The Optimal Amount of Visuals Promotes Children's Comprehension and Attention: An Eye Tracking Study

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Abstract

This preregistered study examined whether extraneous illustration details promote attentional competition and hinder reading comprehension in beginning readers. Reading comprehension was highest in the Streamlined Condition (text + relevant illustrations) compared to a Standard Condition (text + relevant illustrations + extraneous illustrations) and Text Only Condition (no illustrations). Gaze shifts away from the text were highest in the Standard Condition, indicating increased distractibility while reading text with extraneous illustration details. Gaze shifts away from the text were associated with performance on an independent measure of attention, validating eye gaze patterns as an assessment of attentional allocation while reading. Lower comprehension in the Standard Condition was associated with higher gaze shifts away from text and lower scores on the independent measure of selective attention. This study suggests that illustrations can support reading comprehension, but only when they are optimally designed. Importantly, the removal of extraneous details did not decrease book enjoyment.

Keywords: attention; reading; reading comprehension; illustrations; eye tracking; book design

Introduction

Learning to read is a critical skill because *learning-to-read* makes it possible for children to begin *reading-to-learn*. Many children struggle to learn to read for a number of reasons, such as neurodevelopmental disorders, lagging pre-reading skills (e.g., phonological awareness), and vulnerabilities in general cognitive functioning (e.g., Dykman, & Ackerman, 1991; Jacobson et al., 2011; Melby-Lervåg, Lyster, & Hulme, 2012). A recent study focused on one malleable factor that may support or hinder children's reading development, namely the design of reading materials (Eng, Godwin, & Fisher, 2020). Specifically, instructional materials designed for children's reading practice often include extraneous illustrations (also known as seductive details): illustration details intended to be entertaining but unrelated to the plot of the story (Harp & Mayer, 1998).

Extraneous details have been found to reduce recall and comprehension across a diverse array of instructional contexts and mediums including scientific texts (Lehman, 2007), lectures (Harp & Maslich, 2005), and online lessons (Sanchez & Wiley, 2006). According to Cognitive Load Theory, extraneous material may reduce available cognitive resources that can be dedicated to the primary task thus disrupting performance and learning (Kirschner, 2002; Sweller, 2005). Related work on multimedia design suggests that dividing attention between images and text (Split-Attention Principle) and processing extraneous or irrelevant information (Coherence Principle) can significantly reduce comprehension (Clark & Mayer, 2012; Fenesi, Kramer, & Kim, 2016). While there is extensive research examining the design of educational materials for adult learners, who are in most cases proficient readers, more research is needed examining the design of instructional materials for children who are still learning-to-read.

Although extraneous details are potentially engaging, these embellishments may distract children from the primary task of reading and comprehending the story as objects in the environment compete for representation in the visual cortex and working memory (Beck & Kastner, 2009; Downing & Dodds, 2004). If extraneous illustration details promote attentional competition between images and text, beginning readers may struggle to resolve this competition due to both immature goal-directed attention regulation (Fisher & Kloos, 2016) and still developing reading skills. If extraneous illustrations promote attentional competition, children may increase gaze shifts away from text, which could result in encoding irrelevant details into working memory and therefore decreased text coherence.

A substantial body of research suggests that the inclusion of extraneous illustrations in printed materials can lead to decreased learning and performance in adults (Harp & Mayer, 2008; Lehman et al., 2007). In contrast to this sizable body of research with adults who are *reading to learn*, relatively few studies have examined the role of design of

reading materials in performance of children who are *learning to read* (Coldstein & Underwood, 1981).

Recently, Eng and colleagues (2020) examined whether extraneous illustration details induce attentional competition and reduce reading comprehension in first and second grade children. The researchers used a commercially available book designed for reading practice at the first grade level. Children read the book in two conditions: a commercially available Standard Condition and a Streamlined Condition, in which extraneous illustrations were removed. Findings indicated extraneous illustration details promoted attentional competition (increased gaze shifts away from the text) and reduced reading comprehension. Furthermore, there was a negative relationship between children's looking behavior and reading comprehension: children who tended to make more gaze shifts away from text and were more likely to fixate on extraneous illustration details showed higher gains in reading comprehension when the extraneous details were removed.

