A Preliminary Investigation of Eye-gaze Patterns on Fast-mapping Abilities of Children with ASD

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Abstract. Research has suggested that during storybook reading children’s eye-gaze is primarily on the picture versus the text. Further research with written fast-mapping (FM) indicates that children acquire orthographic images during reading after minimal exposure. Limited research has been conducted on the FM or orthographic skills of children with autism spectrum disorder (ASD). The purpose was to investigate eye-gaze patterns of children with ASD to assess orthographic and written FM abilities. Twin 6-year-old boys with ASD and two 5-year-old typically developing children participated. Fast-mapping skills were assessed by presenting novel words and pictures on a computer. Eye-gaze patterns were analyzed using Tobii Studio 2.0.1 eye tracking software. Data was analyzed to determine eye-gaze patterns in relation to FM skills.

1. Introduction
There have been numerous studies conducted to examine the factors that influence the reading and writing skills of typically developing children. Children learn new words through a process termed fast-mapping, which involves the rapid, associative pairing of objects with labels to form words. Through fast-mapping, children create an initial mental representation of the phonological structure of a spoken word which is then refined following subsequent exposures of the spoken word. The fast-mapping of spoken words requires the ability to participate in joint attention, which includes the ability to follow and share information by following another’s eye-gaze. Joint attention is a core deficit in children with autism spectrum disorder (ASD) and is a predictor of concurrent and future language ability.

The research on eye-gaze patterns with typically developing children has suggested that storybook reading is a picture-focused activity, implying that children’s eye-gaze is focused primarily on the picture versus the text [1]. In addition, research with written fast-mapping skills has indicated that children acquire mental orthographic images of words within implicit storybook reading contexts after minimal exposures [2]. Mental orthographic representations are stored mental images of a written word or a prefix or suffix. These mental orthographic representations appear to be crucial for successful reading and writing skills. Consequently, typically developing children with well-developed mental orthographic representations can recognize or recall the visual representations of the word and, therefore, free up memory and attentional resources for comprehending or composing text [3].

Previous research on the fast-mapping abilities of children with Autism Spectrum Disorder (ASD) has focused primarily on the verbal word learning process. The fast-mapping abilities of school-aged children with ASD have been found to be impaired because of using personal focus of attention as a strategy for forming word object associations instead of using the speaker’s eye-gaze [4]. Therefore, the deficits of joint attention that often are seen in children with ASD may have a direct impact on the development of core vocabulary. Similarly, the attention-following skills of children with ASD have a significant predictive relationship with fast-mapping and vocabulary development. Furthermore, it appears that targeting attention-following tasks, such as, joint attention, may increase the vocabulary development in children with ASD.

Research related to the written fast-mapping or orthographic processing skills of children with (ASD) has been limited. Previous research has focused on the fast-mapping abilities of children with ASD in relation to verbal word learning. It is important, therefore, that studies be conducted to investigate the written fast-mapping skills of children with ASD, as well as explore the eye-gaze patterns of children on the autism spectrum when presented with both images and text. The purpose of this pilot study was to investigate the eye-gaze patterns of children with ASD when presented with novel words and pictures to assess their orthographic and written fast-mapping abilities.

2. Experiment, Results, Discussion, and Significance

Method
Participants Twin six-year-old boys with ASD and two 5-year-old typically developing children participated in this study. The participants were assessed to determine nonverbal intelligence (TONI-
3) [5], reading (WRMT-R) [6] and spelling abilities (spelling test), receptive vocabulary skills (PPVT-4) [7], and phonological processing ability (CTOPP) [8] prior to initiating the eye-gaze protocol.

**Apparatus**

A Pentium IV-based PC with 96 dpi 17” monitor with a resolution of 1280 by 1024 pixels integrated with the Tobii 1750 eye-tracking system running at 50Hz was used to capture eye-tracking measures. Tobii StudioTM software was used to record and provide fixation and Area of Interest (AOI) eye-tracking data of the participants.

**Procedure**

As each participant began the research study a visual work system, physical structure of the environment, reinforcement, and mental load were standardized across participants. The participants used a work system that included both picture icons and photographs that indicated what activities would occur and in what sequence. The physical structure of the room was adapted to clarify boundaries and minimize both distractions and stimulation for each participant. Each participant selected a preferred item from the vending machine prior to the initiation of the research study to help motivate participants to complete the research task.

Fast-mapping skills were assessed by presenting 12 stories containing a novel word paired with a picture of novel objects through a storybook context presented on a computer. Each slide of the story appeared for 10 seconds, while an image of the novel object was paired with a pre-recorded female voice reading the sentence that contained the target novel word. The sentence with the novel word was printed below each picture. Each target word was heard and seen four times within the context of the story. After each storybook presentation, participants were asked to generate the novel word through a written response and via receptive identification. The written answer required the child to spell the novel word. For the receptive identification task, the child was asked to point to the target novel word when given a set of four words.

**Results**

In this study, two measures were used to quantify eye-movements. Fixations are a stationary gaze that remains within a 35px radius for 2 consecutive samples. Fixation duration represents the mean period that a fixation lasts, which is expressed in milliseconds.

Due to the small sample size, data were examined descriptively. The ASD group fixated more on images ($M = 727.0$, $SD = 63.64$) than text ($M = 412.0$, $SD = 178.19$). In contrast, the typically developing group fixated more on text ($M = 797.0$, $SD = 530.33$) than images ($M = 582.0$, $SD = 117.38$). The typically developing group ($M = 8.5$, $SD = 3.54$) had greater written fast-mapping scores than the ASD group ($M = 7.5$, $SD = 3.54$). Receptive fast mapping scores ($M = 12.0$, $SD = NA$) were greater for the typically developing group than the ASD group ($M = 10.5$, $SD = .71$).

In summary, written fast-mapping scores had a positive relationship with mean fixation duration ($r = .873$, $p > .05$), and a negative relationship with fixation count ($r = -.298$, $p > .05$). Additionally, fast-mapping receptive scores had positive trends with fixation count ($r = .502$, $p > .05$) and fixation duration ($r = .373$, $p > .05$).

**Discussion**

The participants with ASD focused more on the images than the text, which may have impacted their ability to learn novel words. The results imply that children with ASD have difficulty focusing attention to relevant stimuli in order to develop new vocabulary. The data from this pilot study will be used for exploratory purposes to enhance the research design and protocol for further research. Future research will include a larger sample size to generalize results to the target population.

**Significance**

The data from this study could have an impact on the assessment, instruction, and intervention methods for literacy development among children with ASD. The outcomes from this study may encourage literacy curriculums for children with ASD that focus on both phonemic awareness and orthographic concepts to facilitate reading and spelling skills. In addition, the processes underlying fast-mapping abilities of children with ASD may be understood better with the investigation of eye-gaze patterns when presented with text and images.

**References**