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Do You See What I See?

Visual Attention Patterns of Adolescents With and Without ASD to a Dynamic Videogame Stimulus

Erinn Finke (Penn State University), Benjamin Hickerson (University of North Carolina Greensboro), & Krista Wilkinson (Penn State University)

Abstract

The purpose of this study was to determine if children with and without autism spectrum disorder (ASD) fixate similarly while passively viewing a videogame play stimulus. To answer this research question, eye-tracking technology (i.e., Tobii T60) was used to gather data from typically developing children as well as children with ASD. A coding scheme was developed to determine how often all participants visually attended to various elements of the video game. This study is a first step in determining if videogame play may be an appropriate context for providing opportunities for friendship formation.

Introduction

Autism spectrum disorder is characterized by deficits in social communication and restricted, repetitive behaviors (American Psychiatric Association, 2013). Many individuals with ASD experience social isolation that negatively influences all aspects of development as well as long-term outcomes (Muller, Schuler & Yates, 2008). In particular, limitations in social skills can restrict an individual's ability to make and maintain relationships, obtain and retain employment, live independently, and fully participate in society at large (McConnell, 2002; White, Keonig & Scahill, 2007). One important outcome that is documented to be particularly at risk in individuals with ASD is making and maintaining authentic, reciprocal friendships (Petrina, Carter & Stephenson, 2014; Rowley et al., 2012). Friendship is one of the most fundamental aspects of quality of life, and its benefits are well documented (Parker & Gottman, 1989). Many children with disabilities, including children with ASD, experience substantial difficulty in making and maintaining friends. Moreover, children with disabilities like ASD are often perceived as less socially competent and of lower social status than their typically developing peers (Orsmond et al., 2004).

Finke (2016) reviewed literature on the state of research and clinical practices designed to promote inclusion and peer relationships for individuals with ASD. As she noted, interventions to increase quality and rate of social interactions of children with ASD have primarily sought to teach very specific social skills, such as appropriate ways of entering a social group or asking partner-centered questions. Extensive research has shown children with ASD can indeed learn these targeted social skills (e.g., Odom, McConnell, & Chandler, 1994). Despite this, outcome data suggests, quite convincingly, that successful completion of social skills training does not translate to increases in the number, quality, or duration of friendships for children with ASD (Petrina et al., 2014; Finke, 2016). It seems, based on the data available, an opportunity exists to reframe the effort to promote social outcomes for individuals with ASD by investigating how the naturally-occurring environments and activities in which friendships typically emerge may be used in intervention.

On the basis of her analysis of the construct of friendship, Finke (2016) offered a proposed framework that, together with existing programs, might serve to promote friendship outcomes in individuals with ASD. Specifically, Finke proposed three fundamental elements for friendship interventions: (a) offering a means by which both partners can enjoy equal status/contribution to the relationship (Newcomb & Bagwell, 1995) (b) structuring intervention to include mutually motivating opportunities for interaction; and (c) offering frequent opportunities for interaction in an activity context preferred by both partners. Finke (2016) also offered several potential contexts that may meet these criteria as examples and potential avenues for researchers to begin to explore her ideas empirically. One such context is videogame play. The vast majority of adolescents engage with video games as a form of leisure. Lenhart et al. (2008) reported that 99% of boys and 94% of girls under the age of 18 years old play some form of video-based games on a regular basis. Children with ASD have an interest in video games that is comparable (Hickerson, Finke & Choi, 2014) to individuals without ASD.

In addition to being popular, video games allow players to play cooperatively and as equals at whatever skill level they possess. This allows players of varying ability levels to play together without compromising the ability for either player, or the dyad together, to achieve success within the game. This will be an important factor to consider, as one barrier to the establishment of a friendship could be conflict within an interaction. Varying levels of skill and ability within an activity can cause frustration, which may cause the two children to be less interested in playing together in the future. An activity with real promise, especially when considering dyads comprised of one child with ASD and one child without ASD, would be one where the children could play together, regardless of their experiences and skills, and still achieve success through working together.

Measuring Visual Attention to Videogames as a Necessary First Step

While videogames might have promise as a context for friendship intervention, the behavioral profile associated with ASD introduces several specific and unique issues that warrant examination prior to embarking on any intervention effort using videogames as the context. One of the core features contributing to diagnosis of ASD is atypical patterns of eye gaze during actual social interactions, such as gaze aversion or limited eye contact with social partners (APA, 2013). Videogames are platforms within which game characters (the avatars within the game) enact the action and, oftentimes, interact with one another. If the visual attention atypicalities of individuals with ASD extend to attention paid to characters within videogames, then the play patterns of individuals with ASD might be quite different than those of their peers. In that event, any friendship intervention based on videogame play might be destined to fail, as it might not accommodate potential barriers of differential visual attention of players with and without ASD.

