Visual Attention to Print in Preschool Children with and without Hearing Loss

Avinaash Korrapati, Krystal L. Werfel, Zachary P. Barnett, and C. Melanie Schuele

KEYWORDS. print knowledge, children with hearing loss, eye gaze tracking

BRIEF. This study examined visual attention to print in storybooks of children with and without hearing loss.

ABSTRACT. Children with normal hearing spend much less time looking at print than illustrations during storybook reading. However, these children are more likely to attend to print when storybooks have high print salience. Although children with hearing loss exhibit documented deficits in print knowledge, little is known about attention to print for children with hearing loss. The purpose of this study was to investigate visual attention to print during storybook reading in preschool children with hearing loss. Preschoolers with and without hearing loss participated in storybook reading sessions. One book with high print salience and one book with low print salience were displayed on a computer screen while a female voice read the text. Visual attention to print was tracked using the Tobii X50 eye tracking system. Eye gaze analysis indicated that younger children with hearing loss focused more on print than younger children without hearing loss. Children with and without hearing loss both focused more on print in storybooks with high print salience as compared to storybooks with low print salience. Despite adequate visual attention to print, children with hearing loss do not appear to learn about print during storybook reading when the reading does not include explicit references to print.

INTRODUCTION.

Literacy outcomes for children with hearing loss are notoriously poor. The average 18-year-old with hearing loss reads at a fourth grade level [*1*]. Children with hearing loss exhibit deficits in emergent literacy development as early as preschool [*2*].

Emergent literacy refers to the set of skills that are critical for later reading development, encompassing three broad areas: print knowledge, phonological awareness, and oral language. Indeed, the National Early Reading Panel [*3*] identified these three areas as strong predictors of later literacy skills.

Because reading and writing outcomes are so poor, it is important to understand the performance of children with hearing loss on measures of emergent literacy. Children with hearing loss have documented deficits in phonological awareness and oral language compared to their peers with normal hearing, and as they grow older, this gap widens [*2*]. However, due to lack of specified research, little is known about print knowledge in young children with hearing loss and whether print knowledge follows the same developmental trends as phonological awareness and oral language.

Broadly, print knowledge includes alphabet knowledge as well as conceptual knowledge of print conventions and written words [*4*]. Preliminary results from our lab indicate that children with hearing loss perform substantially below their same-age peers with normal hearing on tasks that measure conceptual print knowledge [*5*].

Shared book reading is widely considered a critical contributor to early literacy development. However, the specific mechanisms by which shared book reading influences children's early literacy development has not been well established. In studies of visual attention to print in storybooks, children with normal hearing spend much less time looking at print than at illustrations [*4, 6*]. However, Justice and colleagues [*6, 7*] reported that preschoolers with normal hearing attended to print more in storybooks with high print salience (e.g., large text, few words on page, contextualized print) than in storybooks with low print salience (e.g., small text, many words on page, no print in illustrations). In addition, children with normal hearing spend more time looking at print when text is within their reading ability than when text exceeds their reading ability [*8*]. Little is known about visual attention to print for children with hearing loss. We hypothesized that preschool children with hearing loss would attend to print even less than their peers with normal hearing.

To provide effective literacy instruction and intervention, it is important to understand all aspects of literacy development in children with hearing loss and to elucidate areas where interventions can improve literacy outcomes in this population. The purpose of this study was to evaluate visual attention to print during storybook reading in preschool children with and without hearing loss.

METHODS.

Participants.

Four children with hearing loss (three 3-year-olds, one 5-year-old) and five children with normal hearing (two 3-year-olds, three 5- and 6-year-olds) participated in a storybook reading session. To test whether the children could actually read the books utilized in the study, random words were chosen from the books and each child was asked to read the words. None of the participants could read the words chosen.

The Phonological Awareness and Literacy Screening – PreK (PALS-PreK)[*9*] was administered to describe emergent literacy skills. The Pals-PreK is a literary screening assessment that measures children's knowledge of important literacy skills and fundamentals. The following are the appropriate ranges for children with typical development: Capital Letter Names (12-21), Letter Sounds (4-8), Initial Sounds (5-8), Rhyme Awareness (5-7), Print Awareness (7-9), Nursery Rhyme Awareness (6-10). See Figure 1 for participant emergent literacy profiles.

Procedures.

Two storybooks were used in the study, *Spot's Birthday Party* (high print salience)[*10*]and *Spot's Show and Tell* (low print salience)[*11*]. *Spot's Birthday Party* is considered to have high print salience because it has large text, few words on each page, and contextualized print (print that is embedded within illustrations). *Spot's Show and Tell* is considered to have low print salience because it has small text, many words on each page, and no contextualized print. Both books had the same main character and illustrator; these features were held constant to control for child interest.

