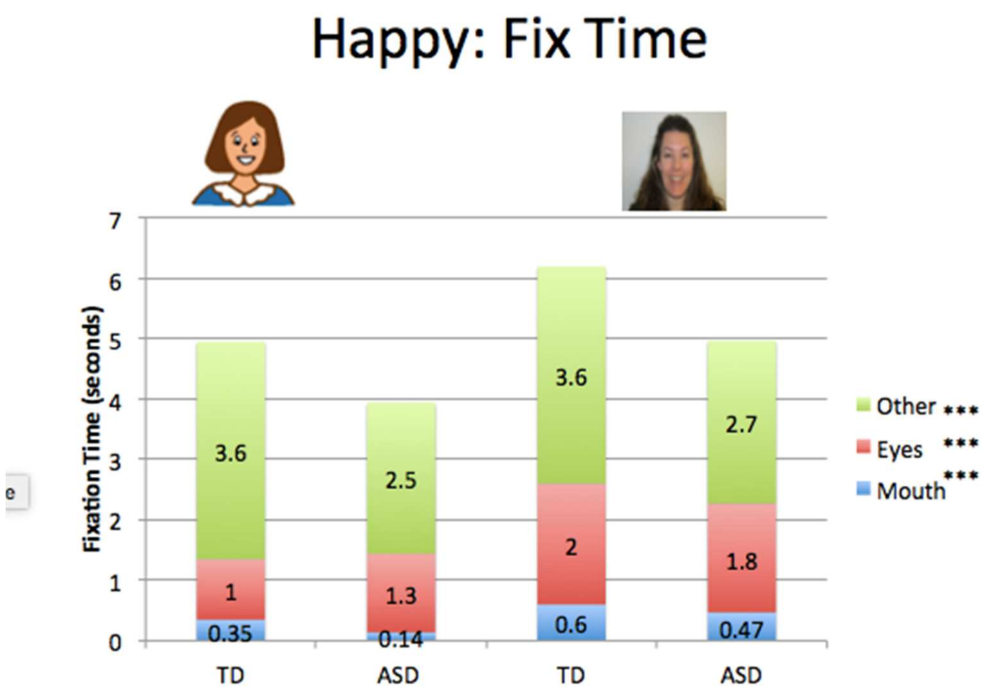


Figure 16: Heat Map of Visual Allocation Patterns of ASD Participant across Stimulus Type for "Play" Slide