High Support Need and Minimally Verbal Children with Autism Playing a Preference Based Computer Game: A Pilot Eye-Tracking Study of Four Individual's Attendance to Eyes

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Abstract

Individuals with autism often exhibit atypical levels of attention to eyes. High support need and minimally verbal individuals with autism have typically received less attention in research. This study explored a preference based computer game to include the less-studied individuals with autism in their own school environment. Four high support need and minimally verbal children with autism played a familiar computer game where correct decisions were contingent on attending to the eyes of a virtual character. Case control analyses were used to compare individual's results to a control group. The analyses revealed that one child spent less time looking at the eyes than did the controls, and two children did not differ from the controls. There was no usable data for the fourth child. Our results suggest that high support need and minimally verbal children can be included in eye tracking research by using familiar positive environments.

Keywords: *autism, high support need, eye-tracking, visual perspective taking, case- control method*

Introduction

High support need (Strnadová, Cumming, & Marquez, 2014) and minimally verbal individuals (Tager-Flusberg & Kasari, 2013) with autism spectrum disorder (ASD) have been variously defined in the research literature. They have also received less research attention than their higher-functioning counterparts (Grynzspan et al., 2013; Kylliäinen et al., 2014; Simmons et al., 2009; Tager-Flusberg & Kasari, 2013; Whittaker, 2012). This lack of research may be due to the difficulty involved in matching and grouping individuals together (Burack et al., 2004; Jacobsen, 2000). These individuals are also a group for whom alternative testing methods should be explored, as standardised assessments may not be suitable due to lack of interest in the tests and their verbal nature (DiStefano, & Kasari, 2016; Kasari, Brady, Lord, & Tager-Flusberg, 2013; McGonigle-Chalmers, Alderson-Day, Fleming, & Monsen, 2013; Skwerer et al., 2015).

One of the key criteria for diagnosing ASD is impairment in establishing and maintaining eye contact. Impairments have also been shown in joint attention (Korhonen, Kärnä, & Räty, 2014), gaze cueing (Nation & Penny, 2008), looking time (Guillon, Hadjikhani, Baduel, & Rogé, 2014), and visual perspective taking (Pearsons, Ropar, & Hamilton, 2013), all of which require the person to attend to the eyes of another person. These abilities are also considered to be associated with the social deficits observed in ASD (APA, 2013; Jones, Carr, & Klin, 2008; Jones & Klin, 2013). Due to the importance of eyes in social communication and a person's life, eye-tracking studies have been used to obtain more accurate and objective knowledge about eye contact and attention to eyes.

One of the first eye-tracking studies, which focused on attention to eyes in individuals with ASD, found reduced fixation on the eye region (Pelphrey et al., 2002). In a task that called for viewing emotional faces, if no specific instructions were given, the study's five adult males with ASD showed less fixation on the eyes than typically developing individuals (TDI). Further studies have confirmed these impaired eye attendance findings (e.g., Boraston et al., 2008; Corden et al., 2008; Dalton et al., 2007; Klin et al., 2002). However, contradictory results have also been found (e.g., de Witt et al., 2008; Falck-Ytter et al., 2010; Rutherford & Towns, 2008; van der Geest et al., 2001). Recent reviews have produced conflicting results in eye-tracking research—for instance, the finding that individuals with ASD are less likely than their TDI counterparts to look into the eyes of another person (Papagiannopoulou, Chitty, Hermens, Hickie, & Lagopoulus, 2014), or the conclusion that only a few studies have found impaired attention to eyes in individuals with ASD (Guillon et al., 2014). This article explored whether high support need and minimally verbal children with ASD could be included in eye-tracking research when the task was designed based on a preference based computer game that had produced positive user experiences (Mäkelä, Berdnarik, & Tukiainen, 2013). We were interested whether these children have atypical temporal attention to eyes. The game was a minimally verbal visual perspective taking task.

Perspective taking is a skill that helps people infer and predict the actions, desires, and beliefs of other people (LeBlanc, Coates, Daneshvar, Charlo-Christy, & Morris, 2003). To function in the social world, one needs to be able to take other people's perspectives into account (Flavel, 1977). Overall, it is thought that perspective-taking ability is associated with empathizing and the ability to understand the other person's point of view (Mattan, Rotshtein, & Quinn, 2016). The ability to understand what other people see is referred to as visual perspective taking (VPT) (Hamilton, Brindley, & Frith, 2009). There are two levels of VPT: Level 1 concerns the ability to ascertain whether the other person sees an object and understand the line of sight and obstructions to the line of sight. Two-year-olds can pass these tasks. Level 2 concerns the ability to understand that the other person sees objects differently depending on their point of view; in this task, even adults have difficulty in this task within naturalistic contexts (Moll & Tomasello, 2004, 2006; Pearson, Ropar, & Hamilton, 2013).

Individuals with ASD have impaired VPT and gaze following, which has been demonstrated by studies such as those requiring children to see where another person is looking. Riby et al. (2013) found that children with ASD looked less at the face and eyes, were less accurate than controls at naming gazed-at objects, and, even when cued, did not increase their looking time at the gazed-at objects. In addition, Falck-Ytter et al. (2012) showed that children with ASD demonstrated less accurate gaze following (correct/incorrect gaze shifts) and showed less correct gaze shifts than TDI children when looking at the gazed-at objects. However, there are contradictory review findings regarding the VPT ability of individuals with ASD (Pearson, Ropar, & Hamilton, 2013). Therefore, in contrast to group-level analyses that found discrepancies in attending to eyes and VPT, this study concentrated on individual-level analyses to detect possible variations between individuals' performance; it has been suggested that these variations influence eye attention research (Ames & Fletcher-Watson, 2010; Bruinsma, Koegel, & Koegel, 2004; Korhonen et al., 2014). Primarily, the individual design was used because high support need and minimally verbal children are difficult to group together.

This research endeavored to explore to include high support need and minimally verbal children in order to see whether diminished attention to eyes was present during a computerized VPT game where eye attention was necessary to play the game successfully. Overall, it has been found that computerized tasks and technologies have motivational advantages for individuals with ASD (e.g. Grynszpan et al., 2013). As motivation is thought to influence looking times in children with ASD (Falck-Ytter, 2015), therefore, in order to encourage the participants to engage with the task, its format was based on a previous computer game designed for children with ASD (Korhonen, Virnes, & Kärnä, 2014) which had produced positive user experiences (Mäkelä et al., 2013). It has already been shown that children do not play the game used in this research randomly; thus, it can be assumed they are demonstrating typical interpretation of the information the eyes provide (*Blinded for review*). Therefore, this study further explored the game to see whether an individual high support need and minimally verbal child with ASD has an atypical total dwelling time in the eye area compared to TDI children when making correct decisions in a task requiring attention to eyes.

Method

As the data were gathered simultaneously with the previous study, the method sections are highly similar (Korhonen,et al.2016).

