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JOURNAL OF COMMUNICATION DISORDERS AND ASSISTIVE TECHNOLOGY

Aster Publications Research ISSN: 2576-3997

Eye-gaze Profiles of Children with Autism Spectrum Disorder in Relation to Visual Search Skills

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Journal: Journal of Communication Disorders and Assistive Technology

Received: November 01, 2023; Accepted: November15 2023; Published: November 20, 2023

Competing interests: The authors have declared that no competing interests exist.

Cite as: Crumrine DL, Self TL. Eye-gaze Profiles of Children with Autism Spectrum Disorder in Relation to Visual Search Skills J Commun Disorder Assist Technol. 2023; 4: 1-12.

Keywords: Autism, Visual search, Eye-gaze, Eye-tracking

ABBREVIATIONS

ASD: Autism Spectrum Disorder
TD: Typical Development
EFT: Embedded Figures Test
RT: Response Time
CPM: Colored Progressive Matrices

ABSTRACT

Previous research involving visual search tasks has suggested that children with autism spectrum disorder (ASD) demonstrate superior visual search skills when compared to typically developing (TD) children More recently, however, researchers have found the visual search skills of children with ASD to be similar to TD children. The purpose of this study was to compare the visual search abilities of children with ASD and TD. Ten children diagnosed with ASD and twenty children with TD, ages 5-7 participated. Participants were matched on nonverbal intelligence and receptive vocabulary skills. The Tobii 1750 eye-tracking system was used to capture eye-tracking measures. Overall, the results revealed that children with ASD and TD demonstrated similar visual search skills and reaction times when locating novel images in a visual scene. Children with ASD demonstrated more errors when locating targets when compared to TD children.

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INTRODUCTION

Studying eye-gaze movements can help researchers learn more about how typically developing (TD) children and children with autism spectrum disorder (ASD) process visual information, whether the stimulus is from a visual scene, a visual search task, or a reading scenario. Important underlying concepts of how children learn new information can be gained by further examining eye-gaze patterns [1]. Information such as where children look, how long they look at a stimulus, how many times they look at a target, or what information children pay attention to can all be analyzed by examining eye-gaze patterns [2].

Eye tracking can be described as the process of measuring either a specific point of a person's gaze or the line of motion of the eyes [3,4]. An eye tracker is the equipment used to measure the eye positions and eye movements of individuals. The ability to track eye movements can provide researchers with valuable insights into cognitive and visual processing [5,6]. By analyzing eye movements associated with ASD researchers can learn more about the psychological processes that take place during visual search tasks and scene perception [1].

Development of eye-gaze in children with typical development

In typical development, spontaneous eye-gaze following behaviors start in infancy [7]. Infants start to become interested in faces very early in their development. Morton and Johnson [8] reported that neonates prefer to look at faces with eyes open rather than faces with eyes closed. Brooks and Meltzoff [9] found that infants look at a target for longer periods of time when the adult's face is turned toward it with their open eyes rather than closed. This could indicate that the visual cue of open eyes might prompt the infant to look longer at an object and sustain their attention.

Infants start to discriminate the gaze direction of others at approximately 4 months of age and gradually start to use gaze information to learn about faces and objects in their environment [10]. By 4 months of age infants use adult eye-gaze to orient their attention. This suggests that eye-gaze may be a precursor to more complex joint attention skills. By 9-10 months, infants can follow head turn and gaze shifts spontaneously to orient to objects that are not in their immediate field of vision [11]. The development of eye-gaze to acquire information about the environment appears to be a necessary component for early language development.

Characteristic eye movements in children with typical development

When children look at visual scenes or search for an object in an array of various other items there are specific characteristic eye movement patterns that can be analyzed. As children are attending to visual stimuli, researchers often analyze saccades, fixations, and durations to further understand the underlying principles of processing perceptual information [3]. By investigating these characteristic eye movement patterns, researchers can begin to understand what visual stimuli children attend to when learning new information.

Saccades, fixations, and durations: When children are presented with visual stimuli on a computer screen, they continually make eye movements referred to as saccades. Saccades are rapid movements of the eyes that can occur with rates up to 500° per second [6,12]. Saccade lengths can vary based on the information and task presented.

