Electronic Story Book Display Method and Kindergartener Reading Behavior: An Eye-Tracking Investigation

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Abstract. If children could be enticed to pay more attention to the print area, it could help increase their print awareness and future reading ability. Along with the development of electronic technology, many books have changed to the electronic format, and storybooks are no exception. The purpose of this study was to understand which electronic storybook display method is best able to increase children's attention to the print area. To this end, we modified the electronic storybook's design and used an eye-tracker to measure children's visual attention during reading. The study included 76 children between the ages of 4–6 from two northern Taiwanese kindergartens. The kindergarteners were split into three groups: a traditional storybook group, the highlight synchronization group (implicit instruction), and the text-discussion group (explicit instruction). This study was conducted over a 6-week period: one week for pre-tests, four weeks of interventions, and one week for post-tests. The result of pre-test suggested that the northern Taiwanese children spent about 80% of their time looking at the picture area, and about 20% at the print area. The result of week 2, the first week of the intervention stage, showed that, when it came to visual attention invested in the print area, the highlight synchronization groups paid significantly more attention to the print area than the traditional storybook group.

Keywords: Electronic book · Literacy · Kindergartener · Shared book reading Eye movements

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1 Introduction

Shared reading is practiced regularly by many families and is seen as helping children's literacy and language development [1]. It's well documented that children aged between 0–6 years accumulate a great deal of knowledge of the written language. The term "emergent literacy" is used to describe all the literacy related knowledge (such as recognizing letters or words), skills (such as understanding words should be read in a certain direction) and attitudes (such as reading habits or affection for reading) that children acquire from birth to the age of six, including pre-school and kindergarten [2–5]. Emergent literacy and the reading ability of older children have a significant correlation [6–8], and the most effective way to improve emergent literacy is for children to directly interact with print. Shared reading is an excellent way to increase that interaction [9, 10].

This following sections will first define the concept of emergent literacy, then introduce the concept of print awareness and how it is related to emergent literacy and follow with how different strategies in shared reading can assist emergent literacy. Finally, this study will investigate the literature surrounding eye movement and emergent literacy to understand how children's eyes behave during shared reading.

1.1 Emergent Literacy

Emergent literacy refers to the reading-and-writing associated knowledge, skills, and attitudes that children have attained before entering formal education. Previous conceptions believed that reading-and-writing ability could only be gradually cultivated after children had entered formal education. Modern conceptions recognize that, contrasting with the above view, that the beginning of reading and writing development precedes formal training. From birth to school attendance, at home children engage in activities involving reading and writing. These activities develop the child's knowledge of language, reading, and writing, and are correlated with the child's later reading and writing ability. Therefore, reading and writing learning should not be relegated to formal education, and should instead be viewed as something that continuously develops from birth onward. Because this process begins before formal education in reading and writing, "emergent literacy" has come to refer to a child's reading and writing ability before any formal schooling on the topic has begun [2–5].

It is precisely because emergent literacy takes place before formal education and accumulates from daily life that knowledge of listening, speaking, reading, writing, and their associated activities and experiences have all become important concepts within emergent literacy [2, 5], and that all of them affect children's future ability to read.

1.2 Factors of Emergent Literacy

Emergent literacy includes a great deal of influential factors, such as oral language ability, phonological awareness, and print awareness [5, 8, 11]. Of these, the latter two will be discussed herein.

Phonological Awareness. What phonological awareness refers to is an individual's sensitivity to the structure of spoken language, associated knowledge, and the ability to use this knowledge to effectively manage written or spoken words [8, 11, 12] in ways such as by rhyming words or disassembling a word into several phonemes (such as breaking up "box" into the four sounds b-o-k-s). Previous research has found that phonological awareness and reading ability are highly correlated and, especially when compared to other reading and writing abilities, that phonological awarness especially requires purposeful training, and as such has received a lot of attention.