Atypicality in visual processing in individuals with ASD has formed the basis for some frequently cited models of ASD (e.g., Happe & Frith, 2006). Describing the nature of visual attention deficits in individuals with ASD has been the focus of much research (see Ames & Fletcher-Watson, 2010). Automated eye tracking technology is gaining popularity as a means of extending what is known about visual processing in social contexts, as the data collected can reveal the features that capture visual attention a momentary marker of underlying cognitive and social processing (Gillespie-Smith & Fletcher-Watson, 2014). As a result there has been a steep increase in the number of eye tracking studies examining the visual social attention patterns and visual responses of individuals with ASD. Visual social attention “refers to the overt attentional bias to orient to and look at other people, notably their face and eyes, as well as to where they direct their attention” (Guillon et al, 2014; pp. 280).

One of the proposed core deficits experienced by individuals with ASD is decreased attention to socially relevant stimuli, particularly faces, when compared to individuals without ASD (e.g., Dawson, Webb & McPartland, 2005). Results of eye tracking studies examining this core deficit in children, adolescents, and adults with ASD have been mixed. Some studies have shown a clear difference in the visual attention patterns between individuals with and without ASD, while other studies suggest between-group performance is indistinguishable. The differences in these outcomes may be related to the differences in the stimuli used (static images vs dynamic videos) as well as the types of social demands presented within the task. To date, studies that used static images that contained a single person within the image as stimuli garnered visual social attention patterns from individuals with and without ASD that were similar (e.g., Fletcher-Watson, et al., 2009). Other studies have examined visual social attention using dynamic stimuli containing more than one person. In these contexts, individuals with typical development increased the quantity of time fixated on faces and eyes in these situations (e.g., Riby & Hancock, 2009). These results appear to suggest that as a stimulus becomes more socially complex (includes more than one person), the visual social attention patterns of individuals with ASD become more divergent compared to participants without ASD.

There is also evidence that, for individuals with ASD, relevance or salience of competing objects or events may affect their attention to faces (Sasson & Touchstone, 2013). This may vary, however, as contexts and stimuli become more naturalistic (Guillion et al., 2014). Overall, current eye tracking research of visual social attention in individuals with ASD appears to suggest individuals with ASD have most difficulty orienting to faces when there are competing non-social objects in the visual field and that individuals with ASD take longer to fixate on faces when the stimuli and display is complex (Guillion, et al., 2014).

Purpose

One major limitation of the eye tracking research involving participants with ASD to date, however, is that, with few exceptions (e.g., Gillespie-Smith & Fletcher-Watson, 2014), eye tracking technologies have rarely been used with individuals with ASD who have concomitant intellectual disabilities. This gap in the literature needs to be addressed as eyetracking technology has the power to reveal information about visual attention that is difficult or impossible to measure behaviorally, particularly in individuals with disabilities who cannot respond to conventional methods of assessment (Wilkinson & Mitchell, 2014). The current study used automated eyetracking technology, to investigate visual attention to a video game stimulus. We examined visual attention to videogame stimuli because videogames appear to offer a uniquely well-suited environment for the emergence of friendships, but it is not yet known if children with ASD attend to and play videogames like children without ASD. We believe that it is critical to examine how children with ASDs look at and interact with characters in a videogame, for two reasons: (a) unusual visual attention patterns, most particularly to human figures, is a core feature of the ASD diagnosis, so it seems possible that children with ASDs might engage differently with videogame characters than their nondisabled peers; (b) in turn, this difference of attention allocation might affect the way the individual with ASD plays the game, and, consequently, how they play with a partner.

Method

Participants

Participants were 11 individuals with ASD and 8 with typical development. Participants with ASD were recruited from a local non-public school for children with ASD. Participants without ASD were recruited through personal contacts. Only children whose parents provided signed informed consent, who also provided their own assent to participate, and who met the inclusion criteria participated in the study. Inclusion criteria for the participants with ASD were: 1) having a documented diagnosis of an autism spectrum disorder from a medical professional, as recorded on school records; 2) being between the ages of 6 and 21, inclusive; 3) having parental (or primary caregiver) permission to participate in the investigation; and 4) providing their own assent to participate (if under the age of 18) or written consent to participate (if over the age of 18). Inclusion criteria for the participants with typical development were: 1) having no reported and/or documented history of any type of disability; 2) having parental (or primary caregiver) permission to participate in the investigation; and 3) giving their own assent to participate (if under the age of 18) or written consent to participate (if over the age of 18).