Book pages were scanned into .jpeg files and a female adult voice was recorded reading the book text. E-prime was used to program the experiment. Book pages were displayed one after another. Audio of the reading began 500 milliseconds after the page appeared, and the page changed 3000 milliseconds after the audio ended to simulate an actual parent-child storybook reading experience.

Each child sat on an examiner's lap in a chair proximal to the computer screen. First the eye tracker was calibrated for each participant. The child was prompted to focus attention on the computer screen during calibration and then he or she viewed the book content. The examiner did not direct the child's attention to print during the reading sessions. While children viewed the screen, visual attention to print was tracked using the Tobii x50 eye tracking system, a non-invasive video camera. Audio of voice recording was played through a speaker placed behind and above the participant.

Tobii x50 eye tracking software was used to analyze the data. In *Spot's Birthday Party*, each page was subdivided into different sections: print, contextualized

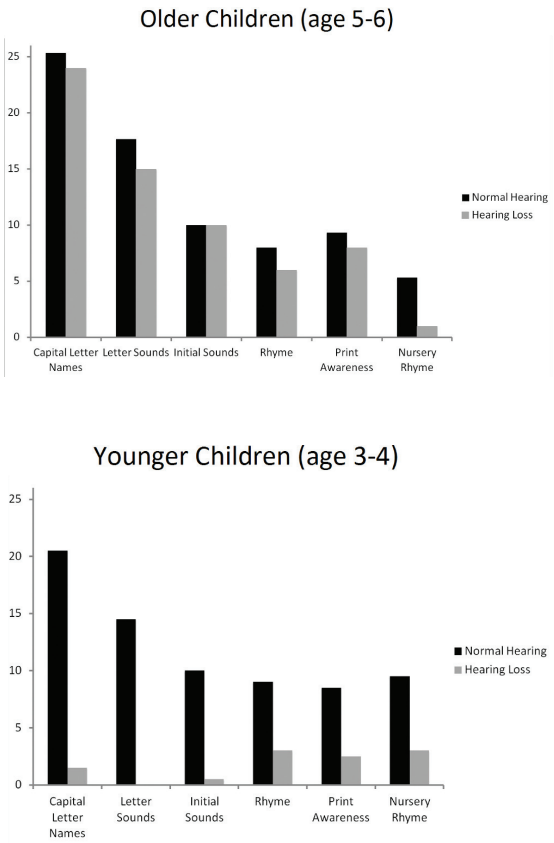

Figure 1. Participant Demographics

print, pictures, and white space. The pages of *Spot's Show and Tell* were similarly subdivided; however, because this book did not have contextualized print, only three categories (print, pictures, and white space) were used. The total time of the categories was subtracted from the length of the book reading to create the final variable: not looking at book. The Tobii x50 eye tracking software calculated the time, in seconds, spent looking in each of these sections per page. The differences in each section were evaluated by calculating *Cohen's d* effect sizes to measure the strength of the phenomenon. A small effect size would have a value of 0.2, while a medium and large effect size would have a value around 0.5 and 0.8, respectively.

RESULTS.

Do children with hearing loss exhibit less visual attention to print than children with normal hearing during storybook reading?

Results indicated that for younger preschoolers (age 3-4) there was little difference in attention to print between children with hearing loss and children with normal hearing in the book with high print salience (see Table 1). However, contrary to our hypothesis, Cohen's *d* indicated that younger children with hearing loss attended more to print in the low print salience book, as well as to contextualized print in the high print salience book than did children with normal hearing. Because there was only one child with hearing loss in the older group (ages 5-6), Cohen's *d* was not calculated. Older children with normal hearing attended to print and contextualized print in the high print salience book more than the older child with hearing loss. However, the older child with hearing loss attended to print more in the low print salience book than did the older children with normal hearing. Older children in both groups attended to print and contextualized print more than younger children. See Figure 2 for heat map illustrations of children's visual attention to print across age, group, and print condition.