Saccadic suppression can be explained when sensitivity to visual stimuli is reduced during eye movement [13]. Individuals do not gain new information during a saccade due to the eyes moving so rapidly across different visual stimuli [14]. There has been great debate as to whether cognitive processing is also inhibited during saccades. Some research has shown that cognitive processes are suppressed during simple activities; however, it is not known whether these processes also are impeded during more complex tasks such as reading [15].

Fixations can best be described as the number of times a person looks at a visual target or stimulus [6,12]. Gaze durations consist of how long an individual looks at one specific part or target of visual information. More specifically, Just and Carpenter [16] defined gaze duration as the sum of the total fixation time spent on a stimulus when presented for the first time. Similarly, total time spent on a stimulus includes the first fixation on a stimulus as well as any additional time spent on the stimulus when reverting [17]. When fixations and saccades are put together, they are referred to as scan paths.

Characteristic eye movements in children with ASD

The visual systems of children with ASD can be affected by impairments in sensory regulation. For instance, according to Bogdashina [18], children can either display hyper- or hypo-visual systems. Children on the autism spectrum who fall under the category of exhibiting hyper-visual sensory symptoms often focus on the smallest and most insignificant details of their environment, dislike dark or bright lights, and look down much of the time to avoid sharp flashes of light.

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Conversely, children with ASD who demonstrate characteristics associated with a hypo-visual sensory system, are often attracted to light, look intensely at people or objects, are fascinated with reflections or bright colored objects, and frequently move their fingers or objects directly in front of their visual field [20]. Limited research has focused on the characteristic eye movements and visual processing abilities of children on the autism spectrum. Investigators have tended to analyze the visual characteristics as a whole rather than specific eye movements.

Saccades and fixations: Research on saccadic functioning in children with ASD has been conflicting. Goldberg et al. [20] found that high functioning children with ASD demonstrated many abnormalities in saccadic functioning when compared to TD children. Similarly, Takarae et al. [21] discovered individuals with high functioning autism demonstrated increased variability in saccade accuracy. In direct contrast, however, Pensiero et al. [22] revealed that children with ASD did not show classic deficits in saccadic development when compared to TD children. Nevertheless, these investigators showed children with ASD displayed slight variations in continuous changes in saccadic velocity profiles, a failure to initiate saccades, and instability of fixation.

Fixations have been studied in terms of attention with children on the autism spectrum. Mottron et al. [23] investigated atypical exploratory eye-gaze patterns towards inanimate objects. The results indicated young children diagnosed with ASD demonstrated lateral glancing toward moving stimuli. Mottron et al. [23] defined lateral glancing as fixation on a target with the pupils turned in the opposite direction. This behavior is thought to be an attempt to over stimulate the peripheral vision to regulate extra quantities of local detailed information.

Eye-gaze studies in children with ASD

Visual search: Several studies have indicated that children with ASD show enhanced performance on conjunction search tasks that involve scanning a visual scene for a specific target defined by two or more features (e.g., searching for a red vertical rectangle among blue vertical and red horizontal rectangles) [24,25]. A review of the literature indicated that children with ASD are significantly faster and more accurate than TD children in inefficient search tasks and specifically in the target absent conditions [27]. More recent studies have found that children on the autism spectrum perform faster or at the same speed when locating items in the Embedded Figures Test (EFT), which is an advanced visual search task that requires participants to locate a simple shape within a complex figure. There appears to be no difference, however, in their ability to correctly identify the item when compared to TD children [26].

Based on the review of the literature and the lack of information regarding visual search skills in children with ASD the specific research questions addressed in this study were as follows: (1) Is there a difference between children with ASD and TD in search efficiency (slope) when locating novel images in a visual scene? Measured by: (a) task success, and (b) time to complete task.; (2) Is there a difference between children with ASD and TD in error rate as a function of set size in detecting novel images in a visual scene? Measured by: (a) task success; and, (3) Is there a difference between children with ASD and TD in the scan pattern used to locate novel images? Measured by: (a) saccade length (b) total fixation duration, and (d) number of fixations.

METHOD

Participants

Ten children (6 males; 4 females) diagnosed with ASD and 20 TD children (5 males; 15 females) participated in this study. These children ranged in age from 5 to 7 years. All participants were recruited from various locations in central Kansas. The study was approved by the University Institutional Review Board.