Participants with ASD ranged in age from 8;11 to 17;10 years. All but one had moderate to severe limitations in receptive vocabulary, as indicated by standard scores in the range of 20-63 on the Peabody Picture Vocabulary Test – IV (PPVT-IV; Dunn & Dunn, 2007); one individual with ASD had a receptive vocabulary score within normal limits. We opted to retain this individual in the sample because visual inspection of the data indicated his eye gaze patterns were no different from the others with ASD, that is, his measures were not outliers, but rather were consistently within the range of measures. All of the participants with ASD had significant expressive limitations documented via school-based testing in their school and academic records; and used various forms of augmentative and alternative communication (AAC) as their primary form of expressive communication.

Matching across the groups of participants was based on chronological age. Chronological age matching was conducted because the study aimed to inform future interventions that might use videogame play as a context for interventions targeting friendships among same-aged peers. Therefore, it was important to determine if the visual attention of adolescents with autism to the videogames was similar or different from the attention of the peers with whom they might be playing, and making friends. There was at least one participant without ASD for every age (in years) of the participants with ASD.

Materials and Stimuli Development

One video game play clip involving the *LEGO Marvel Superheroes* videogame were captured using a Microsoft Xbox One. The picture-in-picture clip with the players face and the game play was captured with an additional, application, Twitch. Twitch is an application the allows video game players to broadcast their gameplay sessions using a picture-in-picture format. The viewer of the Twitch stream is able to see both the game play and the face of the game player. The Twitch stream of the game player for the current project was recorded using the screen recording feature in Apple QuickTime (see Figure 1). The QuickTime recording was then saved and uploaded into the eyetracking software for data collection.

General Procedure

Each participant engaged in one eye tracking data collection session. During this session the participant was calibrated with the eye tracking equipment using a two-point gaze fixation procedure in which the participant was directed to look to the top left and then the bottom right corner of the screen by the presence of a familiar cartoon character. Once proper calibration was achieved, each participant watched the prerecorded videogame play clip that contained the picture-in-picture video inset of the player’s reactions to the videogame. There were no additional sessions and repeated viewing of the video was not allowed.

Figure 1. Twitch feed capture.

The Tobii T60 and the software Tobii Eye Tracking Studio tracked participants’ eye movements. The Tobii T60 captures the movements via infrared light that is projected from the top strip of the monitor. The infrared light bounces off of the participant’s eyeball and these reflections are recorded by detectors along the bottom strip of the monitor. Using the participant’s distance from the monitor, the curvature of the cornea, and the location of the pupil, the system derives coordinates for the gaze location at each sample taken. The Tobii captures six samples of eye position per second (1 every 16 ms). The Tobii was connected to a Dell laptop where all of the data were stored within the Tobii software on the computer.

Data collection setting

All data were collected in a small room designated for the research activity. The room contained a table, the Tobii machine, the Dell laptop, and chairs. Participants were scheduled for 15-minute sessions, which was sufficient for watching the clips and for transition to the data collection room and back to the classroom. Each participant sat in a chair 65 cm from the Tobii T60 screen located on top of the table. The researchers sat to the side of the participant in front of the Dell computer in order to start the video, as well as observe and monitor the participant during the viewing task. For the participants with ASD, the data collection session occurred at their school during school hours. For the participants without ASD, data were collected in a laboratory setting on a university campus.

Data Preparation

The Tobii software program was used to create "areas of interest," that is, to enclose the areas on the screen in which actions or events meaningful to the videogame play. Figure 2 illustrates one frame from the videogame, with the areas of interest (AOIs) illustrated. The primary research question in this study concerned whether or not participants with ASD referenced the real-time video of the videogame player during the videogame play. Therefore, one main area AOI was the square enclosing the picture-in-picture video stream in the lower right corner of the screen (labeled "face" in Figure 2). For the secondary research question, other AOIs related to other meaningful events were evaluated. These included Action Scene (the actual action being engaged in by the Lego character being controlled by the player), Big A (a large "A" shape that the character had to climb during the videogame), Dialog (the written set of instructions that scrolled along the bottom of the screen), and Life (the indicator of how much life the character had remaining). All other areas in the videogame that were not enclosed in the defined AOIs were treated as "Other".