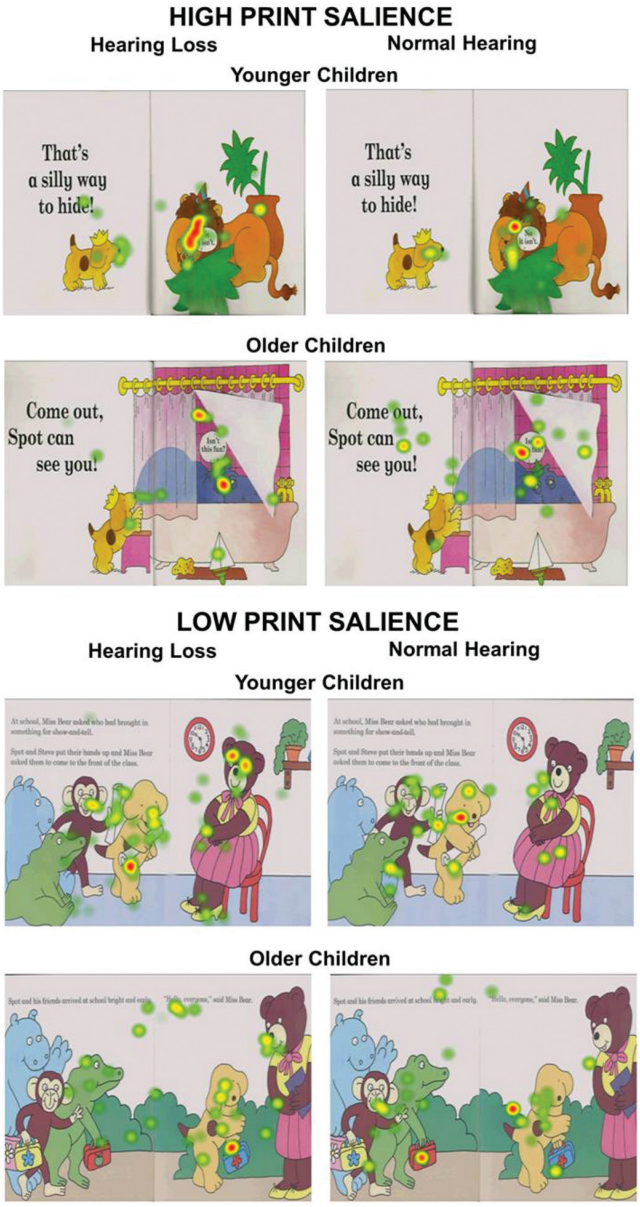

Figure 2. Heat map illustrations of children's visual attention to print. Green indicates less time that gaze was focused on an area; yellow indicates more time; red indicates the longest time focused on an area. Book pages are from *Spot's Birthday Party* [10] and *Spot's Show and Tell* [11].

Table 1. Percent Differences in Attention Times Devoted to Book Sections

	Younger (age 3-4)			Older (age 5-6)	
	HL (n = 3)	NH (n = 2)	Cohen's *d* for Younger	HL (n = 1)	NH (n = 3)
High Print Salience					
Print	0.4 (0-1.18)	0.6 (0-1.25)	0.29	2.0	4.1 (1.3-7.6)
Contextualized Print	4.7 (1.78-6.29)	2.0 (0-3.2)	1.23	5.5	8.5 (3.2-17.3)
Pictures	65.1 (46.2-81)	79.9 (78-82.1)	1.16	78.4	62.8 (55.5-75.2)
White Space	9.3 (4.4-14)	5.5 (4.0-7.1)	1.26	6.2	9.7 (2.0-17.9)
Not Looking at Book	20.3 (8.5-41.1)	11.9 (9.3-14.5)	0.61	8.0	14.9 (12.3-16.5)
Low Print Salience					
Print	0.5 (0.16-0.95)	0.14 (0.1-0.2)	1.43	1.7	0.7 (0.1-1.2)
Pictures	75.6 (55.7-89.6)	90.3 (87-94)	1.13	80.4	81.9 (76.1-86.0)
White Space	7.17 (2.6-15.1)	5.3 (1.1-9.5)	0.29	9.2	6.8 (4.7-9.2)
Not Looking at Book	16.7 (6.2-28.2)	4.3 (3.6-5.1)	1.56	8.8	10.6 (8.8-13.8)

Note. HL = Hearing loss. NH = normal hearing. Values in parenthesis are ranges.

Does print salience affect visual attention to print for children with hearing loss?

Children in all groups attended to print for more time during storybook reading time in books with high print salience (see Figure 3). Younger children with hearing loss attended to print (regular print and contextualized) for 5.1% of storybook reading time in the high print salience book and only 0.5% of storybook reading time in the low print salience book. The older child with hearing loss attended to print for 7.5% of storybook reading time in the high print salience book and only 1.7% of storybook reading time in the low print salience book.