Eligibility requirements for participants with ASD included having an existing medical diagnosis of ASD as well as normal hearing and vision. Participants were also required to score ± 1.5 SD from the mean on both the *Peabody Picture Vocabulary Test, Fourth edition (PPVT-4)* [27] and the *Raven's Colored Progressive Matrices (CPM)* [28] **(Table 1)**. The *Raven's Progressive Matrices* (*RPM)* [28] is a nonverbal assessment of intelligence. There are three forms of the RPM. For this study, the *Colored Progressive Matrices (CPM)* was used. The CPM can be used with children ranging in age from 5 to 11 years and with individuals who exhibit intellectual impairment. This assessment tool can be presented with moveable pieces without the intellectual processes required for success being altered [28].

Two groups of children with TD were created such that one group of ten children was matched to the ASD group on chronological age (TD-Age) and another group of ten children was matched on receptive vocabulary (TD-Language) based on the standard score received on the PPVT [27]. Participants with TD were excluded from the study

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if they had a diagnosis or were receiving services indicative of a developmental delay, language delay, or learning disability. Participant demographics and assessment data have been provided in **Table 1.**

	ASD Group (n = 10) M (SD)	**TD-Age Group (n = 10) M (SD)**	**TD-Language Group (n = 10) M (SD)**
Sex (Males:Females)	6:4	2:8	3:7
Chronological Age (months)	76 (7.5)	77.0 (10.03)	73.4 (7.2)
Raven	77.5 (12.5)	74.5 (14.7)	70.5 (15.4)
PPVT-4	91.4 (13.2)	113.1 (4.5)	103.5 (7.6)

Table 1: Demographic and assessment data

Equipment

Apparatus: A Pentium IV-based PC with 96 dpi 17” monitor with a resolution of 1280 by 1024 pixels was used. The monitor was integrated with the Tobii 1750 eye-tracking system running at 50Hz and was used to capture eye-tracking measures. The Tobii 150 eye-tracking system samples the position of the participant’s eyes every 20 ms (i.e., 50 Hz). This system is a dual-tracking (i.e., both eyes rather than one), video-based eye-tracker that uses dark pupil corneal reflections to compute the participant’s point of regard in relation to the stimuli presented on the monitor. The Tobii 1750 is characterized by the unobtrusive addition of the eye-tracking hardware (i.e., high resolution camera and near infra-red light-emitting diodes) to the monitor frame. This design promotes more natural participant behavior by not placing unnatural restrictions on the participant (e.g., helmets, head rest). Tobii Studio™ software was used to detect and collect participant eye movement data during the testing procedure.

Stimuli: Participants were presented with a total of 12 different novel images *via* the computer system as described above. The novel images were formatted as unfamiliar black and white line drawings, first developed by Apel and colleagues [29]. These researchers designed and named the images so that they did not represent known objects or images so that one could accurately assess children’s fast-mapping skills.

The novel images were embedded into a visual scene. The visual stimuli consisted of various scenes, people, and objects. The visual scenes were similar to black and white cartoon drawings. The novel images were hidden in the visual scene, requiring the participants to search for the image among an area of competing imagery.

Procedure

The experiment was conducted in a room that had been adapted to minimize visual and auditory distractions. The participants were first introduced to a work system which provided the children with the sequence of tasks that were to be completed for the day and the reinforcement that they would receive at the completion of the research session (i.e., preferred snack item).

The two graduate students who administered the qualifying assessments conducted all phases of the experiment. The primary investigator was always in the research room to monitor the research protocol and supervise the graduate students. The research room included a desk with a computer monitor, eye tracker, and visual supports (i.e., work system). A booster seat with foam was placed on a chair for each participant. The participants were positioned approximately 70 cm from the computer monitor for all tasks.

Initially, a calibration process was performed. To visually prepare the participants for the calibration process, children were guided to follow a pre-made, red circle made with construction paper. The graduate student moved the red circle in different directions, allowing the participants to practice the calibration process. The participants were then seated approximately 70 cm from the computer monitor and a formal calibration of the Tobii 1750 eye-tracking system was performed. The calibration process involved having the participant fixate on a dot that appeared on the monitor in a random sequence of five different locations on the screen. This procedure was adjusted to the participant’s specific eye-movements and established a reference for eye positions relative to different areas on the computer monitor.