Print Awareness. Print awareness refers to a child's sense of the written language and its uses, including text structure (such as the concept that a book should have a title and author, or that books in English are read from left to right whereas books in Chinese may be read from top to bottom and left to right, etc.), knowledge of letters (which letters they recognize) and the understanding of how the spoken word and the written word relate to one another, et cetera. Substantial previous research suggests that print awareness can predict future reading ability [7, 13–15]. Adam [16] also found that a child's understanding of the form, function, and usage of print constitutes the basis of their future reading and writing ability.

Although the research demonstrating a beneficial link between a child's ability to perceive sound and their awareness of the written language to a child's future ability to read remains inconclusive, despite controlling covariates such as intelligence, family background, and language ability, phonological awareness itself remains highly correlated with children's reading performance. However, this does not mean phonological awareness is more important than written language knowledge. The National Reading Panel, which reviews the effectiveness of various reading instructional methods for children, found in 2000 that phonological awareness must be taught at the same time as letter knowledge to improve emergent literacy [17].

Although children acquire their emergent literacy through many informal learning methods, shared reading is considered to be a key factor in promoting the cultivation of reading and writing. This is likely because shared reading does not only include print, but also provides an opportunity for social interaction. It could also be because shared reading uses picture books that simultaneously display pictures and print.

1.3 What Children Look at During Shared Reading

The comprehension process while reading storybooks that inherently contain text and figure information, as opposed to traditional pure text reading, is more complicated. To date, the eye-movement methodology has successfully applied to reveal the moment-to-moment activity of the mind and to provide valuable insight into readers' visual attention while learning from online text [18], science text [19] or mathematics [20]. The emergent literacy research field is no exception [21–24].

However, recent studies have discovered that preschool children spend most of their reading time attending to the picture area, rather than to the print area, of storybooks during shared reading. Only about 5% of their reading time is spent looking at the print area [21–24].

Evans and Saint-Aubin [21] examined children during a shared storybook reading experience. They changed the picture book into an electronic format and displayed it on

a computer screen, and then invited five children aged 4–5 to participate in shared-readings of that storybook. Meanwhile, the researchers used an eye tracker to record the children's eye movements. The researchers used three types of picture book layouts. The first had print on the right side and pictures on the left. The second had print and pictures on every page, with print in the upper-and-bottom-most parts of the page. The third put the print in word bubbles on top of the pictures. During shared reading, the child's parent read the content of the picture books out loud for their child and were not allowed to skip or reread a page. The results showed that children spent the vast majority of their time looking at the pictures, and only spent about 6% of their time looking at the print. Even with print embedded in the pictures in the third layout, the proportion of time children spent viewing the print remained quite small.

Justice et al. [23] used two types of children's books, one emphasizing its text (print-salient) and one emphasizing its pictures (picture-salient), as their reading materials, and used an eye tracker to measure the children's visual attention. They took 10 five-year-olds and read both book types to the children. They found that although the visual attention of the five-year-olds of the print increased when reading the print-salient books as compared to when they read the picture-salient books, it still only totaled about 7% of the time spent viewing print.

Examining Chinese reading, Lai and Chen [25] used Chinese picture-books for their research. They recruited 12 4–5-year-olds and had read each five different book formats. Their results were similar to Evans [21] in that they found that children, when reading, spent the vast majority of their time attending to the pictures, and again spent only about 6% of their time looking at the text. They also found that 4- and 5-year-olds had no significant differences in their visual attentiveness to the text: They all gazed at the pictures at least ten times as long as the text. The results of this study also showed that children paid more attention to text when the pictures were black and white rather than in color, and that making the text more salient in appearance did nothing to entice the children to look at it more.

1.4 Print Referencing Strategies

If children could be enticed to pay more attention to the print area, it could help increase their print awareness and future reading ability. For example, Evans, Shaw, and Bell [26] believed that typical shared reading by family members only tended to increase a child's oral language ability and did not affect the child's ability to written language. They suggested that if parents wanted shared reading to increase the child's print knowledge, that they would have to use a print referencing strategy to guide the attention of children to the print, the names of the letters, how the letters are pronounced, and engage the child in a discussion of the text. By doing so, shared reading could develop the reading and writing skills of the child.