Participants

This study had an ethical premise for a small number of participants as it was the first of its kind to investigate high support need and minimally verbal children with ASD using portable eye-tracking methodology while playing a standing up computer game. Hence, it only looked at four individuals. Piloting is particularly important in this population; research methodologies need to be carefully planned due to the children's backgrounds, skill levels, and especially because of the potential harm that failure and frustration may bring to their daily lives (e.g., Burack, Iarocci, Flanagan, & Bowler, 2004).

Children with ASD

A convenience sampling method was used. Four high support need pupils from a regional school for individuals with special needs—which uses an adjusted syllabus due to pupils' poorer academic performance—participated in the study. The study took place in a familiar setting at the children's school. All the children were previously diagnosed with ASD (based on ICD-9 criteria) and assessed as high support need (e.g. Strnadová, Cumming, & Marquez, 2014) and minimally verbal (e.g. Tager-Flusberg & Kasari, 2013) by school services (medical doctor, speech therapist, and teachers). A teacher-rated Autism Spectrum Screening Questionnaire (ASSQ) was used with a sensitivity/specificity of 0.73/0.74 for clinical populations and a cut-off score of ≥ 22 (Mattila et al., 2012). The ASSQ scores for the four participants (23, 36, 41, and 30) were all above the cut-off score. The participants were all male, and their age levels were equivalent to those of Finnish primary and secondary school pupils (ages: 9, 12, 14, and 11 years). See Appendix A for more detailed descriptions of the children.

Standardized test results could not be collected because the tests were stopped based on the children's systematic task-irrelevant behavior, such as inventing their own play action unrelated to the task, and an evaluation of their willingness to participate. Further testing with these children was not considered due to the possibility of causing too many negative emotions (such as feeling unsuccessful, forced to participate, or unable to understand the task), which could adversely influence their schooling and everyday life. More subjectively, the teachers and researchers characterized these children as having extremely limited use of verbal language; they mainly used single words, expressed echolalic speech, and most often communicated non-verbally but could understand simple and clear verbal requests and instructions. All the children participated based on their own, parental, and school consent. The children's consent was received by asking verbally and pictorially, and their willingness to participate was monitored and evaluated by the school staff and researchers. This research was approved by the Research Ethics Committee of the University of Eastern Finland.

TDI Children

A convenience sampling method was used: Finnish universities have teacher training schools designed to work in collaboration with researchers. This study involved all consenting and TDI second grade primary school children from the university training school; their individual consent, as well as that of their parents and school, was obtained. Second grade was selected to ensure that the youngest participants age-matched the youngest individuals with ASD: the mental and language age in the control group was therefore either at least equivalent but more likely higher than the level of the youngest child with ASD. This age-matching was done because the participating children with ASD demonstrated considerable task-irrelevant behavior during testing and hence cognitive levels could not be matched. The school reported that the participating children had no medical, psychological, or neurological diagnoses nor other learning disabilities or difficulties. A teacher-rated ASSQ was used to exclude potential individuals with ASD: for the whole population sample, the sensitivity/specificity was 1.00/0.94 (ASSQ: Mattila et al., 2012), and the cut off was ≤ 7 (Mattila et al., 2012). The ASSQ scores in the TDI group were all below the cut-off; all scores were < 3. Altogether, 16 TDI children between the ages of 8 and 9 participated in the study (8 males and 8 females). The study took place in a familiar setting at the children's school.

Materials and Measures

Game apparatus.

The VPT game ran on the Visual Studio® software on a PC computer using the Microsoft Windows® operating system with a Kinect sensor, Microsoft Xbox 360® (version 1.8). The Kinect sensor has an operating range from 0.8 to 4.0 m and features 640 x 480 resolution (30 frames per second). The game was played on a white screen with a VGA connection to a projector/smartboard. Xbox Kinect® uses body movement in its games (see Ilg et al., 2012; Munson & Pasquel, 2012).

The Kinect sensor was placed in front of the player below the white screen (see Figure 1a. for an example of game playing on Kinect and Figure 1b. for the layout of the game playing). No physical contact with the screen was needed. The player saw a silhouette of him- or herself and used the silhouette of his or her hand to select and catch items on the screen by placing either hand on top of the item. The software was programmed to only allow hands to make the selection. The distance to the screen could be altered by the player moving within the room; hence, the visual angle was not constant. The size of the screen was 2.6 m (width) x 2.01 m (height), and the projected image was 2.1 m x 1.54 m.

Eye-tracking apparatus.

Portable SMI (Senso Motoric Instruments, Germany, www.smivision.com) eye-tracking glasses were used for data recording. Two small cameras captured eye movements on the rim of the glasses, and the fixations were mapped onto a scene video camera coinciding with the participant's line of sight. A binocular 30 Hz sampling rate and up to 0.5° accuracy was combined with a 24 Hz field-of-view camera. The gaze tracking range was 80° horizontal and 60° vertical. In accordance with the manufacturer's recommendations, a one-point calibration procedure was used. We used children's finger pointing as a cue whereby they were looking at a small screen for calibration: 'touch the red circle with your finger'. The screen was held at arm's length (a 5-inch touchscreen, approximately 50 cm distance). As the children touched the red circle, we knew where they were looking and calibrated the device to that point. For calibration purposes, the device was held slightly downward (a 15–20 degree angle) from eye level, as recommended by the manufacturer. We performed systematic offline calibration (offset correction) to an attractive looming stimulus using the BeGaze® (Version 3.3) software (www.smivision.com) before each trial as the children sometimes moved the glasses after the initial calibration procedure. The correction was performed on the only moving object on the screen if their gaze followed the object and was fixated in close vicinity of it (see Figure 2. for an example game view). Tracking ratios were used as an exclusion criteron: participants with a tracking ratio of < 30% would be excluded (Amso, Haas, & Markant, 2014). The eye area was defined using SMI BeGaze® software, and the analyses were performed using semantic gaze mapping in the BeGaze software. The eye region encompassed 1.2% of the overall screen size (see Figure 3). A cartoon character and images were used to maintain the game-like feature and because these cartoons have been found to elicit similar gaze behavior towards real images in individuals with ASD (Riby et al., 2009). The character's height was 97 cm, with the eyes being 20 cm x 13.2 cm (see Figure 2). We also kept the sclera of the virtual character white and the pupil color dark so as not to reverse eye viewing behavior (Frishchen et al., 2007).