The results of the Eng et al. (2020) study suggest that extraneous illustration details may induce attentional competition and reduce reading comprehension in beginning readers. However, in the Eng et al. study there was no independent measure of attention. As a result, it remains an open question whether the observed effects of book design on gaze behavior stem from children resolving attentional competition or other factors (e.g., motivational value of more engaging illustrations). Furthermore, the Eng et al. study did not include a no-illustration condition, making it impossible to estimate the potential value of including illustrations in printed materials for beginning readers.

This preregistered study aims to both replicate the findings of Eng et al. (2020) and address the aforementioned limitations by including (1) a no-illustrations condition and (2) an independent measure of attention. Additionally, the present study included measures of book enjoyment to examine whether removing extraneous illustration details may affect children's enjoyment of the book.

Method

Participants The study used a randomized block between-subject design with 117 children in grades 1-2 (M = 7.89 years, SD = 8.4 months; 58 females, 57 males, 2 unreported). Participants were blocked by reading proficiency level, grade, and classroom. Within each block, children were randomly assigned to read in one of the three book conditions: the commercially available Standard Condition (n = 40; text + relevant illustrations intermixed with extraneous illustrations, Figure 1A), the Streamlined Condition in which extraneous illustration details were removed (n = 39; text + relevant illustrations, Figure 1B), or a Text Only Condition (n = 38; no illustrations, Figure 1C).

Children's gaze shifts away from the text while reading were recorded with an eye tracker. Participants were recruited from schools in and around a Mid-Atlantic city in the United States. Signed consent was obtained from the parents of participants. The race and ethnicity information for the sample reported by the parents was as follows: 56.4% White, 18.8% African American or Black, 0.9% Latino or Hispanic, 0.9% South Asian or Indian American, 12.8% Multi-Racial, 9.4% reported as Other, and 0.9% unreported. The experimental protocol was approved by the University Institutional Review Board. Children were tested individually by researchers naive to the study hypotheses and given a small prize for their participation.