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Experimental protocol: Participants were directed to the work system and asked to select a preferred snack item to be used as motivation for task completion. Practice trials were provided for all participants via a black and white visual scene presented on an 8.5 x 11 piece of paper. At least three practice trials were presented to provide instruction for the visual search tasks. For participants who did not appear to understand the directions involved in locating a hidden image, practice trials were continued until the researcher was confident that the participant understood the visual search task (i.e., participants located hidden image independently). The participants then started the calibration protocol for the Tobii eye-tracker.

Orientation to visual scenes: The participants were presented with three visual scenes. Each scene was presented for 10 seconds (**Figure 1**).

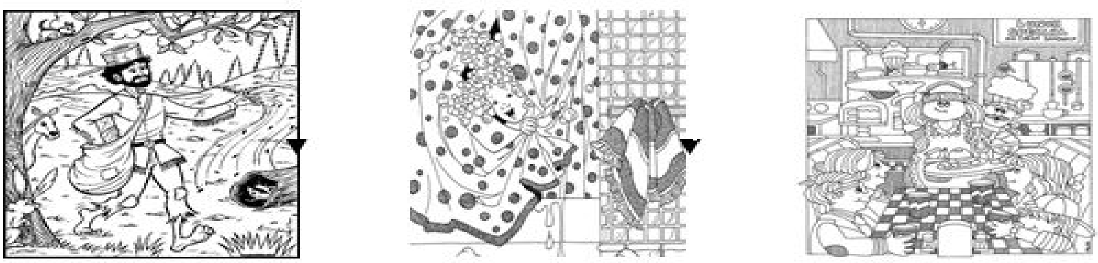
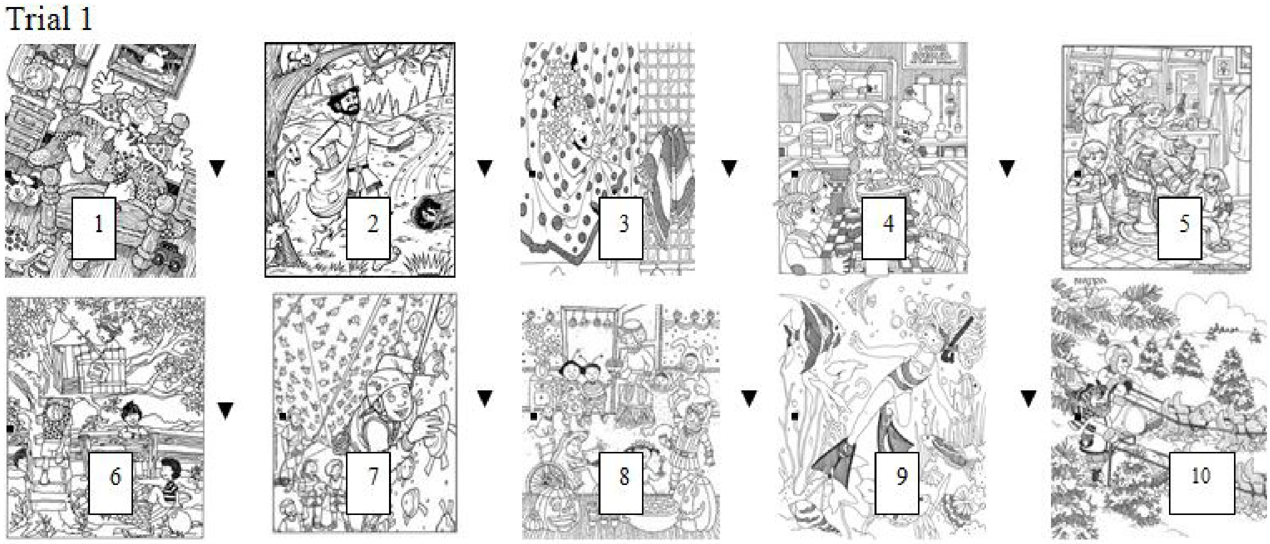


Figure 1: Orientation to visual scenes

Visual search condition: To begin the visual search condition, a blue dot was presented in the middle of the screen to capture the attention of the participants prior to the presentation of the research stimuli. This process was repeated before the beginning of each visual scene in the experiment. Next, participants were presented with a novel image in conjunction with a visual scene, along with an auditory cue (e.g., Find the chab). Participants were required to locate the novel image embedded in the visual scene. Trials were completed once the participant located the novel image or after 1 minute had lapsed. Participants were encouraged to try again if they exhibited a false identification of the target until the 1-minute time frame had expired. The identification of the novel image scene, which contained a novel image, was presented as either a whole or half visual scene, operationalizing the variable of set size (i.e., the number of items an observer must search in a display). The participants were presented with 10 trials per set size. All trials (visual scenes) were randomized for each participant **(Figure 2).**

Visual Search Condition
Auditory cues: Find the *chab*.



