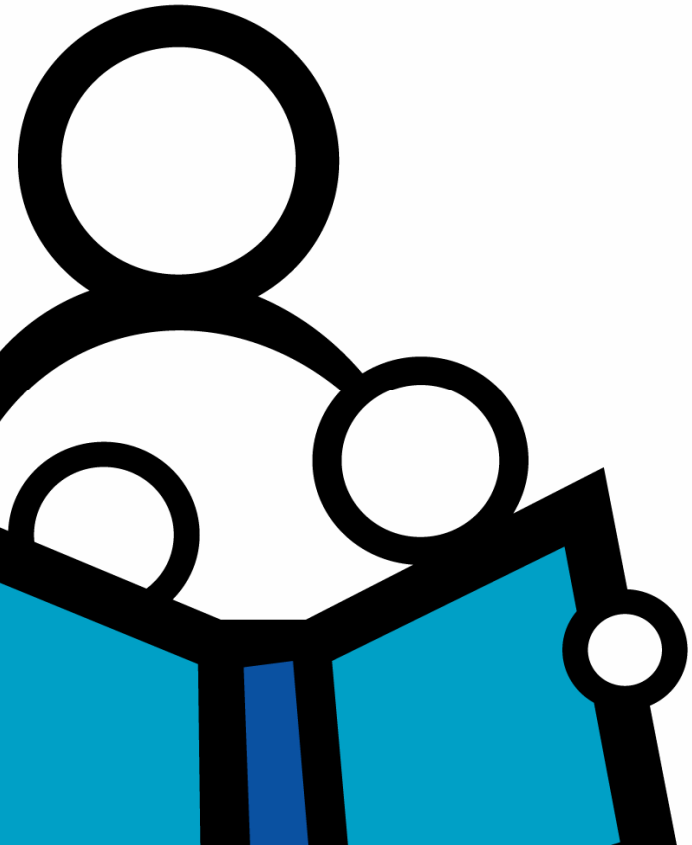
Complexity, Movement, and Text Familiarity: Correlates of Visual Attention to Onscreen Print



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Introduction

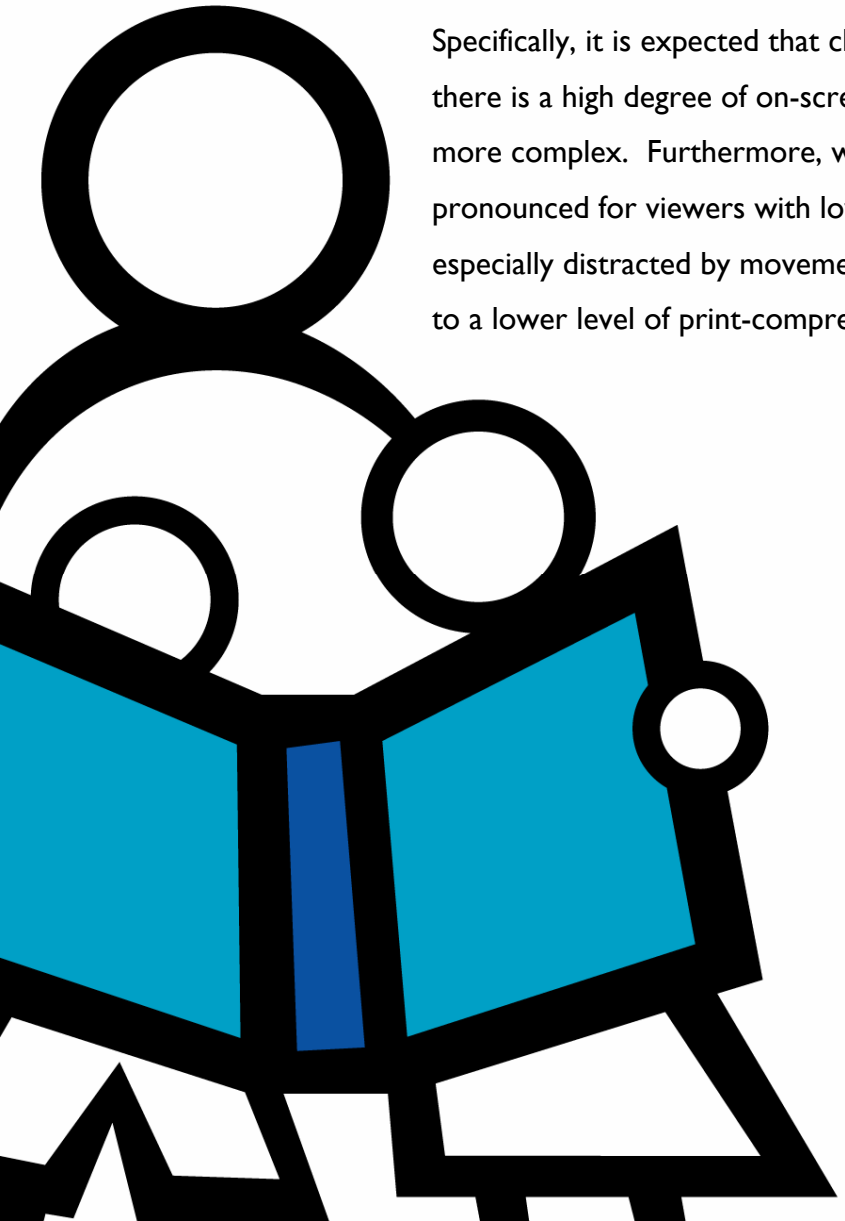
Research indicates that educational television can be a valuable tool in building children's language and literacy skills (Linebarger, Kosanic, Greenwood, & Doku, 2004; Linebarger, 2001). A common technique among educational television programs is to include text on the screen, enabling visual redundancy of words as they are spoken aloud. Although this is a popular practice, there is a general lack of research regarding what factors influence children's attention to onscreen text, and the degree to which their attention to the text impacts literacy and comprehension. The present study uses eye-tracking techniques to examine children's visual attention to text in the presence of other visual stimuli and movement on screen.