Figure 1a. Example of the game playing using the Kinect technology in which the silhouette of the player is projected in the game via the Kinect sensor

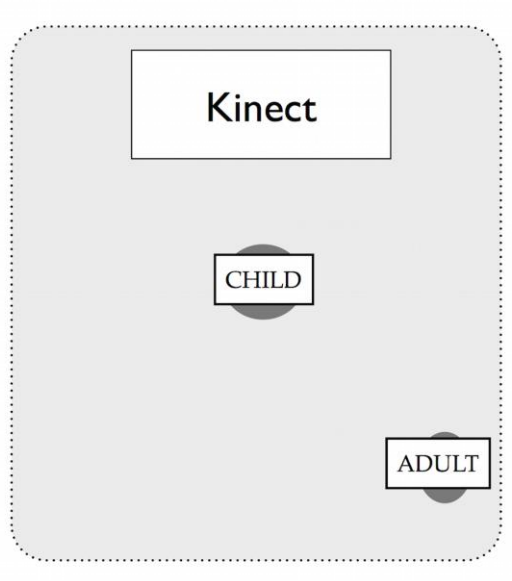

Figure 1b. The setting of the game room: the Kinect sensor and the white screen are in front of the player and an adult /teacher can sit on the background during the game playing

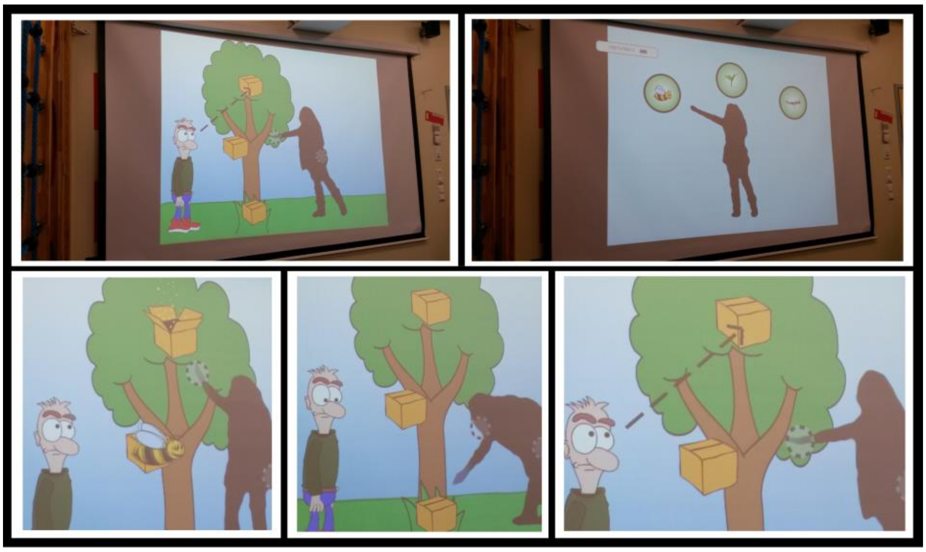

Figure 2. The game view: top left 1) choosing preferred object (bumblebee); top right 2) both eye cue and arrow cue indicating the location (looking at the box on the top); bottom left 3) eye cue and arrow cue to the top box; bottom middle 4) eye cue only (looking at the box on the ground); bottom right 5) The top- most box is open and the participant is trying to catch the bee that flew from the box (can be seen on top of the middle box: bumblebee).

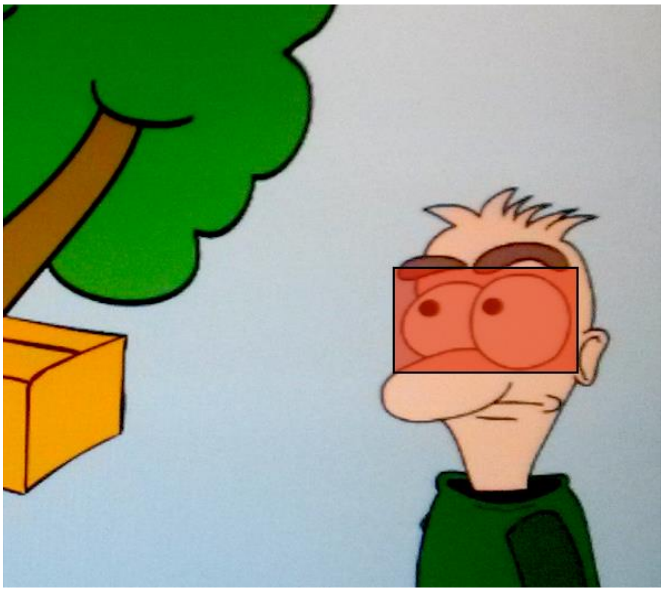

Figure 3. The area of interest (AOI): eye region

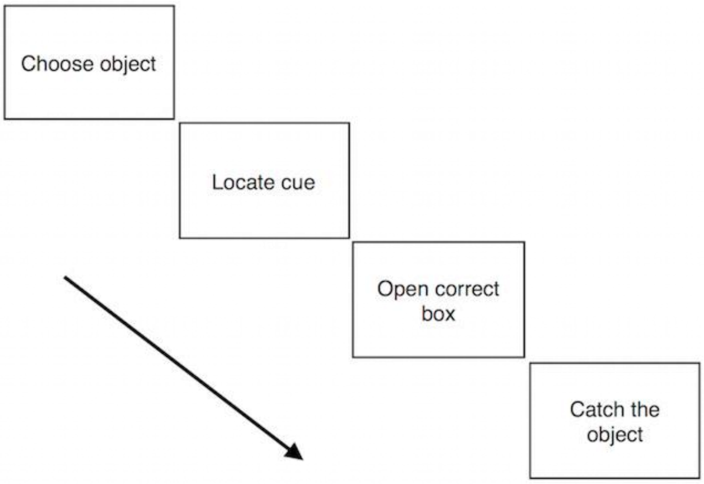

Figure 4. The order of the events in the game: 1) the player chooses an object, which he would like to look for; 2) the player locates the correct box using the eye gaze or arrow cues; 3) the

player opens the correct box; 4) the player catches the object that emerges from the box. After the final trial with either a gaze cue or the double cues, the participant can choose a different object to play the game again.

The task

To produce the least amount of discomfort for the children, the game play was designed by considering existing activities at the participants' school. The format was based on a computer game with a positive user experience (Mäkelä et al., 2013) that was familiar to the children.

Eye contact in the VPT task, a line of sight task, was key to successfully playing the game. The task was similar to the task utilized by Gould et al. (2011), whose original task consisted of pictures on a table in which a person was looking in one of four directions: up, down, left, or right. The children needed to understand where the person was looking and name the object the person was seeing: 'What does s/he see?' The task was also comparable to Baron-Cohen's (1989) line of sight task (that was classified a level 1 VPT by Pearson, Ropar and Hamilton (2013) in their review on VPT), where the participant identifies which object the experimenter was seeing.

Similar to the original game, first participants chose an object of their preference (for example, a bird, a bee, a plane, etc.) by placing a hand on top of the item (see Figure 2); thus, the children were engaged with the game through their own decision-making. Then participants needed to recognize which in direction the virtual character was looking (there were three boxes on the screen: up, down, or middle) and open the box in that location with the help of eye-gaze cues or with eye-gaze and arrow cues (Figure 2; for the order of the events, see Figure 4). If the participants tried to open the incorrect box, it would not open; it would shake for a moment and make a sound inviting them to try again. Three attempts were allowed before the next cue appeared. Once they chose the correct box, the participants needed to catch the flying object emerging from the box.