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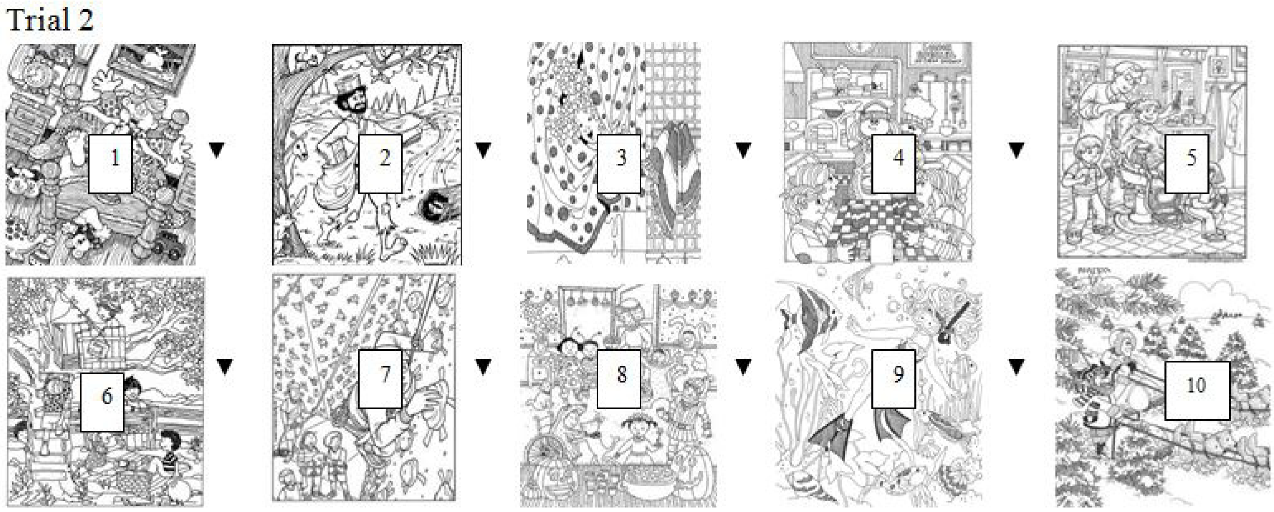

Figure 2: Protocol for visual search condition

RESULTS

The eye-gaze patterns of children with ASD and TD children were compared by collecting and analyzing eye-movement data from the experimental conditions. The eye tracking data were examined both in terms of the task as a whole and participants' visual fixations on an Area of Interest (AOI) within the screen content during a task. The eye-gaze patterns of children with ASD and TD were compared by collecting and analyzing eye-movement data from the experimental conditions. The performance measures of interest in this study were as follows:

(1) task success: finding a target that meets the requirement of the trial (e.g., Find the *chab.*), (2) time to complete a task: time elapsed from when the visual scene appears on the screen to the time the participant locates the target or the researcher ends the trial, saccade length: rapid eye-movement from one part of the visual field to another, total fixation duration: average duration of fixations recorded within an AO, and fixation count: total number of visual fixations recorded on an AOI [30].

Error rates for novel image search

Miss error rates are presented in **Table 2.** For this study, miss errors were categorized as an incorrect identification of the target; that is, multiple miss errors could be committed on a single trial. The miss error rates between the ASD and both TD groups differed significantly for half of the visual search display, $F(2,27) = 18.2$, $p < .01$, $\eta = .27$ and for the whole display, $F(2,27) = 2.6$, $p < .05$, $\eta = .21$.

	Miss Error Rates		
	Half Display M (SD)	**Whole Display M (SD)**	**Average M (SD)**
ASD	1.1 (1.4)**	2.2 (1.6)*	1.7 (1.5)*
TD-Age	.00**	1.1 (.99)*	.60 (.89)*
TD-Language	.20 (.42)**	.90 (.74)*	.60 (.69)*

Note. .*p < .05. ** p < .01

Table 2: Miss error rates in visual search tasks

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The number of supplementary attempts to identify the target was also calculated. Supplementary attempts were classified as the number of tries beyond the first attempt. Average number of supplementary attempts were 2.9 (ASD), 1.8 (TD-Age), and 1.0 (TD-Language). The average number of attempts between the ASD and TD groups did not differ significantly, *p* > .05. Error rates and number of supplementary attempts were calculated on the average of missed identification of targets.