A viewer's visual attention to television is influenced by a variety of factors involving both the child and the medium. In particular, formal features of the medium (e.g., movement, auditory intensity, pans and zooms) play an important role in capturing children's attention (Bickham, Wright & Huston, 2001). The movement of onscreen stimuli, one example of a formal feature, attracts a viewer's attention due to its salient perceptual characteristics (Calvert et al., 1982; Berlyne, 1960).

Individual aspects of the child viewer also help to guide what she attends to on the screen. In the case of onscreen text, comprehensibility, determined by text-familiarity, may play a role. The traveling lens model, developed by Huston and her colleagues, predicts a viewer's interest arousal as a function of level of comprehension of the stimulus (Rice, Huston & Wright, 1982). The shape of the model is an inverted U, where peak attention is predicted when the stimulus is perceived as

moderately novel and of intermediate complexity. Decreased attention, then, occurs when the material is overly familiar and easy for the viewer, or, conversely, too novel and complex (see Figure 1).

The present study explores visual fixation to text on screen by five- and six-year-old children with varying levels of text-familiarity, while viewing a segment from *Between the Lions*. Specifically, average fixation durations, as well as the percent of time fixated on text during scenes containing high and low text complexity, and high and low non-textual onscreen movement are examined. The combination of characteristics of the individual viewer (familiarity with text) and the stimulus (complexity of text and degree of non-textual onscreen movement) should influence a viewer's attention to text in the presence of other onscreen stimuli. Specifically, it is expected that children will attend less to print when there is a high degree of on-screen movement or when the words are more complex. Furthermore, we expect these trends to be particularly pronounced for viewers with low text-familiarity, who are likely to be especially distracted by movement and deterred by text-complexity due to a lower level of print-comprehensibility.