There were two kinds of trials in the game: 1) only the eye gaze cue indicated which box to choose (hereafter eye cue) and 2) the eye gaze cue and an additional arrow cue simultaneously indicated which box to choose in order to make the task easier (hereafter double cue). The double cue was added to increase the likelihood that the children would not find the task too difficult and not have negative feelings about participating. The idea was based on earlier VPT task results by Gould, Tarbox, Hora, Noone, & Bergtsrom (2011). This research was only interested in seeing how the children performed using only the eye cue. The double cue trials were undertaken to give the children easier trials to ensure more positive than negative experiences of the game (See Korhonen et al., 2016 for details on the children's performance in the double cue trials).

Trials

The data collection began with practice trials for both the TDI and ASD participants. This practice was done because it was not known whether the target behavior was part of the repertoire of children with ASD. Task failure could have evoked negative feelings in the children with ASD thereby resulting in refusals to play and participate in similar activities in the future. The practice trials included two eye cue trials and five double cue trials. The practice measurements involved only two attempts at the eye cue condition to avoid multiple failures, as guided by Morgan and Morgan (2009). Similarly, the trial numbers were kept low (in both the practice and real trials) to keep the playing time short and because of the pilot nature of the study. During the practice trials, the eye cue trials came before the double cue trials to ascertain whether the children could play the game when only eye gaze cues were given: two eye cue trials (length of the arrow: trial 1. = no arrow and trial 2. = no arrow). There was only one attempt for each eye cue trial. After the two eye cue trials, five prompted trials using the fading procedure (number of dashes in the arrow on each trial: trial 1. = 5, trial 2. = 4, trial 3. = 3, trial 4. = 2. trial 5. = 1) with three attempts were used to help players understand the game and provide them with a feeling of control. The TDI children had one practice trial, after which they understood the game (based on their comments).

Following the practice trials, two playing sessions were analyzed; there were six double cue trials and three eye cue trials in order to have more easier trials than difficult trials (the assumption was that the arrow cues would make the task easier. See Gould et al., 2011). In the double cue trials, the game used a fading procedure in which each successive cue had a shorter arrow until there was no arrow cue. The order followed the fading procedure: the length of the arrow started with 5 dashes, then 4, 3, 2, and finally 1; the three final trials did not have the arrow cue (amount of dashes: 5-4-3-2-1-0-0-0). All the trials allowed three attempts before proceeding to the next trial.

Design.

We were interested in determining for how long, when choosing a correct box in the VPT game during the eye cue condition, they were looking inside the eye area. We only analyzed the eye cue trials, and not the double cue ones, since we were interested in attending to eyes when no support was given. We chose to concentrate on correct trials as there can be multiple reasons for errors. We applied a neuropsychological case-control method in which an individual's data can be statistically compared to those of a control sample (Crawford & Howell, 1998; Crawford et al., 2010). A statistical program (SINGLIM_ES.EXE, http://homepages.abdn.ac.uk/j.crawford/pages/dept/psychom.htm) was applied to test whether participants' total dwelling time, calculated automatically by SMI BeGaze®, in the eye area, were significantly lower than those of a control sample. The dependent measure was the dwelling time in the eye area in the eye cue condition.

Procedure

When the children arrived in the game playing room at their school, they were welcomed and then instructed that they needed to first choose a preferred item on the screen and then locate the hiding place of that item. They were then told that the man on the screen would help them find the correct box. The eye-tracking glasses were placed on their heads and taken off by the researchers. When they were finished, the children were thanked for playing the game.

Results

The total dwelling time inside the eye area was counted in milliseconds (ms). The recording began when the virtual character turned its eyes to the box and ended when the participant chose the correct box. Correct choices were seen in the eye-tracking video recordings as well as in the computer log files. For the control group's first trial in the eye cue condition, the correct choice rate was 80.7%, and for the second, it was 86.2%. For the ASD children's first trial in the eye cue condition, the correct choice rate was 67.5%, and for the second, it was 57.1%. The chance of making a correct choice was 33.3%. No child played the game at a chance level. All the children had tracking ratios above the exclusion criteria.

Comparisons of single cases to controls

Statistics appropriate for single case studies (case controls analysis) were used (Crawford, Garthwaite, & Porter, 2010). Case-control analyses were used to compute the means of the total eye area dwelling times for the first two sessions. Data were analyzed for three of the four children participating as the eye tracking data showed the fourth child did not look at the screen during the game playing.

The control group's (N = 16) mean total eye area dwelling time was 561.6 minutes (SD 270.9). As the data was not normally distributed, a LOG10 transformation was applied to the control group and individuals with ASD. Since the children with ASD were all male, which was not the case for the control group, gender differences in the dwelling times were explored. No evidence of gender differences was found in the control group when it was divided into two groups based on gender $t(14) = -0.254$, $p = 0.803$.

The SINGLIMS_ES.EXE software program was used; individual results are presented in Table 1, as suggested by Crawford, Garthwaite, and Porter (2010). One child (Aaron) spent significantly less time (116.5 minutes, SD = 164) than the controls in the eye area. Two other children (Billy and Derek) did not differ in total dwelling time (375.8 minutes, SD = 109 and 407.6

minutes, SD = 57) compared to the control group. For the child with a shorter total dwelling time compared to the controls (Aaron), the effect sizes were large, and only a small percentage of the controls would be expected to show such a score (Table 1).

Table 1. The results of the case-controls analyses using the DISSOCS_ES.EXE (Crawford, Garthwaite & Porter, 2010).

Table 1. Results of the case-control analysis

The asterisk (*) indicates significant difference between controls and the participants in a given task.

		Control sample				Significance test (* meets criteria for a deficit compared to controls)		Estimated percentage of the control population obtaining a lower score than the case		Estimated effect size (Zcc)	
Participant	Task (eye cue)	N	Mean	SD	Case's score	t	p	Point	(95% CI)	Point	(95% CI)
Aaron	Correct	16	2.709	0.189	2.07	- 3.280	0.003*	0.25	(0.0002 to 1.88)	-3.381	(- 4.666 to – 2.079)
Billy	Correct	16	2.709	0.189	2.57	- 0.713	0.24	24.3	(10.0 to 43.3)	-0.735	(- 1.28 to – 0.17)
Derek	Correct	16	2.709	0.189	2.61	- 0.508	0.31	30.9	(14.9 to 50.3)	-0.524	(-1.040 to 0.008)

Discussion

This study aimed to use a positive game playing environment to extend research in eye-tracking and attending to eyes to high support need and minimally verbal children with ASD. In contrast with group studies, the goal was to examine attention to eyes individually. The analyses were performed individually in order to detect possible individual variations compared to a control group and consider each high support need and minimally verbal child with ASD separately. This study used a computer game with a history of positive user experience to engage the children and lessen the possibility of negative feelings about participating in research. In sum, we wanted to explore do high support need and minimally verbal children with ASD, as individuals, have atypical looking time in the eye area in comparison to typically developing children. To our knowledge this has not been studied before.