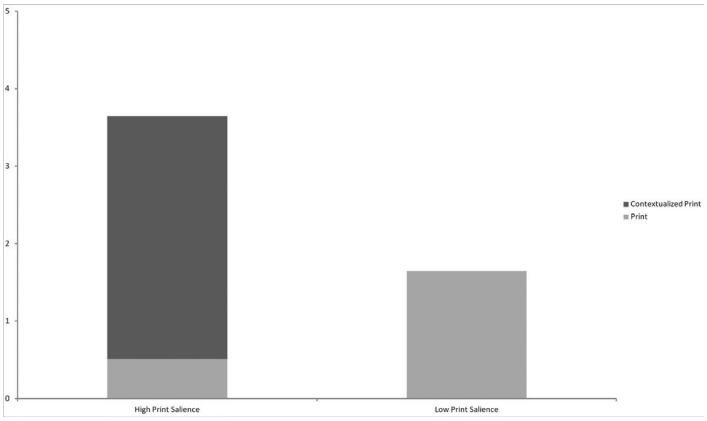

Figure 3. Effect of print salience on visual attention to print for children with hearing loss during storybook reading.

DISCUSSION.

Children with hearing loss exhibit documented deficits in print knowledge [2]. One possible explanation for these deficits is that children with hearing loss do not attend to print during storybook reading. However, contrary to our hypothesis, younger children with hearing loss did not attend less to print during storybook reading than children with normal hearing. In fact, effect sizes indicated that younger children with hearing loss looked at print, particularly contextualized print, more than their peers with normal hearing.

The older child with hearing loss, in contrast, attended to print less than peers with normal hearing. This finding suggests that children with hearing loss may develop print awareness skills at a slower rate than children with normal hearing. This rate surprisingly seems to mimic the trend leading to older children with hearing loss lagging behind children with normal hearing further suggesting a link between literacy development and print awareness [2]. Furthermore, perhaps this slower rate of growth of visual attention to print can explain deficits in print knowledge. It is important to note that because only one older child with hearing loss was tested for this study, further data must be gathered to confirm our results. Nevertheless, the results do offer interesting insight into the literacy and print awareness development of children with hearing loss.

Children with hearing loss were much more likely to visually attend to print in books with high print salience than low print salience. When targeting print knowledge during storybook reading, books with high print salience should be used.

However, despite early strong visual attention to print, children with hearing loss spent a large portion of time not looking at the novel at all. This might provide a partial explanation as to why children with hearing loss begin to lag behind children with normal hearing in literacy development and print awareness as they grow older. Therefore, to increase focus on the book as well as to print, explicit print referencing during storybook reading [12, 13] may be an effective intervention method to prevent a gap from developing between this population and children with normal hearing. Future research should explore the effectiveness of explicit print referencing interventions for children with hearing loss.

ACKNOWLEDGMENTS: I would like to thank my research mentor, Dr. Krystal L. Werfel, as well as Dr. C. Melanie Schuele, who not only provided me with the opportunity to work on this research project, but also guided and taught me about the process. I would also like to thank Zachary P. Barnett for his time to help me program the E-Prime system, Emily Lund for her guidance, and everyone in the Department of Hearing and Speech Sciences for their support and aid.

REFERENCES.

1. S Qi, R Mitchell. *J. Deaf Stud. Deaf Educ.*, 17, 1 (2012).
2. MP Moeller, JB Tomblin , *et al. Ear & Hearing*, 28: 740 (2007).
3. NEL Panel. *Developing early literacy: Report of the National Early Literacy Panel.* NIL, Washington, DC (2008)
4. MA Evans, J Saint-Aubin. *Psychol Sci*, 16, 913 (2005).
5. K Werfel, E Lund , *et al.* in *Symposium on Res Child Lang Disord*. Madison, WI (June 2012).
6. L Justice, L Skibbe , *et al. J Res Reading*, 28, 229 (2005).
7. L Justice, C Lankford. *Comm Disord Q*, 24, 11 (2005).
8. A Roy-Charland, J Saint-Aubin , *et al. Read Writ*, 20: 909 (2007).
9. M Invernizzi, A Sullivan, *et al. Phonological awareness literacy screening-PreK* (University of Virginia, Richmond, VA, 2004)
10. E Hill. *Spot's Birthday party* (Puffin Books, New York, NY, 2003).
11. E Hill. *Spot's Show and Tell* (Grosset & Dunlap, New York, NY, 2004).
12. L Justice, H Ezell. *American Journal of Speech-Language Pathology*, 9, 257 (2000).
13. L Justice, H Ezell. *American Journal of Speech-Language Pathology*, 11: 17 (2002).

Avinaash Korrapati is a student at Saint Francis High School in Mountain View, California, and participated in the Research Experience for High School Students Program (REHSS).