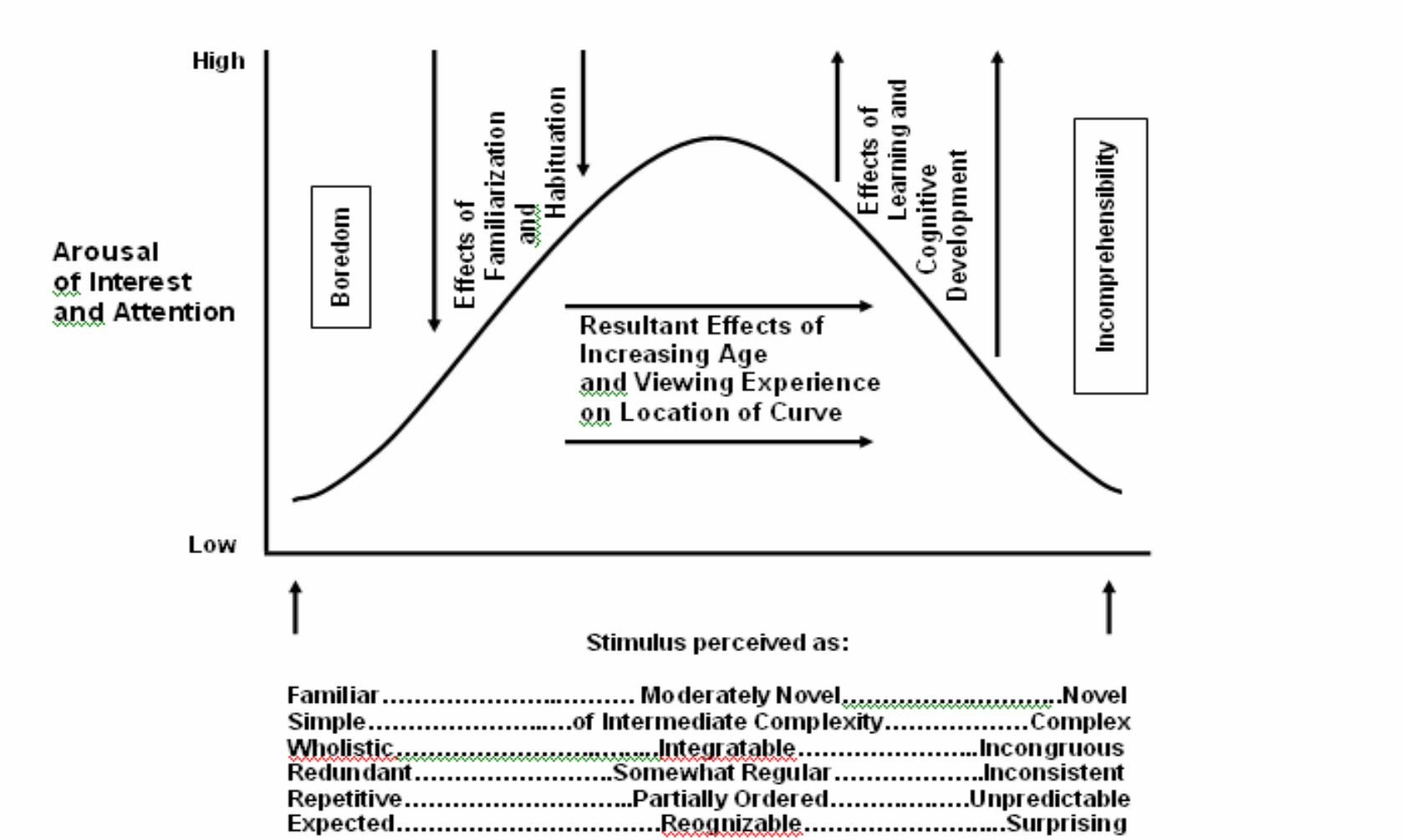


Figure 1. Traveling Lens Model (Rice et al., 1982)

Method

Research Design

This study employed a mixed design. The between-subjects factor was parent's education (3 levels; high school; some college; college degree or higher). Within-subjects factors included onscreen movement (2 levels; high, low), complexity of onscreen text (2 levels; high complexity, low complexity), and scene placement (4 levels; 1st scene, 2nd scene, 3rd scene, 4th scene).

Stimuli

We examined children's attention to a clip from the children's educational television series *Between the Lions* (BTL). *BTL* follows a whole-part-whole approach to instruction in early literacy. This approach establishes a meaningful context for learning, and then guides kids to explore specific details such as text structure, individual words, and other print features (Strickland, 1998). The whole-part-whole sequence for each episode begins with a story, poem, or other form of text that the Lion family reads together. In the chosen clip, the older brother puppet, Lionel reads a story titled "Shooting Stars" about a family of lions who watch a meteor shower together. The book-reading-portion of this clip consists of 16 pages or scenes. Each scene contains both text and animation related to the text. The text is comprised of one or two lines placed in the top left or bottom left of the screen.

Scene Characteristics

Each of 16 scenes was coded for onscreen movement and text complexity. Onscreen movement was determined by the percentage of the screen that was moving; the movement velocity; and the amount of panning and zooming. Text complexity was determined by using the Automated Readability Index (ARI). The

ARI provides an approximation of the United States grade level needed to comprehend the text and is based on the number of characters per word and the number of words per sentence found in each scene. ARI is highly correlated with the Flesch index of readability.