It was found that while playing a computer game, in which attending to the eyes of a virtual character is mandatory, we were able to collect eye-tracking data of high support need and minimally verbal children with ASD. The results showed that one child (Aaron) out of three with ASD had a shorter total dwelling time in the eye area compared to the TDI. Billy and Derek did not differ in dwelling time in comparison to the controls and Carl was excluded since no dwelling time data were available (Carl may have used peripheral vision to play the game as his performance was above the chance level). No child with ASD had a longer eye area dwelling time than the control group. The game and the case controls analyses are an appropriate methodology for these children with very different backgrounds and abilities because they were able to play the game voluntarily and independently. Individual analyses of the eye-tracking data for the participants from this group showed expected levels of performance variation.

These findings were on the correct trials which suggest that dwelling time may not be the key element for all individuals in terms of being able to perform successfully in a task that requires attending to eyes. Therefore, because the dwelling time can be shorter, it may be more appropriate for future research to determine the relevance of attention to eyes and dwelling time for each individual separately. The fact that the two ASD children did not differ from the controls in their dwelling time can be an artefact of the game; that is, an enjoyable game that may have engaged the participants more than a live situation that had less motivation and more distractors. However, it is also possible that this is an indication of the individual differences seen in ASD.

Eye-tracking reviews have indicated both intact (Guillon et al., 2014) and impaired fixations on eyes (Papagiannopoulou et al., 2014), both of which were found in the study's participants. In attention research, some believe that group and individual differences can explain discrepant results in the field (Ames & Fletcher-Watson, 2010; Dereu et al., 2012) and that individuals with ASD have not been taken into consideration in assessment and task procedures (Korhonen et al., 2014). Therefore, this study emphasizes that in some children with ASD, differences may exist even when the children are matched according to mental or language age (Korhonen et al., 2014); individual variation should thus receive greater attention. In the case of high support need and minimally verbal children, individual-level analyses may be the best option since these children show more pronounced heterogeneity in their profiles, making it more difficult to match them with other participant groups (e.g. Burack et al., 2004; Jacobsen, 2010). An individual-level approach could also shed light on the discrepancies found in eye area looking time results in the higher functioning population. The case-control design was found to be useful in understanding how these individuals were able to attend to eyes and to show variation in their performance.

Guillon et al. (2014) believe that the complexity of a social situation might lead to diminished eye gazing, something we should also consider in this study. Complexity can be defined on an individual level and may vary from person to person. Nevertheless, in the present study, the complexity of the situation was adopted from a study in which this particular skill was believed to be impaired (Gould et al., 2011). Therefore, the results regarding the children in this study are not based merely on a lack of complexity. Moreover, complexity by itself would not explain variation when performing the task correctly; it may reflect the individual's perception of the complexity of the task.

This study took several steps to design and utilize a virtual environment for eye-tracking research purposes that was based on positive user experiences of environments seen as specifically challenging for high support need children and those with ASD (e.g., Andersson, Josefsson, & Pareto, 2006; Lányi, Mátrai, & Tarjányi, 2006). This aspect is particularly interesting for future research since individuals with ASD are found to benefit from technology, and computer game production has become increasingly more available, cheap, and commonplace (e.g., Colby, 1973; Grynszpan, Weiss, Perez-Diaz, & Gal, 2013; Parsons, Leonard, & Mitchell, 2006; Wass & Porayska-Pomsta, 2013). The use of activities or technologies in research, which are already preferred by individuals with ASD, could be a relatively easy way of engaging children with high support needs as it may otherwise be difficult to motivate them to participate in tasks. Therefore, it is possible that the design of the task in this study influenced task performance; this aspect should be explored further.

This study had a number of limitations as there were factors whose impact could not be excluded. How a person views the cue cannot be determined. One contention is that whether participants consider the eye cue as social (social reading hypothesis) or geometric shapes (feature correspondence theory) is not important if they use the cue (e.g., Ristic et al., 2005). We also did not attempt to determine what happened when the children made errors as such decisions were sometimes made with or without looking at the eyes. However, since the comparison of correct trials was performed under the same conditions (eye cue) for children with ASD and the control group, the differences observed were not associated with incorrect choices and, hence, have no influence on the interpretation of the data. An analysis of the incorrect trials could lead to conclusions made based on multiple reasons why the errors appeared.

The children were also able to revise their answers when the first guess was incorrect and try again to choose the correct box. This feature may add an element in which the child can try to guess the answer, which could impact the interpretation of the results. However, since both groups had the same possibility, it is believed that this did not affect the results. Furthermore, had this been the case only in children with ASD, it should have appeared as shorter dwelling times compared with the TDI children. Moreover, it would have been ethically difficult not to give this possibility to the children because otherwise, the game would merely concentrate on failure and not be supportive of the player. The question remains as to whether the deficits seen in previous research were based on a true deficit in attention to eyes and motivation or the appropriate use of the cue. What the results of this study show, however, is that some individuals do use eye cues appropriately, regardless of the dwelling time in the eye area.

The length of the trial was allowed to vary from person to person, but this is seen in free viewing situations where atypical eye attention has been found. Time is also a factor that can skew data as these children may not be engaged with the task for the same time frame, and hence, in the game and research design trial, time was not considered (for time measurements see Korhonen et al., 2016).

The participating children also need to be considered: this study's comparison group was matched by minimal chronological age (matching the control children with the youngest ASD child), which is somewhat weak methodologically. However, since the children with ASD have an adjusted syllabus based on their school performance, the language and mental age of TDI children can be inferred to be much higher than the level of the four children with ASD. Therefore, the difference between TDI children and children with ASD should be more evident, and if no differences between the children can be observed, it cannot be due to matching problems. Conducting research on high support need and minimally verbal children with ASD will continue to encounter this problem in the future. If researchers concentrate on the children's impairments by using tests they are unwilling to take, they are likely to mislabel and group these children erroneously (e.g., as suggested for minimally verbal by Kasari et al., 2013). Similarly, the variety of impairments (e.g., Jacobsen, 2000) and definitions regarding these children (Strnadová et al., 2014; Tager-Flusberg & Kasari, 2013) make the matching procedures for research difficult; thus, there is a need to develop new methodologies to enable further research. Problems with gathering background information or matching individuals with control groups should encourage researchers to explore other means to detect skills or impairments. However, this study could not gather data from one child which shows that this data collection method is not always suitable for all children.

The gender ratio in this study was skewed as all the children with ASD were male. In the general ASD population, while there are more boys than girls, not all are boys (e.g., Fombonne, 2009; Rutherford et al., 2016). The control group was not comparable as the division was a 50/50 split between boys and girls. Since gender differences are not fully understood in ASD, the control sample was kept equally divided between genders. Although no evidence of gender differences among the control group was found, this aspect is an interesting avenue for future studies to explore in greater detail.

Overall, due to the small sample size of children with ASD and considering that only three of the four children could be analyzed, caution should be exercised in generalizing the results. They can be used to indicate the benefits of looking at individual data on top of group data simultaneously. The results also provide justification for exploring individual performance further; for example, by using data from previous group studies and developing, improving, and increasing the use of individual-level designs.