Dependent Measures

The dependent measure was the proportion of each participant's own total fixation time allocated to each of the defined AOIs, and to "other". For each participant we first derived the total time spent fixated anywhere on the videogame, and then calculated the proportion of that amount of time spent fixating on each of the AOIs. Fixations were defined as gaze that dwelled within a 35-pixel area for at least 100 milliseconds (6 or more samples), using the default filter settings on the Tobii Studio software. Data were analyzed for those participants who were calibrated and for whom more than 33% of the samples were obtained over the course of the session. Of the 13 children with ASD who participated in the eye tracking data collection sessions, usable data were collected and analyzed from 11 of them.

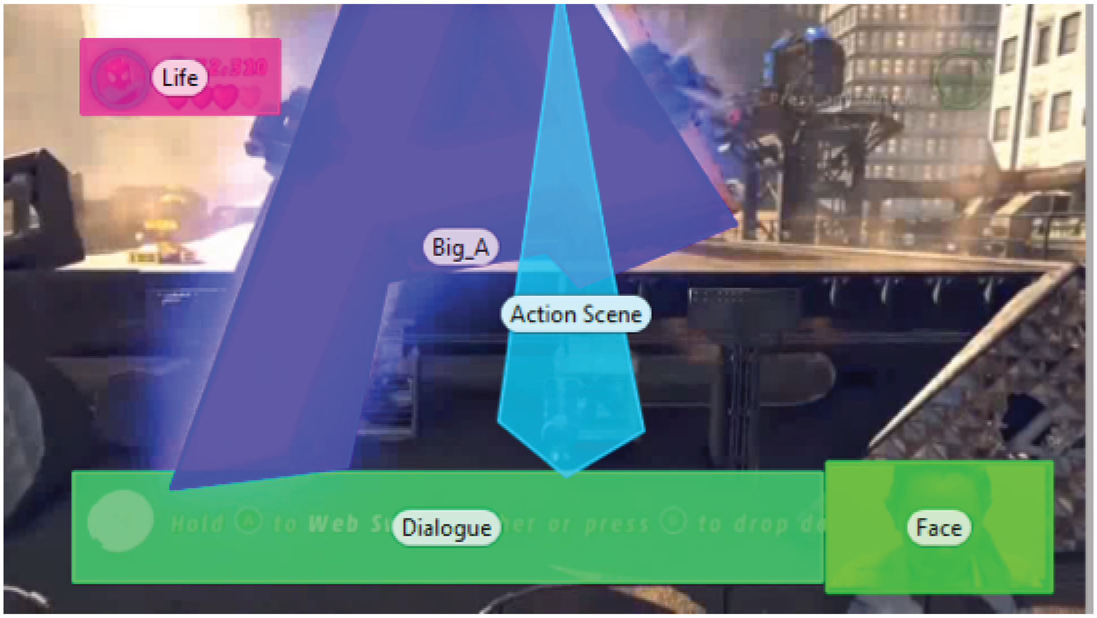

Figure 2. Areas of interest for visual attention coding.

The proportion of time allocated to each AOI was calculated based on each participant's own time spent fixated anywhere on the screen, rather than the total possible viewing time. The clip was 160.38 seconds in length, however, no participant showed fixations for that entire period; gaps in fixation can occur for any number of reasons, including saccades, blinks, looks away from the screen, or presence of stereotypic behaviors that momentarily occlude the infrared recording (e.g, bringing a hand to the face). Previous eyetracking research with individuals with ASD and concomitant intellectual disability indicated that the overall amount of time spent fixated, anywhere on the screen, can be significantly less for individuals with ASD than for those with typical development (Wilkinson & Light, 2014). In the current study, the individuals with ASD spent a mean of 120.12 seconds fixated on the screen, while the matched peers spent a mean of 153. 78 seconds fixated on the screen. Independent samples Mann-Whitney U statistic confirmed this difference was of statistical significance (U = 70, p = .033). Logic dictates an individual with a lower overall fixation time will also spend shorter times fixated on any given element, thus potentially compromising comparison across individuals if the absolute time values are used. Proportion of attention allocation was therefore calculated to reflect the allocation of attention to different elements relative to each individual's own total fixation time.

Results

Five separate one-way analysis of variance (ANOVA) comparisons were calculated on participants' visual attention patterns to each of the established AOI. The analysis was significant for the AOI of Dialog, $p = .023$. Visual attention patterns between the groups of participants were similar (i.e., did not yield statistically significant outcomes) for the other four AOI (see Figure 3). That is, visual attention patterns were not significantly different for Action, $p = .377$; Big A, $p = .974$; Face, $p = .924$; or Life, $p = .850$.