Evans et al. [27], researched how the "pointing" and "no-pointing" methods of shared reading differently affected 3–5 year-olds, and found that if, during shared reading, there was only reading (no-pointing), that children attended to the text at most 2% of the time; if, instead, they read and named the words (pointing) all three age groups significantly increased their attentiveness to the text. Among them, the 4-year-old children in the pointing and no-pointing groups demonstrated significantly better performance on

subsequent text recognition tests over their comrades in the pure reading group. Evans et al. [27] recommended that during shared reading parents point at the words they are reading to let children become accustomed to their language's print conventions, and to entice children to look at words so they observe, name, and learn vocabulary.

Justice et al. [4] studied how adult guidance, either silent or audio-visual, affected the visual attention of children during shared reading. They recruited 44 children for an experiment where the children separately engaged in the shared reading of four storybooks. The children were divided into four groups: Pure reading, picture discussion, print discussion, and pointing. Each group was further equipped with eye-tracking hardware to measure the visual attention of the children. The results showed that the children spent about 6% of their time attending to the print, though when adults, through explicit verbal or nonverbal indicators, guided the children to pay attention to the text the children spent significantly more time attending to the print.

Roy-Charland et al. [28] recruited 36 children for a shared reading experiment, of which 10 were pre-school children, 14 were first graders, and 12 were second-graders. They selected 6 published French picture books for modification, making 3 of the books "easy" and 3 of the books "difficult." They found that preschoolers spent about 5% of their time viewing the print. First graders instead spent about 26% of their time looking at the easy books attending to the print, whereas they only spent about 16% of their time attending to the print while reading the difficult books. Meanwhile, the second graders spent about 38% of their time looking at the print. No matter their age, the vast majority of their time was spent looking at the pictures. They also separated the children into different strategy groups: pure reading, pointing, and highlighting. They found that, during shared reading, that when using a print reference strategy to help children, overall, that pointing at the print significantly increased the amount of visual attention paid to the print.

In summary, shared reading can increase children's phonological awareness and print awareness, promoting emergent literacy. However, if parents want to optimize shared reading for bolstering print knowledge, they must use a print referencing strategy to coax children to pay attention to the print and participate in discussions of the print.

Along with the development of electronic technology, many books have changed to the electronic format, and storybooks are no exception. To increase the reading and writing skills of children, many electronic storybooks have also began implementing print referencing strategies, such as pointing, highlighting, or having a bouncing ball or other multimedia focus the attention of the children on the text. For example, Guo and Feng [29] found that during shared reading if the child could follow their father's reading trajectory, then the child was able to read the story on the screen along with their parent, and doing so increased the child's overall participation in the shared reading.

2 Purpose

The purpose of this study was to understand which electronic storybook display method is best able to increase children's attention to the print area. To this end, we modified the electronic storybook's design and used an eye-tracker to measure the children's visual attention during reading.

3 Method

This study included 76 children between the ages of 4–6 from two northern Taiwanese kindergartens. Informed consent was obtained from all preschoolers' parents. Their native language was Mandarin Chinese. Before the experiment was conducted, questionnaires were distributed to evaluate the children's reading conditions at home. This study was conducted over a 6-week period: one week for pre-tests, four weeks of interventions, and one week for post-tests. The kindergarteners were split into three groups: a traditional storybook group (group 1), the highlight synchronization group (implicit instruction; group 2), and the text-discussion group (explicit instruction; group 3). Each group had 25, 25, and 26 children, respectively. The difference in each group lied in how these storybooks were displayed during the intervention stage: In the traditional storybook group, the print was simply read aloud by a recording, synchronized with the displayed page. In the highlight synchronization group, individual Chinese characters were highlighted in blue when they were being pronounced, thus implicitly teaching the children which Chinese characters were associated with which sounds. The text-discussion group added explicit instruction in the form of cuing to or discussions of the print. This study used six storybooks, each book included 16–17 pages. Half of the area of each page was picture area, and half was print area. Each child was individually presented with the same electronic storybooks. An experimenter sat next to each child during reading sessions but did not engage in shared reading. In the pre-test stage each child's print awareness and vocabulary were tested, and then all children read the same electronic storybook accompanied by its recording, meanwhile the eye-tracker was used to record how the children read their storybook. Then the 76 children were randomly assigned to the three groups, and their print awareness scores, vocabulary scores, and eye data were previewed to ensure there were no pre-existing differences between the groups. Weeks 2–5 were the intervention stage, with one session per week and two books read per session. Eye-tracking was conducted during the week 2 readings. The 6th week was the post-test stage, and, beyond merely reading an additional storybook, eye-tracking was added to the reading and post-tests (identical to the pre-tests) were administered to each child.