Task definition is also difficult. This study defined the game task as perspective taking because joint attention was not possible, per se; the situation was not interactive, and the player and virtual character did not know what the other person saw nor communicated about their shared attention. However, the task could also be interpreted as nearly declarative or imperative joint attention, where the gaze functions simply to prompt action by the other person. (e.g., Carpenter & Liebal, 2012). One could also consider the task as reflexive gaze following where the person is merely looking at the gazed location based on the eye cue (e.g., Kylliäinen & Hietanen, 2004). We classified the game's line of sight task as level 1 VPT, similar to the review of VPT by Pearson, Ropar, and Hamilton (2013).

Conclusions

This study showed that it is plausible to study attention to eyes of high support need and minimally verbal children by using computer games and eye-tracking methodology. We infer that by using individual-level analyses and utilizing preferred computer games we were able to learn more about these children. The results from high support need and minimally verbal children with ASD suggest that diminished eye attention may vary per individual. The discrepancies in group studies could be explored further using individual-level analyses such as case-control analyses. More importantly, conducting research in a positive context may be an important factor in the participants' ability to perform well in the task and can be a key element when planning research. However, more extensive and large scale research on using eye-tracking methodology is needed to validate the inferences.

References:

Andersson, U., Josefsson, P., & Pareto L. (2006). Challenges in designing virtual environments training social skills for children with autism. *International Journal on Disability and Human Development*, *5*(2), 105–112. doi:10.1515/IJDHD.2006.5.2.105

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Ames, C., & Fletcher-Watson, S. (2010). A review of methods in the study of attention in autism. *Developmental Review*, *30*(1), 52–73. doi:10.1016/j.dr.2009.12.003

Amso, D., Haas, S., & Markant, J. (2014). An eye tracking investigation of developmental change in bottom-up attention orienting to faces in cluttered natural scenes. *PLoS ONE*, *9*(1), e85701. doi:10.1371/journal.pone.0085701

Ashwin, C., Hietanen, J. K., & Baron-Cohen, S. (2015). Atypical integration of social cues for orienting to gaze direction in adults with autism. *Molecular Autism*, *6*(1), 5. doi:10.1186/2040-2392-6-5

Boraston, Z. L., Corden, B., Miles, L. K., Skuse, D. H., & Blakemore, S.-J. (2008). Brief report: Perception of genuine and posed smiles by individuals with autism. *Journal of Autism and Developmental Disorders*, *38*(3), 574–580. doi:10.1007/s10803-007-0421-1

Bruinsma, Y., Koegel, R. L., & Koegel, L. K. (2004). Joint attention and children with autism: A review of the literature. *Mental Retardation and Developmental Disabilities Research Reviews*, *10*(3), 169–75. doi:10.1002/mrdd.20036

Burack, J. A., Iarocci, G., Flanagan, T. D., & Bowler, D. M. (2004). On mosaics and melting pots: Conceptual considerations of comparison and matching strategies. *Journal of Autism and Developmental Disorders*, *34*(1), 65–73. doi:10.1023/B:JADD.0000018076.90715.00

Carpenter, M., & Liebal, K. (2012). Joint attention, communication, and knowing together in infancy. In A. Seemann (Ed.), *Joint attention: New developments in psychology, philosophy of mind, and social neuroscience* (pp. 159–181). Cambridge, MA: MIT Press.

Colby, K. (1973). The rationale for computer-based treatment of language difficulties in non- speaking autistic children. *Journal of Autism and Childhood Schizophrenia*, *3*, 254–260. doi:10.1007/BF01538283

Corden, B., Chilvers, R., & Skuse, D. (2008). Avoidance of emotionally arousing stimuli predicts social–perceptual impairment in Asperger's syndrome. *Neuropsychologia*, *46*(1), 137–147. doi:10.1016/j.neuropsychologia.2007.08.005

Crawford, J. R., Garthwaite, P. H., & Porter, S. (2010). Point and interval estimates of effect sizes for the case-controls design in neuropsychology: Rationale, methods, implementations, and proposed reporting standards. *Cognitive Neuropsychology*, *27*(3), 245–260. doi:10.1080/02643294.2010.513967

Crawford, J. R., & Howell, D. C. (1998). Comparing an individual's test score against norms derived from small samples. *Clinical Neuropsychologist*, *12*(4), 482–486. doi:10.1076/clin.12.4.482.7241

Dalton, K. M., Nacewicz, B. M., Alexander, A. L., & Davidson, R. J. (2007). Gaze-fixation, brain activation, and amygdala volume in unaffected siblings of individuals with autism. *Biological Psychiatry*, *61*(4), 512–520. doi:10.1016/j.biopsych.2006.05.019

Dereu, M., Roeyers, H., Raymaekers, R., & Warreyn, P. (2012). Exploring individual trajectories of social communicative development in toddlers at risk for autism spectrum disorders. *Research in Autism Spectrum Disorders*, *6*(3), 1038–1052. doi:10.1016/j.rasd.2011.12.003

De Wit, T. C. J., Falck-Ytter, T., & von Hofsten, C. (2008). Young children with autism spectrum disorder look differently at positive versus negative emotional faces. *Research in Autism Spectrum Disorders*, *2*(4), 651–659. doi:10.1016/j.rasd.2008.01.004

Distefano, C., & Kasari, C. (2016). The window to language is still open: Distinguishing between preverbal and minimally verbal children with ASD language in preschool children with ASD distinguishing between pre-verbal and minimally verbal children. Perspectives of the ASHA special interest groups, 1(Part 1), 4–11. Retrieved from http://perspectives.pubs.asha.org/article.aspx?articleid=2512169

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, 41(10), 1040–1048. doi:10.1037/0003-066X.41.10.1040

Falck-Ytter, T. (2015). Gaze performance during face-to-face communication: A live eye tracking study of typical children and children with autism. *Research in Autism Spectrum Disorders*, 17, 78–85. doi:10.1016/j.rasd.2015.06.007

Falck-Ytter, T., Fernell, E., Hedvall, A. L., von Hofsten, C., & Gillberg, C. (2012). Gaze performance in children with autism spectrum disorder when observing communicative actions. *Journal of Autism and Developmental Disorders*, *42*(10), 2236–45. doi:10.1007/s10803-012-1471-6

Falck-Ytter, T., Fernell, E., Gillberg, C., & Von Hofsten, C. (2010). Face scanning distinguishes social from communication impairments in autism. *Developmental Science*, *13*(6), 864–875. doi:10.1111/j.1467-7687.2009.00942.