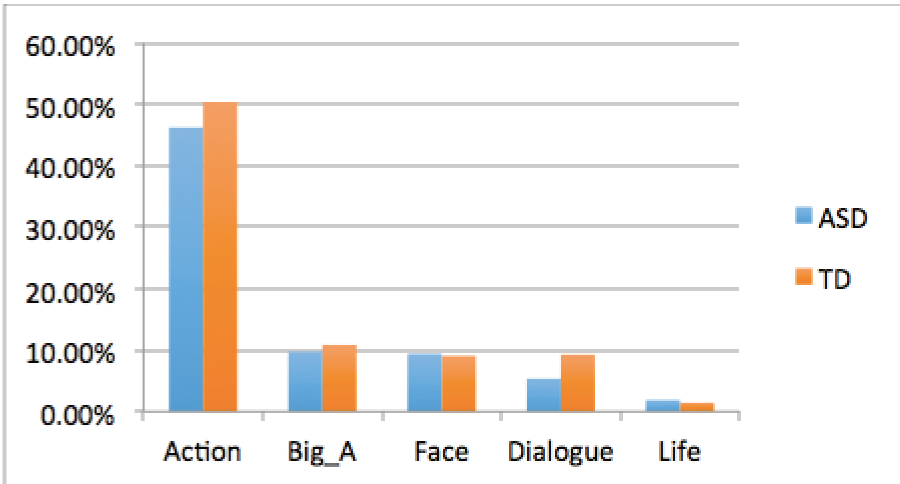

Figure 3. Percent fixations on AOI by group.

Discussion

The current study used automated eyetracking technology, to investigate visual attention of individuals with and without ASD to a videogame stimulus. We examined visual attention to a videogame stimulus because videogames appear to offer a uniquely well-suited environment for the emergence of friendships. The results of the current study indicated the participants with and without ASD visually attended to the videogame stimulus similarly for all but one variable analyzed. The only variable with a significantly different pattern of visual attention between the groups was the text-based instructions/ dialog. This could be a significant finding as text is frequently used within videogames to direct players and to provide information regarding how to move through the game and make progress. The differences between groups for this variable could be related to differences in literacy skill between the two groups. Many, if not all, of the participants with ASD were nonliterate, and all of the participants without ASD were literate. In an actual gameplay situation or intervention, this discrepancy between the groups could imply a need for careful game choice, in terms of familiarity with the game, or the need for the literate partner to read the text to the nonliterate partner.

The overall similarity in the results between the groups is very promising for the use of videogames as a context for friendship-based interventions and interactions. Overall, the participants with and without ASD attended to the same features of the game with similar levels of intensity and frequency. This appears to indicate the two groups are following the actions of the characters and the progression of the videogame story similarly. This could mean the two groups would also play videogames similarly, but this needs to be investigated further.

Important implications for individuals with ASD are related to the complexity of the videogame stimuli used in the current investigation, the chronological age matching procedures used for the comparison grout and the contrasting findings to previous eye tracking research involving participants with ASD. First, the videogame stimuli used for data collection in the current study were socially complex. The similarity of the findings in the picture-in-picture condition indicate that, in this situation, with this stimuli, individuals with ASD socially oriented and alternated their gaze between a human face and the game play scene similarly to their non-ASD peers. This is a significant finding as the face in the picture-in-picture condition was a human, and not the human-like LEGO figures that were featured in the other stimuli clips used in this investigation. This may suggest something unique about the way individuals with ASD process and participate with people during videogame play.

Limitations and Future Directions

The current study has several recognized limitations. This study was limited to twenty individuals, twelve with ASD and eight typically developing. This study only recruited participants with ASD from one school in central Pennsylvania, leaving very similar demographic profiles, which may limit generalization. Only individuals between the ages of 6 and 21 participated, which did not permit the study of young children, or older adults. The participants only watched one video game (*LEGO Marvel Superheroes)*, not allowing examination of visual attention patterns for other types of videogames. All participants sat in a chair facing the Tobii T60 screen located on top of the table while researchers sat to the side of the participant to reduce distractions. And lastly, only participants for whom the Tobii system had captured 50% or more of their fixations were used for the data analysis, removing some individuals from the study.

The results of the current study demonstrated individuals with ASD visually attend to videogame stimuli similarly to typically developing individuals during passive viewing of a video game play clip, however this research must be expanded to determine whether or not videogames are played similarly by children with and without ASD. Future studies should investigate how children with and without ASD physically play videogames, alone and with a play partner. Attending to, and playing video games are two different tasks and need to be studied separately. A longitudinal study that observes how children with ASD play video games together as well as interact as they play could be helpful in providing insight as to how the nature of friendship is affected by ASD and can be facilitated through a mutually motivating activity, such as videogaming.

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