Eye-Tracking Apparatus and Software

Children's eye movements were measured using the *Eye Movement Data Collection System*, an Applied Science Laboratories (ASL) Model 504 with a magnetic head tracker, which captures x and y eye- position coordinates. *Gazetracker*™ software interprets these parameters, allowing researchers to identify where on-screen a subject is looking at any given point in time and how long each "look," or fixation, lasts. Gazetracker™ was also used to create LookZones, or specific, on-screen regions of interest (as defined by the researcher). The software then calculates the amount of time a subject's gaze is within a given LookZone or collection of LookZones. These zones thus provide a means of determining the extent to which subjects visually attend to relevant program features and allow comparisons to be made between these features (e.g., do children pay attention to print onscreen and does this attention differ by differing scene characteristics). In the present study, LookZones were created around the text in each scene of the stimulus clip.

Participants

Participants were 17 children in kindergarten and first grade (mean age = 6.00 years, SD = .62 years; 8 boys, 9 girls) living in the greater Philadelphia metropolitan area. Accompanied by parents, children participated in the assessments and eye tracking sessions in our laboratory. Parents completed a questionnaire covering demographic information, their perceptions of media, and their child's experience with media. Fifty-three percent of the children were European American, 41% were African American, and 6% were from other

backgrounds. Parental education varied from 11 years to 20 years; 56% had at least a 4-year degree (mean years of education = 15.12 years, SD = 3.60 years) while 25% reported a high school diploma or less. Parents reported that their children watched an average of 12 hours of television per week (SD = 11.79 hours), slightly higher than recent national averages (8.2 hrs; Rideout et al., 2003).

Measures

Demographic Information

Parents reported their years of formal education. We then averaged both father's and mother's education to create a composite number of years of education. This variable was re-coded into high school or less (n = 5), more than high school but less than bachelor's degree (n = 6), and bachelor's degree or higher (n = 6).

Eye Movement Parameters

Eye-tracking parameters associated with the text onscreen provide a more detailed measure of children's visual attention to the clip. These were obtained by calculating the amount of time children spent looking at the LookZones around each scene's text. We identified the average fixation duration and the percent time fixated on print associated with each of 16 scenes. Fixations occur when the eye is oriented and steady over a particular area of interest onscreen. Generally, a fixation occurs at locations or features of the stimulus that are perceived as more salient to the child compared with other onscreen locations or features. Therefore, percent time fixated reflects the percentage of time children spent looking at the text in each scene. The average length or duration of a child's fixations within a pre-determined LookZone is a measure of processing difficulty (Goldberg & Kotval, 1999). Longer average fixation durations indicate increased effort at processing the onscreen content. Finally,

the eye track equipment occasionally lost a subject's eye, resulting in short periods of time where eye-position data was unavailable (e.g., if a child moves his or her head very quickly, the system may briefly lose track of the child's eye). In the present study, data loss was minimal (M = 7.35%, SD = 7.23).

Procedure

After institutional review board approval was obtained from the University of Pennsylvania, parental consents forms were delivered via word of mouth techniques to parents of children in our target age. Once parental consent was received, parents were called to schedule an appointment to bring their children to our eye tracking laboratory. While parents were completing a detailed questionnaire, we met with children to lead them through a series of pre-tests including a literacy task and another task related to their knowledge of gender (not reported here). Upon completion of these two pre-test measures, children were seated before the viewing monitor, and a head band with a small sensor was placed around their heads. The children then viewed a 2-minute video clip featuring flowers taken from the educational television program *Bill Nye the Science Guy*. During this time, we "captured" the child's eye with our eye tracking equipment. Then, each child was led through an eye calibration procedure where they were asked to look at nine points on the screen (i.e., top far left, middle top left, top far right; middle far left, middle, middle far right; bottom far left, bottom middle, bottom far right). After this calibration was completed, the experimental stimulus was shown. Once the video was completed, the child was removed from the monitor and asked a set of comprehension questions (not reported here). The session then ended. Sessions lasted approximately 45-50 minutes. Breaks were given if needed; however, for the most part, because the session was grouped into pre-test, viewing, and post-test, fatigue and disinterest did not appear to affect any of the results. When all procedures were completed, children were able to choose bookmarks for their participation. Parents were given travel/parking reimbursement and a small gift card for their time.

Analytical Approach

We computed 3 (Parent's Education) x 2 (Text Complexity) x 2 (Onscreen Movement) x 4 (Scene Placement) repeated measures ANOVAs with repeated measures on the last three factors to examine Average Fixation Durations (AFD) and Percent Time Fixated (PTF) associated with viewing the onscreen print. Given the small sample size and the large effect sizes, we determined that effects at $p < .10$ were significant.