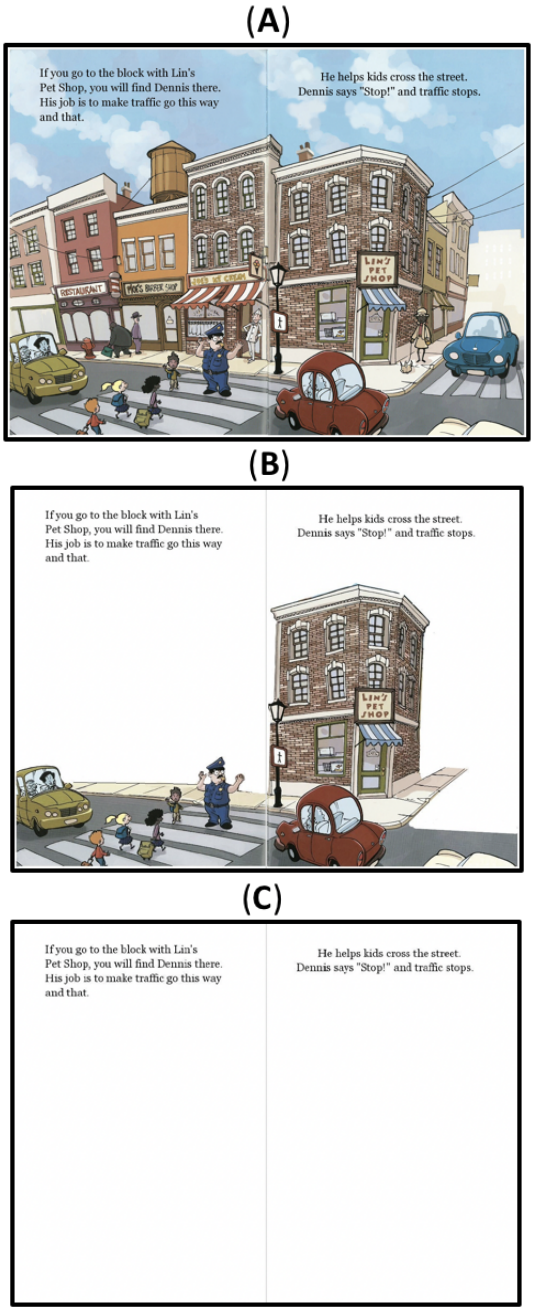

Figure 1**:** Sample pages in the (A) Standard condition, (B) Streamlined condition in which extraneous illustrations are removed, and (C) Text Only condition in which no illustrations are provided.

Design and Procedure

Predictions and analyses were preregistered on the Open Science Framework in advance, where the materials and protocols utilized in this study are available (Eng, 2020).

The Storybook Following Eng et al. (2020), children read a commercially available book designed for reading practice. The book, Good Job Dennis, is part of the "Hooked on Phonics®" curriculum for first grade ("Hooked on Phonics®" is a trademark of Sandviks HOP, Inc. This study is not sponsored or endorsed by Sandviks HOP, Inc.). The choice of reading material allowed us to maintain a high level of ecological validity. The book was displayed on a laptop computer and children engaged in guided reading with a trained researcher. Children read the book aloud and advanced through the 12 pages of the book in a self-paced fashion. Note that the book was lightly edited to reduce the length of the story to ensure that all participants could read the book in a single testing session. The testing sessions were videotaped with a Logitech C920 HD Pro Webcam. Illustration details were classified into Relevant and Extraneous illustration details using the same approach as described in Eng et al. (2020). In short, a group of adults who were fluent readers were presented with the commercially available version of the book and asked to outline the details in the illustrations they believed were relevant to the story. We considered the illustrations as Relevant when participants reached over 90% agreement in making this judgment; otherwise the illustrations were deemed Extraneous.

Measures of Attention and Enjoyment

Eye Tracking Eye gaze is a common measure of attention in a variety of settings and is a particularly appropriate measure in the context of reading (Rayner, Ardoin, & Binder, 2013). An SMI RED250 mobile eye tracker (SensoMotoric Instruments, Inc.) was used to measure children's eye movements while reading. On each page of the book, text, illustration, and white space Areas Of Interest (AOI's) were created. SMI BeGaze Eyetracking Analysis Software was then used to calculate gaze shifts away from the text AOI's and the average number of gaze shifts away from the text per page was then calculated.

Attention Task Children were administered a Conjunction Visual Search Attention task developed by Woods et al. (2013). Performance on this task has been found to be related to executive function and spatial attention, and is considered developmentally appropriate for children. This task displays 25 objects evenly distributed in a 5 × 5 rectangular grid (Display size: 330 × 205 mm; Total grid dimensions: 275 × 180 mm). The task contains 24 distractor objects comprised of either red squares with smiley faces (n = 11) or blue circles with smiley faces (n = 13). The target was a red circle with a smiley face. If a red circle was present, participants were instructed to press one button, and if it was not, they were instructed to press another button. Children were instructed to respond as quickly and accurately as possible. The tasks consisted of 24 trials: 16 test trials in which distractors are pseudo-randomly distributed and the target is located in one of the 16 unique target locations that is not in the center row or column, and 8 catch trials in which no target is present in the display (i.e., trials that contains only distractors). Participants were given six practice trials with feedback containing 2 catch trials and 4 test trials. If children did not understand the directions, practice trials were repeated. Stimulus duration went up to 8000 ms, followed by a fixation asterisk of 1000 ms. Once participants responded, the next fixation screen was presented, followed by the next stimulus. The main dependent variable of interest was reaction time calculated as the mean response time across test trials.

Enjoyment Immediately after reading the story, children were asked how much they enjoyed reading the book and were presented with a 5-point Likert *Smileyometer* scale that consisted of 5 faces ranging from a large frowny face (Not at All) to a big smiley face (Very Much). Children were asked to rate their enjoyment of the book using the Likert *Smileyometer* scale (Read & MacFarlane, 2006).