Flavell, J. H. (1977). The development of knowledge about visual perception. *Nebraska Symposium on Motivation*, *25*, 43–76. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/753993

Fombonne, E. (2009). Epidemiology of pervasive developmental disorders. *Pediatric Research*, *65*(6), 591–598. doi:10.1203/PDR.0b013e31819e7203

Frischen, A. (2007). Gaze cueing of attention: Visual attention, social cognition, and individual differences. *Psychological Bulletin*, *133*(4), 694–724. doi:10.1037/0033-2909.133.4.694.Gaze

Gould, E., Tarbox, J., Hora, D. O., Noone, S., & Bergstrom, R. (2011). Teaching children with autism a basic component skill of perspective-taking. *Behavioral Interventions*, 26(1), 50–66. doi:10.1002/bin

Grynszpan, O., Weiss, P. L. T., Perez-Diaz, F., & Gal, E. (2013). Innovative technology-based interventions for autism spectrum disorders: A meta-analysis. *Autism: The International Journal of Research and Practice*. 18(4), 346–361. doi: 10.1177/1362361313476767

Guillon, Q., Hadjikhani, N., Baduel, S., & Rogé, B. (2014). Visual social attention in autism spectrum disorder: Insights from eye tracking studies. *Neuroscience and Biobehavioral Reviews*, 42, 279–297. doi:10.1016/j.neubiorev.2014.03.013

Hamilton, A. F., Brindley, R., & Frith, U. (2009). Visual perspective taking impairment in children with autistic spectrum disorder. *Cognition*, *113*, 37–44. doi:10.1016/j.cognition.2009.07.007

Ilg, W., Schatton, C., Schicks, J., Giese, M. A., Schöls, L., & Synofzik, M. (2012). Video game-based coordinative training improves ataxia in children with degenerative ataxia. *Neurology*, 79(20), 2056–60. doi:10.1212/WNL.0b013e3182749e67

Jacobsen, K. (2000). Difficulties in understanding the impact and functions of visual attention patterns of persons with autism. *Scandinavian Journal of Disability Research*, 2(2), 87–99. doi:10.1080/15017410009510761

Jones, W., Carr, K., & Klin, A. (2008). Absence of preferential looking to the eyes of approaching adults predicts level of social disability in 2-year-old toddlers with autism spectrum disorder. *Archives of General Psychiatry*, 65(8), 946–954. doi:10.1016/S0084-3954(09)79477-1

Jones, W., & Klin, A. (2013). Attention to eyes is present but in decline in 2–6-month-old infants later diagnosed with autism. *Nature*, 504(7480), 427–431. doi:10.1038/nature12715

Kasari, C., Brady, N., Lord, C. & Tager-Flusberg, H. (2013). Assessing the minimally verbal school-aged child with autism spectrum disorder. *Autism Research*, 6(6), 479–93. doi:10.1002/aur.1334

Klin, A., Jones, W., Schultz, R., Volkmar, F. & Cohen, D. (2002) Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, 59(9), 809–816.

Korhonen, V., Räty, H., & Kärnä, E. (2014). Autism spectrum disorder and impaired joint attention: A review of joint attention research from the past decade. *Nordic Psychology*, *66*(2), 1–14. doi:10.1080/19012276.2014.921577

Korhonen, V., Virnes, M. & Kärnä, E. (2014). Catching Game: A Body Movement Game for Children with Autism Spectrum Disorders. In J. Viteli & M. Leikomaa (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology 2014* (pp. 2057-2061). Association for the Advancement of Computing in Education (AACE).

Kylliäinen, A., Jones, E.J.H., Gomot, M., Warreyn, P., & Falck-Ytter, T. (2014). Practical Guidelines for Studying Young Children With Autism Spectrum Disorder in Psychophysiological Experiments. *Review Journal of Autism and Developmental Disorders*, 1(4), 373–386. doi:10.1007/s40489-014-0034-5kat

Lányi, C. S., Mátrai, R., & Tarjányi, I. (2006). Analyzing navigation of mentally impaired children in virtual environments. *International Journal on Disability and Human Development*, 5(3), 217–222. doi:10.1515/IJDHD.2006.5.3.217

LeBlanc, L. A., Coates, A. M., Daneshvar, S., Charlop-Christy, M. H., Morris, C., & Lancaster, B. M. (2003). Using video modelling and reinforcement to teach perspective-taking skills to children with autism. *Journal of Applied Behavior Analysis*, 36(2), 253–257. doi:10.1901/jaba.2003.36-253

Mattan, B. D., Rotshtein, P., & Quinn, K. a. (2016). Empathy and visual perspective-taking performance. Cognitive Neuroscience, 7(1-4), 1–12. doi:10.1080/17588928.2015.1085372

Mattila, M.-L., Jussila, K., Linna, S.-L., Kielinen, M., Bloigu, R., Kuusikko-Gauffin, S., ... Moilanen, I. (2012). Validation of the Finnish Autism Spectrum Screening Questionnaire (ASSQ) for clinical settings and total population screening. *Journal of Autism and Developmental Disorders*, 42(10), 2162–2180. doi:10.1007/s10803-012-1464-5

McGonigle-Chalmers, M., Alderson-Day, B., Fleming, J., & Monsen, K. (2013). Profound expressive language impairment in low functioning children with autism: An investigation of syntactic awareness using a computerized learning task. *Journal of Autism and Developmental Disorders*, 43(9), 2062–81. doi:10.1007/s10803-012-1753-z

Mesibov, G. B., Schopler, E., & Caison W. (1989). The adolescent and adult psychoeducational profile: Assessment of adolescents and adults with severe developmental handicaps. *Journal of Autism and Developmental Disorders*, 19(1), 33–40. Retrieved from http://link.springer.com/article/10.1007/BF02212716

Moll, H., & Tomasello, M. (2004). 12- and 18-month-old infants follow gaze to spaces behind barriers. *Developmental Science*, *7*, F1–F9. doi:10.1111/j.1467- 7687.2004.00315.x

Moll, H., & Tomasello, M. (2006). Level 1 perspective-taking at 24 months of age. *British Journal of Developmental Psychology*, 24, 603–613. doi:10.1348/026151005X55370

Morgan D. L., & Morgan R. K. (2009). *Single-case research methods for the behavioral and health sciences*. London: SAGE Publications, Inc.