Results

Average Fixation Duration to Onscreen Text

There was a significant 3-way interaction among movement, text complexity, and scene placement[1]. There were significant two-way interactions between text complexity and parent's education[2]; movement and text complexity[3]; and movement and scene placement[4]. There was also a main effect of text complexity[5].

In general, AFDs averaged 0.38 seconds. Over time, AFDs tend to decline. This decline is particularly noteworthy when both movement and text complexity are high (See Figure 1). Conversely, when text complexity is low and movement is high, AFDs are generally maintained across scenes. When text complexity is low and movement is low, AFDs appear more idiosyncratic; that is, there is no consistent pattern over time. Instead, AFDs decline until the last scene, when they recover to levels similar to the first scene.

[1] $F(3, 12) = 3.01$, $p < .072$, $\eta^2 = .43$
[2] $F(2, 14) = 3.26$, $p < .069$, $\eta^2 = .32$
[3] $F(1, 14) = 4.43$, $p < .054$, $\eta^2 = .24$
[4] $F(3, 12) = 3.04$, $p < .071$, $\eta^2 = .43$
[5] $F(1, 14) = 6.40$, $p < .024$, $\eta^2 = .31$

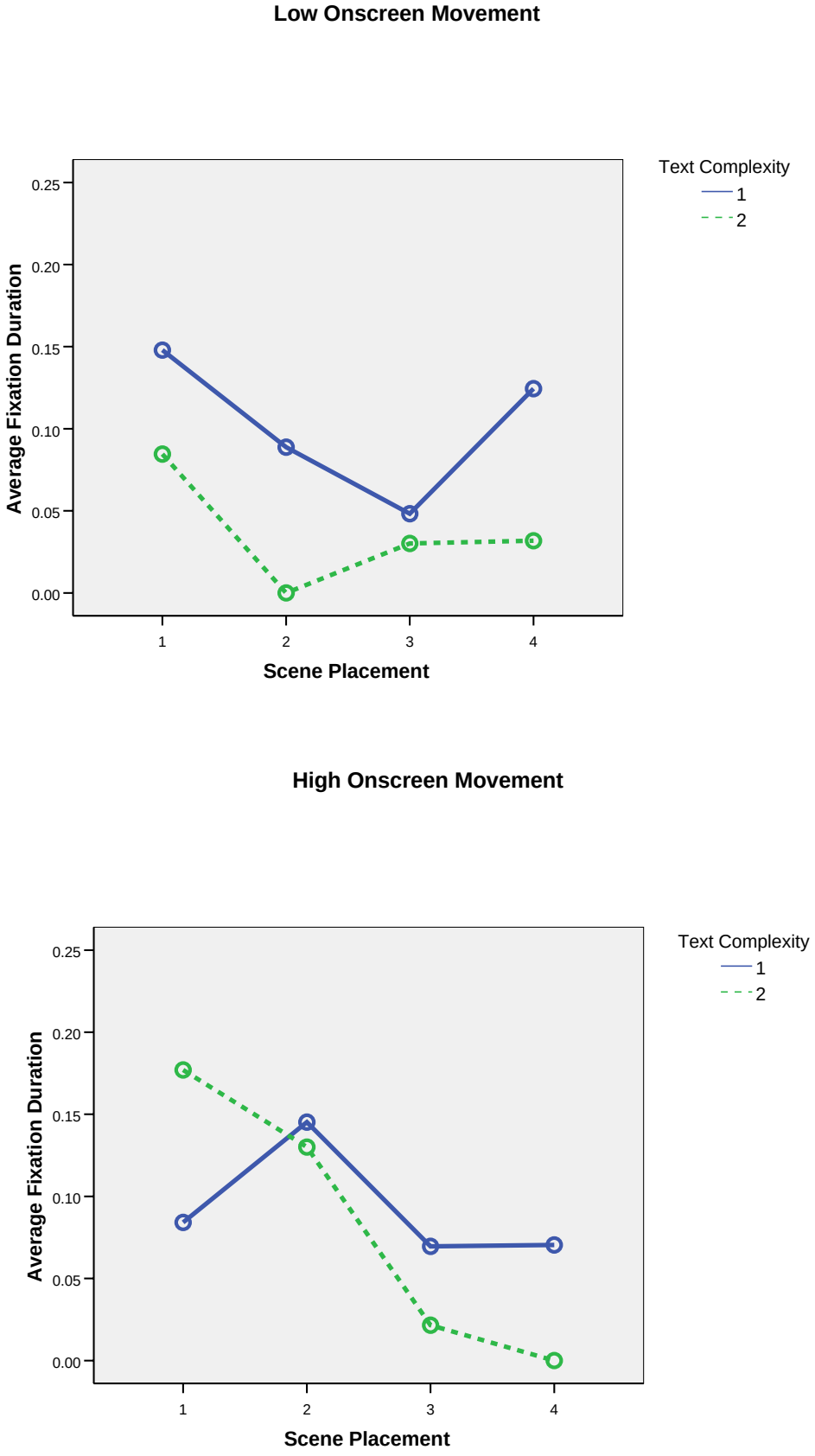


Figure 2. Three-Way Interaction among Movement, Text Complexity, and Scene Placement

The results are further complicated by parental education. Children with college-educated parents fixate onscreen print for longer periods of time when compared with children whose parents are less educated. AFDs are substantially higher for these children when text complexity is low (see Figure 2).

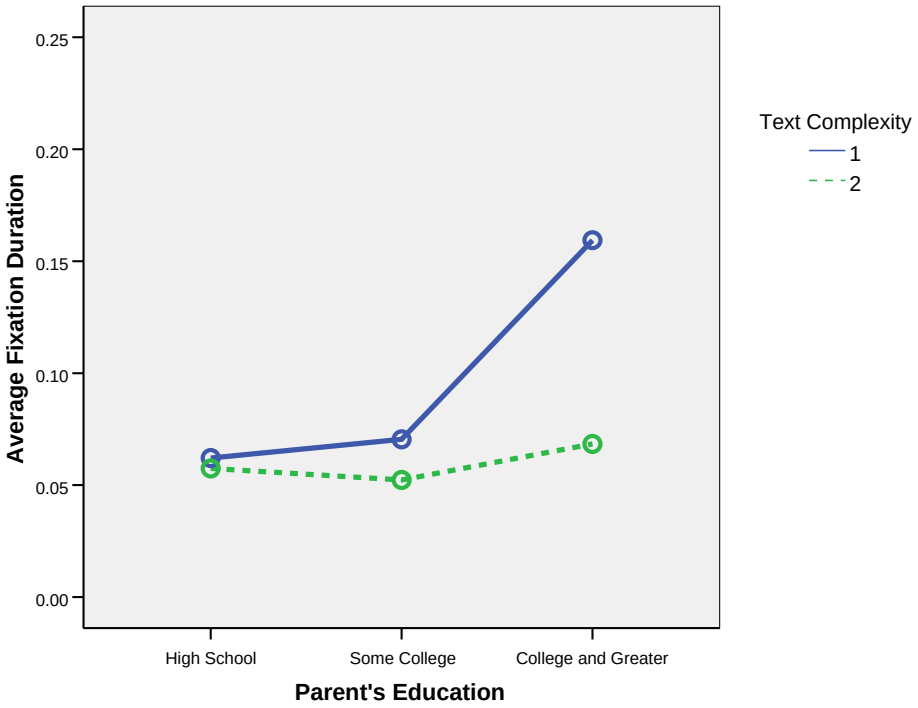


Figure 3. Text Complexity by Parent's Education

Finally, when examining only movement and text complexity, AFDs demonstrate less decline in scenes with high movement regardless of text complexity (see Figure 3). However, when there is less movement onscreen, children spend significantly longer fixating onscreen text when text complexity is low compared with when text complexity is high.