Reading Measures

Reading Comprehension Following Eng et al. (2020), we used six open-ended comprehension questions provided by the book publisher (with minor modifications) as the measure of reading comprehension. There were six questions (two 2-point questions, and four 3-point questions), with a total of 16 points possible. Asking open-ended recall questions about the characters, settings, story plot conflict and resolution from the narrative is one of the most common approaches to reading comprehension assessments with young children (Cain & Oakhill, 2006; Kendeou et al., 2009; Paris & Paris, 2003). For example, for the 2-point story question, children were asked about the main character, "What is Dennis' job?" Children received full credit if they identified that Dennis directs traffic and helps children cross the street, 1 point for a partial answer (e.g., he helps children), and 0 points if they failed to recall Dennis' job or provided an incorrect response. For the 3-point question, children were asked about the story conflict of various animals escaping from a pet shop including cats, dogs, birds, rabbits, and frogs, "What animals get out of the pet shop?" Children received full credit if they correctly identified all of the animals that escaped, 2 points if they identified at least 3 animals, 1 point if they identified 1-2 animals, and 0 points if they failed to recall the animals that escaped or provided an incorrect response. Reading comprehension was measured as the percentage of correct responses (out of 16 possible points). Responses to story questions were typed verbatim and scored by a researcher naïve to the study hypotheses. Recordings were used to archive the data in case it was necessary to validate the recorded responses of a participant. The typed responses were subsequently scored by two researchers naïve to the participants' condition assignment. Inter-rater reliability using Cohen's kappa (Cohen, 1960) was .92, indicating substantial coder consistency.

Reading Proficiency A modified Word Recognition in Isolation Test (WRI; Morris, 2013) was administered to children prior to reading the story. The WRI measures the ability to recognize and decode individual words that are graded in difficulty. Scores were calculated as the number of words read accurately in 90 seconds out of 100 total possible words. The WRI is a valid predictor of contextual and oral reading levels (Frye & Gosky, 2012; Morris et al., 2011). The experimenter also utilized a Running Record (Clay, 1985) to record the child's decoding accuracy for each word in the story calculated as the percentage of correct responses out of 256 words total.

Results

Children were beginning readers as evidenced by their performance on the WRI, the independent measure of children's reading proficiency ($M = 68.21$, $SD = 18.62$). The selected book was an appropriate difficulty level for independent reading based on children's Running Record, the measure of children's decoding accuracy while reading ($M = 95.59\%$; $SD = 3.80\%$). The manipulation to the book condition did not influence children's Running Record decoding accuracy (Standard: $M = 95.71\%$; $SD = 3.09\%$; Streamlined: $M = 94.98\%$; $SD = 4.94\%$; Text Only: $M = 96.22\%$; $SD = 3.03\%$), $F = 1.30$, $p = .28$; $\eta p2 = .02$. As per preregistered analyses, one-way ANOVAs were conducted with comprehension scores and gaze shifts away from the text as dependent variables and Condition as the explanatory variable. Planned contrasts based on a priori hypotheses were conducted if a significant main effect of condition was found.

Reading Comprehension Reading comprehension scores revealed a significant effect of condition, $F(2, 114) = 10.96$, $p < .001$, $\eta_p^2 = .16$. Planned contrast analyses revealed that comprehension scores were significantly larger for the Streamlined Condition ($M = 71.96$; $SE = 2.62$), relative to the Standard Condition ($M = 58.59$; $SE = 2.75$) and Text Only Condition ($M = 52.80$; $SE = 3.47$). Scores in the Text Only Condition, did not differ from the Standard Condition ($p = .35$, see Fig. 2). The results indicate that reading from the Streamlined Condition resulted in higher comprehension compared to reading from the Standard Condition and Text Only Condition.