4 Results

For the ratio of total fixation duration (RTFD), please see Table 1.

A mixed design three-factor ANOVA was conducted on the time, area, and group variables to see their effect on RTFD, of those the time and area variables were considered as within subject variables, and group was considered as the between subject variable. The results indicate that the time variable had a significant effect ($F(1, 64) = 4.283$, $p = .043$, $\eta 2 = .063$). The RTFD of teaching period ($M = .491$, $SD = .304$) was significantly longer than the pre-test's RTFD ($M = .483$, $SD = .353$). The area variable had a significant effect as well ($F(1, 64) = 135.755$, $p = .000$, $\eta 2 = .680$). The picture area had a significantly longer RTFD ($M = .747$, $SD = .201$) than the text area's RTFD ($M = .227$, $SD = .200$). Group had no significant effect ($F(2, 64) = .693$, $p = .504$, $\eta 2 = .021$).

Table 1. Ratio of total fixation duration

		Group 1	Group 2	Group 3	Total
N		22	22	23	67
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Pre-test	Picture area	.786 (.228)	.757 (.196)	.774 (.192)	.773 (.203)
	Text area	.191 (.227)	.193 (.183)	.197 (.191)	.194 (.198)
Week 2 (intervention stage)	Picture area	.826 (.176)	.599 (.177)	.739 (.173)	.722 (.197)
	Text area	.155 (.176)	.387 (.179)	.238 (.173)	.260 (.198)

The time, area, and group variables all had significant interactions ($F(2, 64) = 27.001$, $p = .000$, $\eta 2 = .458$), and so a simple effects test was conducted ($F(1, 64) = 71.006$, $p = .000$, $\eta 2 = .526$). For teaching period, group and area had a significant simple effect ($F(2, 128) = 8.305$, $p = .000$, $\eta 2 = .115$). For picture area, group and time both demonstrated a significant simple effect ($F(2, 128) = 20.986$, $p = .000$, $\eta 2 = .247$). For text area, group and time both had significant simple effects ($F(2, 128) = 28.396$, $p = .000$, $\eta 2 = .307$).

For group 2, a further simple main effect test was conducted on the interaction between time and area. For group 2's pre-test, area had a significant simple main effect ($F(1, 128) = 48.920$, $p = .000$, $\eta 2 = .277$). The mean RTFD of the picture area ($M = .757$, $SD = .196$) was significantly longer than the text area's mean RTFD ($M = .193$, $SD = .183$). For group 2's teaching period, area continued to show a significant simple main effect ($F(1, 128) = 6.890$, $p = .010$, $\eta 2 = .051$). The picture area's RTFD ($M = .599$, $SD = .177$) was significantly longer than that of the text area's RTFD ($M = .387$, $SD = .179$). When it came to group 2's picture area, time had a significant simple main effect ($F(1, 128) = 52.495$, $p = .000$, $\eta 2 = .291$). The pre-test's RTFD ($M = .757$, $SD = .196$) was significantly longer than the teaching period's RTFD ($M = .599$, $SD = .177$). As for group 2's text area, time had a significant simple main effect ($F(1, 128) = 78.377$, $p = .000$, $\eta 2 = .380$). The pre-test's RTFD ($M = .193$, $SD = .183$) was significantly shorter than the RTFD of the teaching period ($M = .387$, $SD = .179$).