Search efficiency and fixed search costs

Response time (RT) to correctly identify the target was measured as a function of the set size of the displays, which was manipulated in these scenes by presenting either the whole or half of the display. The slope of the RT x set size function measured search efficiency (i.e., the increase in response time cost for searching the whole display vs. half of the display). The slopes of the ASD and TD-groups did not differ significantly, *p* > .05, indicating that on average, the ASD group did not differ in search efficiency from the TD groups. **Table 3** displays the means and standard deviations for the slopes in the ASD and TD groups.

	Slope	**Intercept**
Group	**M (SD)**	**M (SD)**
ASD	4.01 (8.5)	6.13 (4.13)
TD-Age	7.7 (4.9)	2.52 (3.55)
TD-Language	4.46 (5.86)	5.15 (4.24)

Table 3: Slopes and intercepts for visual search tasks

The intercept of the RT x set size function is typically used to measure fixed costs associated with visual search (e.g., initial perception and motor responses). The intercept between the ASD and TD- groups did notdiffer significantly, *p* > .05. **Table 3** displays the means and standard deviations for the fixed costs in the ASD and TD groups. **Figure 3** displays the slopes and intercepts for whole and half display scenes.

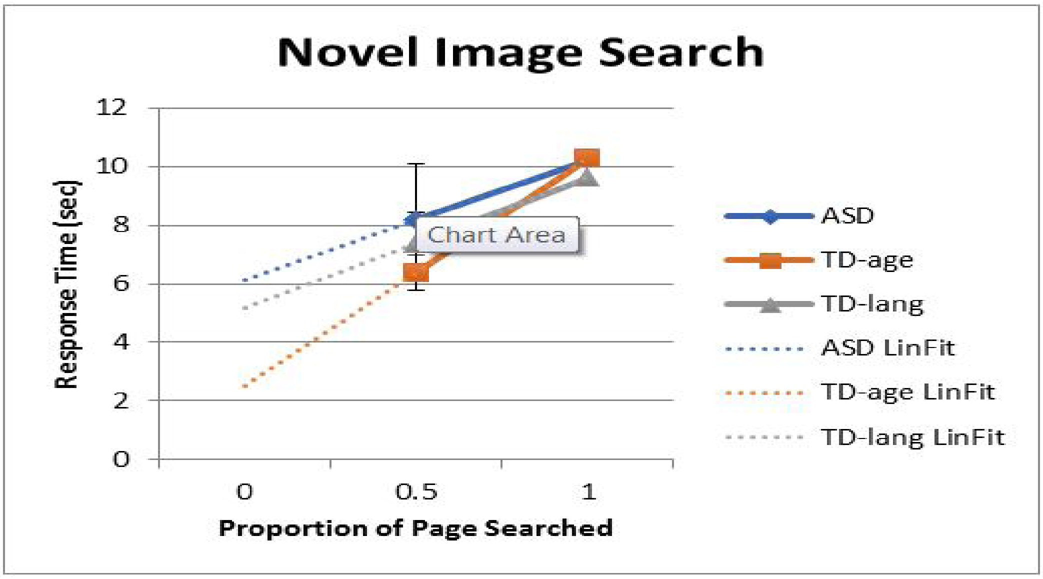

Figure 3: Slopes and intercepts for ASD, TD-Age, and TD-Language across whole and half visual search scenes.

"LinFit" indicates a linear fit of the data for determining the intercepts of the RT x set size function. Error bars report standard error of the mean.

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RTs as a function of set size for the ASD and TD groups were compared with a 3x2 (Group x Set Size) mixed ANOVA. Box's Test of Equality of Covariance for the multivariate test was significant, Box's M = 14.41, $F(6, 18168.92) = 2.14$, $p = .04$. In addition, Levene's Test of Equality of Error Variance was significant for each set size. Thus, significant differences should be interpreted with caution. Overall, the participants had slower RTs in the whole display condition than in the half display condition, $F(2,27) = 20.12$, $p < .001$, $r = .43$. There was, however, not a significant difference in the interaction between set size and group, $p > .05$, consistent with the analysis of search slopes reported above. **Table 4** displays the means and standard deviations for response times in the ASD and TD groups.