Munson, J., & Pasqual, P. (2012). Using technology in autism research: The promise and the perils. *Computer*, 45(6), 89– 91. doi:10.1109/MC. 2012.220

Mäkelä, S., Bednarik, R., & Tukiainen, M. (2013). Evaluating user experience of autistic children through video observation. *CHI '13 extended abstracts on human factors in computing systems – CHI EA '13*, 463. doi:10.1145/2468356.2468438

Nation, K., & Penny, S. (2008). Sensitivity to eye gaze in autism: Is it normal? Is it automatic? Is it social? *Development and Psychopathology*, 20(1), 79–97. doi:10.1017/S0954579408000047

Papagiannopoulou, E. A, Chitty, K. M., Hermens, D. F., Hickie, I. B., & Lagopoulos, J. (2014). A systematic review and meta-analysis of eye-tracking studies in children with autism spectrum disorders. *Social Neuroscience*, 9(6), 1–23. doi:10.1080/17470919.2014.934966

Parsons, S., Leonard, A., & Mitchell, P. (2006). Virtual environments for social skills training: Comments from two adolescents with autistic spectrum disorder. *Computers & Education.* 47(2), 186–206. doi:10.1016/j.compedu.2004.10.003

Pearson, A., Ropar, D., & Hamilton, A. F. de C. (2013). A review of visual perspective taking in autism spectrum disorder. *Frontiers in Human Neuroscience*, 7, 652. doi:10.3389/fnhum.2013.00652

Pelphrey, K. A., Sasson, N., Reznick, J. S., Goldman, B., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders*, *32*(4), 249–261. doi: 10.1023/A:1016374617369

Riby, D., & Hancock, P. J. B. (2009). Looking at movies and cartoons: Eye-tracking evidence from Williams Syndrome and autism. *Journal of Intellectual Disability Research: JIDR*, 53(2), 169–181. doi:10.1111/j.1365-2788.2008.01142.x

Riby, D. M., Hancock, P. J., Jones, N., & Hanley, M. (2013). Spontaneous and cued gaze-following in autism and Williams syndrome. *Journal of Neurodevelopmental Disorders*, 5(1), 13. doi:10.1186/1866-1955-5-13

Ristic, J., Mottron, L., Friesen, C. K., Iarocci, G., Burack, J. A., & Kingstone, A. (2005). Eyes are special but not for everyone: The case of autism. *Cognitive Brain Research*, 24(3), 715–718. doi:10.1016/j.cogbrainres.2005.02.007.

Rutherford, M., McKenzie, K., Johnson, T., Catchpole, C., O'Hare, A., McClure, I., … Murray, A. (2016). Gender ratio in a clinical population sample, age of diagnosis and duration of assessment in children and adults with autism spectrum disorder. *Autism: The International Journal of Research and Practice*, 20(5), 628–634. doi:10.1177/1362361315617879

Rutherford, M. D., & Towns, A. M. (2008). Scan path differences and similarities during emotion perception in those with and without autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *38*(7), 1371–1381. doi:10.1007/s10803-007-0525-7

Simmons, D. R., Robertson, A. E., McKay, L. S., Toal, E., McAleer, P., & Pollick, F. E. (2009). Vision in autism spectrum disorders. *Vision Research*, 49(22), 2705–2739. doi:10.1016/j.visres.2009.08.005.

Skwerer, D., Jordan, S. E., Brukilacchio, B. H., & Tager-Flusberg, H. (2015). Comparing methods for assessing receptive language skills in minimally verbal children and adolescents with autism spectrum disorders. *Autism*. 20 (5), 591–604. doi:10.1177/1362361315600146

Strnadová, I., Cumming, T., & Marquez, E. (2014). Parents' and teachers' experiences with mobile learning for students with high support needs. *Special Education Perspectives*, 23(2), 43–55.

Tager-Flusberg, H., & Kasari, C. (2013). Minimally verbal school-aged children with autism spectrum disorder: The neglected end of the spectrum. *Autism Research*, *6*, 468–478. doi:10.1002/aur.1329

Van der Geest, J. N., Kemner, C., Camfferman, G., Verbaten, M. N., & Van Engeland, H. (2001). Eye movements, visual attention, and autism: A saccadic reaction time study using the gap and overlap paradigm. *Biological Psychiatry*, 50, 614–619. doi:10.1016/S0006-3223(01)01070-8

Wass, S. V., & Porayska-Pomsta, K. (2014). The uses of cognitive training technologies in the treatment of autism spectrum disorders. *Autism: The International Journal of Research and Practice*, 8(18) 851–871. doi:10.1177/1362361313499827

Whittaker, C. A. (2012). The speech aversion hypothesis has explanatory power in a minimal speech approach to aloof, non-verbal, severe autism. *Medical Hypotheses*, 78(1), 15–22. doi:10.1016/j.mehy.2011.09.031

Appendix A

Descriptions of the children:

Aaron is 9 years old and has an ASSQ score of 23. Aaron has developmental delays and hence has elongated schooling planned. He enjoys school. He is still learning how to dress himself but is making progress, and needs support using a toilet. Aaron has sensory sensitivities which makes cutting hair or doing physical examinations difficult. He appears happy in everyday life but has difficulties in concentrating on tasks. If irritated he may scratch or headbutt. He has good gross motoric skills but needs support and training fine motor skills, e.g. using a pencil/pen. He is often restless in his motor actions. Aaron needs support in outside activities, and in public spaces he needs careful supervision. Aaron needs support and guidance in eating. Aaron can understand clear context related instructions but has trouble with comprehending more abstract concepts. He is able name individual everyday items but cannot use plurals. He can use a picture communication folder for communication with several pictures to form a sentence to ask for something. Aaron cannot produce L, K, R sounds, and J and N sounds only as individual sounds. He can produce some sentences by combining two words, however the intelligibility is often inadequate and he feels irritated when asked for clarification.

Billy is 12 years old and has an ASSQ score of 36. Billy has developmental delays. He communicates with pictures and supportive sign language. Billy’s day is organized by using a pictorial calendar. He cannot be left alone without supervision. Billy needs support using a toilet, washing up and brushing his teeth. Billy sometimes uses his mouth to feel new items. He can do puzzles at least up to 25 pieces. He is still in the progress of training to use pens and pencils but can use scissors to cut paper into triangular shapes. He gets easily frustrated if there is no planned activity. Billy can understand clear short instructions

Carl is 14 years old and has an ASSQ score of 41. Clark has developmental delays and has therefore elongated schooling planned. Clark takes very little contact with others and gets distracted easily and falls to his own thoughts. With verbal guidance he is easily brought back to the task. He may grab hair or pinch from seconds to up to minutes without a specific reason. When disappointed the time is often longer. His motor skills are monotonous but he likes physiotherapy in which he needs verbal and manual support and guidance. His fine motor abilities need training; using a pencil or scissors is difficult. Clark’s activity level is very varied; sometimes he needs constant guidance and often the tasks get done without support. He uses words to communicate, and does not use signs or pictures. He can write his own name and can recall most numbers. Clark can name geometric shapes (square, circle, house, heart). Clark has echolalic speech and often recites sentences from cartoons.

Derek is 11 years old and has an ASSQ score of 30. Derek is almost always a cheerful child. He has made progress in play and does not only do certain play activities. He is currently more willing to be guided by an adult. When stuck, giving time and showing pictures help him to move one. He is eager to play but still for only a short while, and needs adult supervision and guidance to plan and execute activities. In motor play activities Derek is shy. Fine motor skills, e.g. holding a pen, is in the process of learning. Derek has started to train to do simple addition and subtraction math with tangible items. Big social events at the school are a challenge for Derek that can be addressed by encouragement and pictorial planning of the events. Derek communicates with words, gestures and pointing. Derek uses the same phrases frequently, with 1-3 words. He can name colors, numbers and play related items. He can ask for help by using words such as *help* or *give.* He also uses picture communication file to communicate with adults.