Due to the significant simple interaction between group and area under the teaching period condition, a simple main effect test was conducted. For group 1's teaching period, area had a significant simple main effect ($F(1, 128) = 69.272$, $p = .000$, $\eta 2 = .351$), and the RTFD of the picture area ($M = .826$, $SD = .176$) was significantly longer than the text area's RTFD ($M = .155$, $SD = .176$). As for group 2, area had a significant simple main effect ($F(1, 128) = 6.890$, $p = .010$, $\eta 2 = .051$), with the picture area's RTFD ($M = .599$, $SD = .177$) being significantly longer than the text area's RTFD ($M = .387$, $SD = .179$). As for group 3, area had a significant simple main effect ($F(1, 128) = 40.366$, $p = .000$, $\eta 2 = .240$), with the picture area's RTFD ($M = .739$,

SD = .173) significantly longer than the text area's RTFD (M = .238, SD = .173). For the teaching period's picture area, group had a significant simple main effect ($F(2, 256) = 8.011$, $p = .000$, $\eta 2 = .059$). A post-hoc analysis using Scheffe's test was run and found that group 1's RTFD (M = .826, SD = .176) was significantly longer than group 2's RTFD (M = .599, SD = .177; $p < .001$), and group 3's RTFD (M = .739, SD = .173) was longer than group 2's RTFD ($p < .05$). As for teaching period's text area, group showed a significant simple main effect ($F(2, 256) = 8.381$, $p = .000$, $\eta 2 = .061$). A post hoc Scheffe's test was conducted and revealed that group 2's RTFD (M = .387, SD = .179) was significantly longer than group 1's RTFD (M = .155, SD = .176; $p < .001$), and group 2's RTFD was significantly longer than group 3's RTFD (M = .238, SD = .173; $p < .05$).

Due to the significant simple interaction between the time and group variables under the picture area condition, a simple main effect test was conducted. For group 2's picture area, time had a significant main effect ($F(1, 128) = 52.495$, $p = .000$, $\eta 2 = .291$). The pre-test's RTFD (M = .757, SD = .196) was significantly longer than the teaching period's RTFD (M = .599, SD = .177). As for the picture area of the teaching period, group had a significant simple main effect ($F(2, 256) = 8.011$, $p = .000$, $\eta 2 = .059$). A post hoc Scheffe's test was run and found that group 1's RTFD (M = .826, SD = .176) was significantly longer than group 2's RTFD (M = .599, SD = .177; $p < .001$), and group 3's RTFD (M = .739, SD = .173) was significantly longer than group 2's RTFD ($p < .05$).

Due to the significant simple interaction between time and group under the text area condition, a simple main effect test was conducted. For the text area of group 2, time had a significant simple main effect ($F(1, 128) = 78.377$, $p = .000$, $\eta 2 = .380$). The pre-test's RTFD (M = .193, SD = .183) was significantly shorter than the RTFD of the teaching period (M = .387, SD = .179). As for the text area of the teaching period, group had a significant main effect ($F(2, 256) = 8.381$, $p = .000$, $\eta 2 = .061$). A post hoc Scheffe's test demonstrated that group 2's RTFD (M = .387, SD = .179) was significantly longer than group 1's RTFD (M = .155, SD = .176; $p < .001$), and group 2's RTFD was significant longer than group 3's RTFD (M = .238, SD = .173; $p < .05$).

5 Conclusion and Discussion

The result of the pre-test suggested that the northern Taiwanese children spent 77.3% of their time looking at the picture area, and 19.6% at the print area. This is substantially higher than the findings of previous research. Meanwhile, the result of week 2, the first week of the intervention stage, showed that, when it came to visual attention invested in the print area, the highlight synchronization groups paid significantly more attention to the print area than the traditional storybook group. Any number of factors could explain the difference between our result and previous research, such as native language, nationality, socioeconomic status, and at-home reading habits, to name a few. Future research is necessary to explain this discrepancy. Meanwhile, this study did not examine the literacy skills of the children, and thus it is impossible to know whether the children's literacy skills influenced the amount of visual attention paid to the print

area. Future research could add such measures to see if there is any relationship between the two. Follow-up research could also track the children two years later to examine the children's reading literacy. Due to the week 2 results, we recommend future electronic-storybook designs should not adopt a pure-speech reading design, and instead should synchronize the reading of the words with dynamic highlighting and add direct discussions of the text. Doing so will help to entice children to pay more attention to the print area.

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