	Half Display	**Whole Display**
Group	**M (SD)**	**M (SD)**
ASD	8.18 (2.95)	10.22 (6.03)
TD-Age	6.39 (1.40)	10.26 (1.93)
TD-Language	7.38 (2.61)	9.61 (3.35)

Table 4: Reaction times for whole and half display vsual search scenes

Search patterns

Saccade length: Average saccade lengths when searching through whole and half displays between the ASD and the two TD groups were analyzed with an ANOVA. In addition, data for saccade length were analyzed by eliminating all participants' first fixation point (i.e., gaze point maintained in one place for a given amount of time) across all conditions. All participants demonstrated shorter saccade patterns for the set size of half and longer saccades when presented with the whole set size as evidenced by a significant difference in saccade length for half displays vs. whole displays, $F(2, 27) = 44.97$, $p < .001$, $\eta = .63$. However, the analyses neither detected a main effect of groups, nor an interaction of groups by display size (both $p > .05$). On average, all groups demonstrated similar saccade patterns in the whole and half set sizes. **Table 5** displays the means and standard deviations for saccade length.

Measurement	**ASD**		**TD-Age**		**TD-Language**	
	M (SD)		**M (SD)**		**M (SD)**	
	Half	**Whole**	**Half**	**Whole**	**Half**	**Whole**
Average Saccade Length	.92 (.12)	1.1 (.17)	.88 (.09)	1.1 (.19)	.86 (.10)	.1.0 (.16)

Table 5: Average saccade length in whole and half display scenes

Total fixation duration: Total fixation duration for the referent AOI in the whole display scene between the ASD and TD groups was analyzed with an ANOVA. The total fixation duration for the referent in the whole display scene between the ASD and TD groups did not differ significantly, $p > .05$. Similarly, the total fixation duration was analyzed for the whole display scene between the ASD and TD groups. The total fixation duration for the whole display scene between the ASD and TD groups did not differ significantly, $p > .05$. **Table 6** displays the means and standard deviations for referent and whole display. In addition, the total fixation duration for the referent AOI in half of the display scene between the ASD and TD groups was analyzed with an ANOVA. The total fixation duration for the referent in half of the display scene between the ASD and TD-age group differed significantly, $F(2, 27) = 3.71$, $p = .04$, $\eta = .22$. The ASD had longer total fixation duration for the referent AOI in half of the display scene when compared to the TD-Age group. There were not, however, significant differences between the ASD and TD-Language groups, p > .05. Furthermore, the total fixation duration was analyzed for half of the display scene between the ASD and TD groups.

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The total fixation duration for half of the display scene between the ASD and TD groups did not differ significantly, *p* > .05. **Table 6** displays the means and standard deviations for total fixation duration. **Table 7** displays the means and standard deviations for the referent and half display.

Measurement	**ASD**		**TD-Age**		**TD-Language**	
	M (SD)		**M (SD)**		**M (SD)**	
	Referent	**Whole**	**Referent**	**Whole**	**Referent**	**Whole**
Total Fixation Duration	1.5 (.63)	12.1 (6.9)	1.2 (.46)	13.4 (3.8)	.98 (.39)	12.4 (4.5)
Fixation Count	3.6 (1.3)	29.8 (13.9)	3.0 (1.1)	33.0 (11.2)	2.6 (.97)	30.8 (12.4)

Table 6: Eye-gaze measurements for whole visual search display

Fixation count: Average fixation count for the referent AOI when presented with the whole display scene between the ASD and both TD groups was analyzed using an ANOVA. The number of fixations made on the referent AOI during the whole display scene between the ASD and both TD groups did not differ significantly, *p* > .05. All participants on average had approximately the same number of fixations on the referent AOI for the whole display scene. Similarly, fixation count was analyzed within the whole display scene between the ASD and TD groups. The number of fixations made in the whole visual scene did not differ significantly between the ASD and TD groups, *p* > .05. Table 7 displays the means and standard deviations for the referent and whole display. In addition, the average fixation count was analyzed for the referent AOI in the half display scene between the ASD and both TD groups. The number of fixations made on the referent AOI when presented with half of the display scene did not differ significantly between the ASD and TD groups, *p* > .05. Furthermore, the number of fixations made in half of the display size was analyzed between the ASD and TD groups. The number of fixations made in half of the display size between the ASD and TD groups did not differ significantly, *p* > .05. **Table 7** provides the means and standard deviations for the referent and half display.