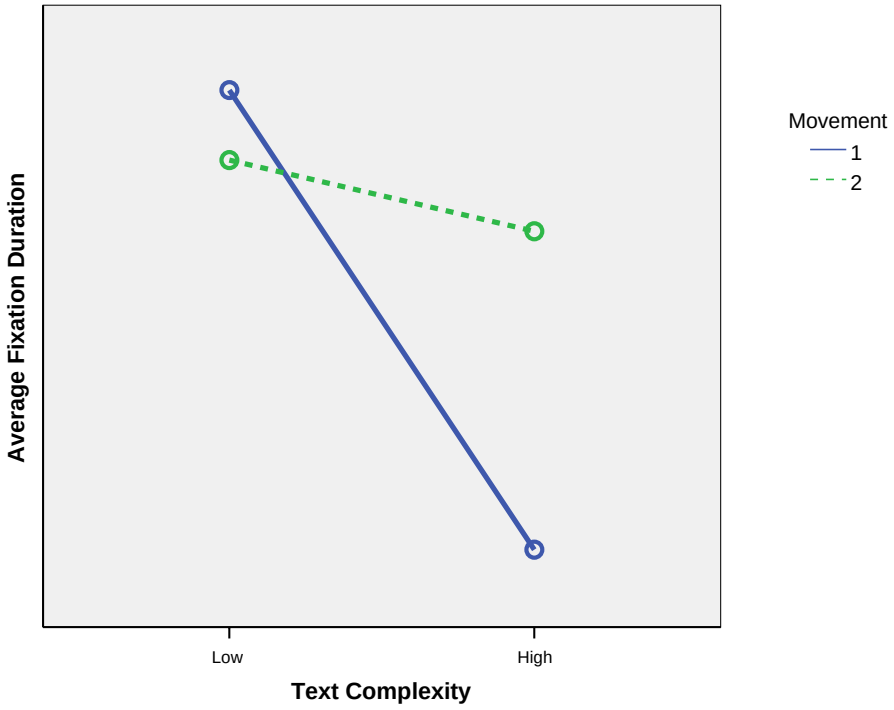


Figure 4. Text Complexity by Movement

Percentage of Time Fixated on Onscreen Text

There were significant two-way interactions between movement and text complexity[6]; and movement and scene placement[7]. There were also main effects of text complexity[8] and scene placement[9].

PTF declines from scenes with low text complexity to scenes with high text complexity as well as across scenes. PTF tends to be more stable in situations of high movement compared with low movement scenes. Although low text complexity scenes garner the most PTF, the decline in PTF is quite dramatic when low movement scenes are coupled with high text complexity (i.e., 20% decline compared with 5% decline).

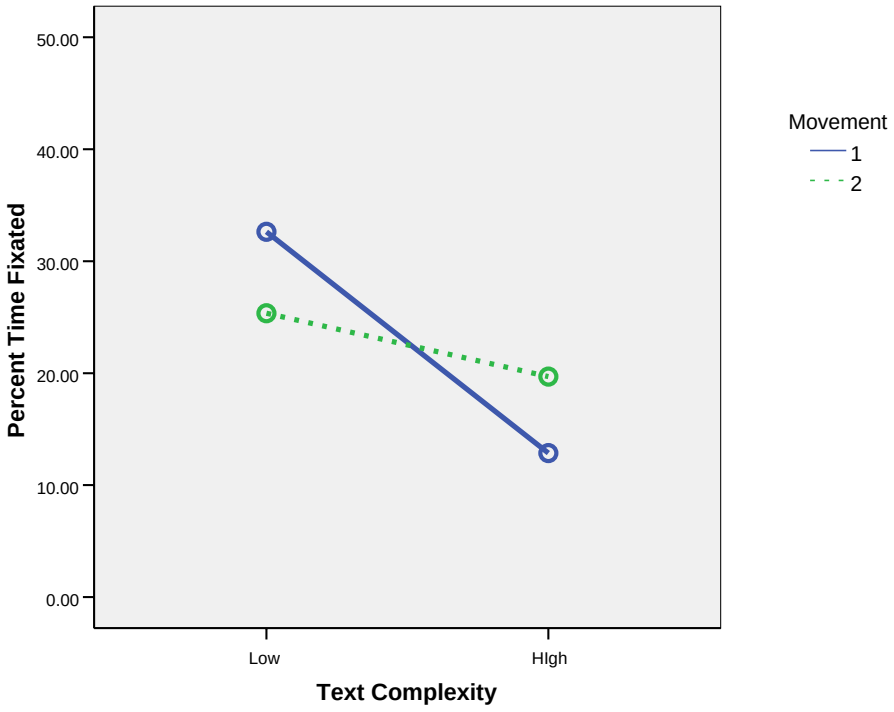


Figure 5. Movement by Text Complexity

[6] $F(1, 14) = 4.43$, $p < .054$, $\eta^2 = .24$
[7] $F(3, 12) = 3.04$, $p < .071$, $\eta^2 = .43$
[8] $F(1, 14) = 9.06$, $p < .009$, $\eta^2 = .39$
[9] $F(3, 12) = 2.62$, $p < .099$, $\eta^2 = .40$

Movement also plays a role in PTF across scenes. In high movement scenes, PTF stays high for the first two scenes, and then drops precipitously. In contrast, PTF drops quite suddenly from the first low movement scene to the second, but recovers to roughly half of the scene 1 PTF for scenes 3 and 4.