Measurement	**ASD**		**TD-Age**		**TD-Language**	
	M (SD)		**M (SD)**		**M (SD)**	
	Referent	**Half**	**Referent**	**Half**	**Referent**	**Half**
Total Fixation Duration	1.2 (.65)	6.1 (3.0)	.73 (.15)	5.3 (1.2)	.90 (.33)	6.8 (3.5)
Fixation Count	2.8 (1.3)*	14.8 (6.0)	2.0 (.34)*	11.8 (2.8)	2.44 (.92)	16.1 (8.9)

Note. .*p < .05. ** p < .01

Table 7: Eye-gaze measurements for half of the visual search display

DISCUSSION

Current research involving visual search tasks has suggested children with ASD demonstrate similar visual search skills compared to TD children [26]. To investigate the visual search skills of children with ASD it was necessary to analyze the error rates, search efficiency and fixed search costs, as well as the search patterns when presented with visual search scenes.

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Error rates for novel image search

Research from Horlin et al. [26] indicated that error rates were similar between ASD and TD groups. In this study, the ASD group on average made more errors than both TD groups regardless of set size. The variation in search abilities in this study may be due to the difference in the age of the participants.

Search efficiency and fixed search costs

The results of this study revealed the ASD group and both TD groups had similar search efficiency and fixed costs when searching for targets in whole and half visual displays. These results contrast with previous research which suggested adolescents on the autism spectrum were significantly faster than TD children on visual search tasks that involved vertical targets, target absent, and larger set sizes [31]. Rather, this study corroborates more recent studies which have suggested children with ASD perform similarly to TD children in search efficiency [26].

Search patterns

The results of this study aligned with the results presented by Horlin et al. [26]. TD children and those with ASD demonstrated similar patterns in saccade length regardless of whether they were presented with whole and half visual scenes. Furthermore, the ASD and TD groups displayed similar patterns of total fixation duration and number of fixations on the referent in the whole display scene as well as within the whole visual search scene itself. Interestingly, the ASD group demonstrated longer total fixation durations for the referent when presented with the half display scenes when compared to only the TD-age group. This may have been due to the ASD group using a personal focus of attention or that the referent was more interesting [32-34].

LIMITATIONS

Given the heterogeneous nature of children on the autism spectrum, it can be difficult to include these children in investigations that compare them to children with typical development. Also, children with ASD have difficulties with new environments and unfamiliar situations. Consequently, this reduced the potential number of children that may have qualified for this study as the parents of these children may have assumed that their child would experience too much anxiety and would not be able to fully participate. Consequently, participant numbers are often lower in these types of studies. This was the typical trend for the research referenced in this study.

An experimental testing environment often creates challenges when children are included. Such was the case in this study, as it was often difficult to keep all children properly positioned in front of the Tobii Eye Tracker. ™ This may have been because the children had prior experience with computers, and they were used to independently operating the equipment. Therefore, the investigator found it necessary to remove the keyboard and the mouse to further limit distractions. In addition, children often had to be repositioned as they tended to lean forward, which may have affected the calibration of the equipment.

During visual search studies it is typical that participants indicate they have located a target by pressing a key on the keyboard and/or using a mouse click. In this study, the investigator did not want the response time to reflect the participants' ability to remember to perform an additional response set to indicate they had located the target. Rather, it was determined that the actual response time of the participants would be better represented if a research assistant pushed the button when the participant pointed to the target on the screen. Furthermore, the position of the attention directing stimulus (i.e., blue dot) was not randomized. This may have affected the data for search patterns when the target was presented in a similar location relative to the blue dot.

CONCLUSION

This study supports recent literature which has reported children with ASD and TD have similar visual search skills. This body of research could potentially impact speech-language pathologists' (SLPs) implementation and development of Augmentative and Alternative Communication (AAC) systems for children with ASD. SLPs may refer to the evidence provided by these studies to consider and support their selection of more robust AAC systems for children with ASD.

Cite as: *Crumrine DL, Self TL. Eye-gaze Profiles of Children with Autism Spectrum Disorder in Relation to Visual Search Skills J Commun Disorder Assist Technol. 2023; 4: 1-12.*

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