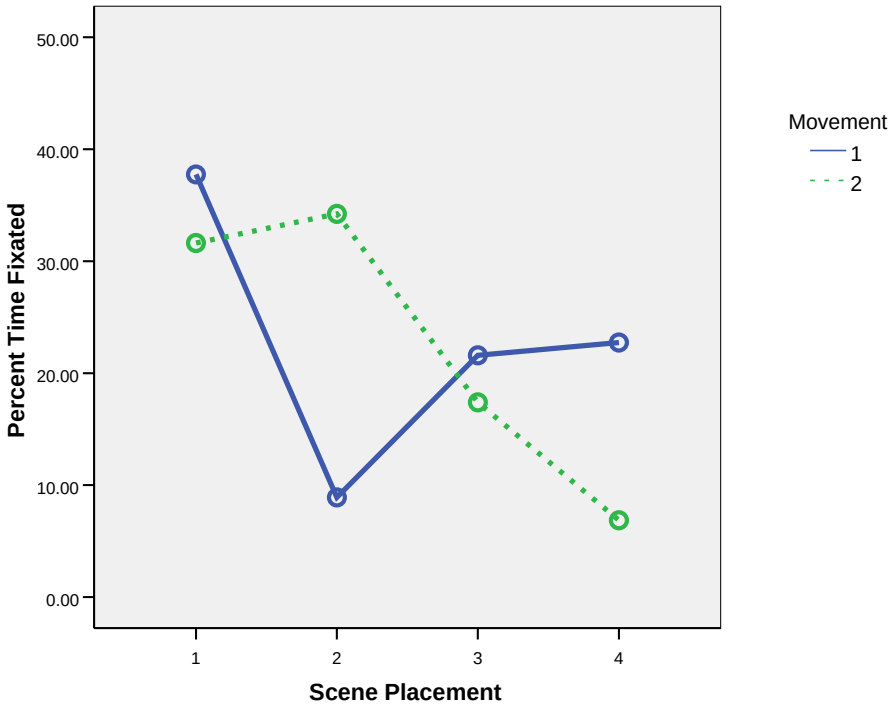


Figure 6. Movement by Scene Placement

Discussion

The findings suggest that the degree of onscreen movement and text complexity are particularly influential on children's visual attention to onscreen text. Specifically, most children in this study spent little time fixating text (i.e., about 23% of fixations were to print onscreen) and, when fixated, looks tended to last approximately 0.38 seconds, (Note. AFDs were fairly small because the many zero scores when, a child did not fixate the onscreen print pulled the means down). Furthermore, children's attention to print declined over time, suggesting that the stimulus was not effective in sustaining the child's attention. We found similar results when tracking attention over an entire episode of *BTL* (Wainwright & Linebarger, 2007). It may be important to include particular salient perceptual features (e.g., change the highlighting of the text, change the font type or size, animate the text or have it slide in from offscreen) that are able to re-direct children's attention to the onscreen print.

When scenes featured low levels of movement, looks tended to last longer but only for children whose parents were well-educated, suggesting that these children were working harder to process the text compared with other children and in scenes where there was a good deal of movement. Moreover, these children showed only slightly better attention compared with children whose parents were less educated when the text was more complex. Previous research indicates that children whose parents are more educated tend to have increased access to books and magazines than those with less-educated parents (Linebarger et al., 2004). In this study, all children whose parents had more than a high school diploma had more than 40 books in the home and spent fewer hours per week watching television (i.e., 8.2 hours versus 10.2 hours). In contrast, those whose parents were less educated tended to have fewer than 40 books in the home. The "print-rich" environments of the more educated families may place emerging readers on a more desirable literacy trajectory, leading to

increased familiarity with text and the resulting prolonged time spent looking at print on screen, just as the traveling lens model would predict (Rice et al., 1982).

Future research should examine the effect of repeated program exposure on children's visual attention to print on screen. Other research has found that young children show increased comprehension gains from repeated exposure to educational programming (Crawley et al., 1999). Thus, repeated exposure to television content that features onscreen text may be a particularly effective learning tool for children from low print-rich environments.

Finally, we expect that increased visual attention to text enhances children's literacy skill development. However, the direct effects of attention to on-screen print on literacy skill development were not assessed in this study. We have evidence that viewing *BTL* over time is associated with literacy gains although we do not have an index of attention in that study (Linebarger et al., 2004). The next step in this research will be to determine the extent to which such attention yields literacy skill gains for young emergent readers.

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