Gaze Shifts Data from 7 children were not included in the eye tracking analyses due to tracking ratios <50%. Eye tracking analyses revealed a significant effect of condition, $F(2, 107) = 14.58$, $p < .0001$, $\eta_p^2 = .21$. The planned contrast analysis revealed that compared to the Standard Condition ($M = 40.71$; $SE = 6.60$), gaze shifts away from the text were significantly lower for the Streamlined condition ($M = 13.96$; $SE = 2.36$) and Text Only Condition ($M = 9.73$; $SE = 1.60$, see Fig. 3).

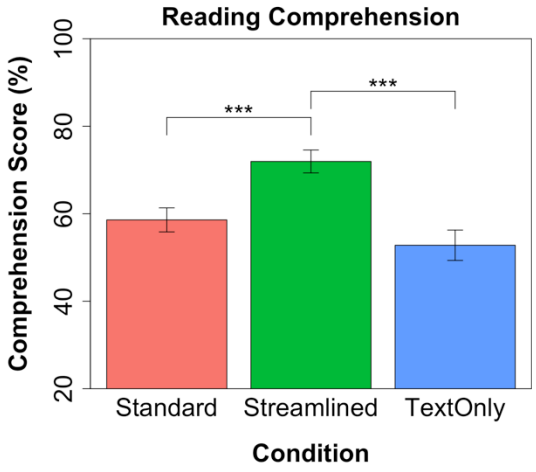

Figure 2: Percentage of correct answers on the story questions as a function of book condition. ***$p < .001$.

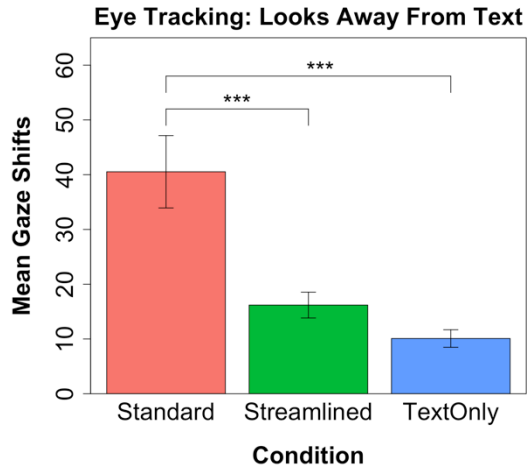

Figure 3**:** Average gaze shifts away from the text per page as a function of book condition. ***$p < .001$.

Association between Reading Comprehension and Eye Gaze Patterns, by Condition Next, we examined the association between mean gaze shifts away from the text and reading comprehension performance. Increased gaze shifts away from the text in the Standard Condition, $r(38) = -.50$, $p = .002$, and Text Only Condition, $r(37) = -.37$, $p = .025$, were negatively associated with children's comprehension scores, but not in the Streamlined Condition, $r(35) = .19$, $p = .280$ (see Fig. 4). In other words, children who frequently looked away from the text while reading in the Standard and Text Only Conditions had lower reading comprehension scores, whereas in the Streamlined Condition–where only relevant illustrations are present–children's gaze shifts away from the text while reading *were not* negatively associated with their reading comprehension scores.

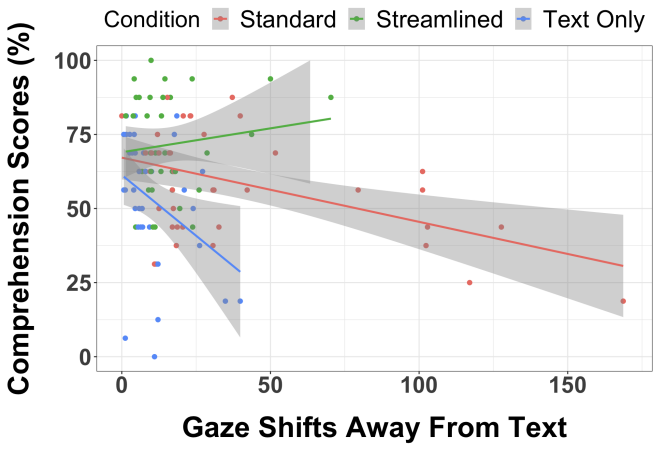

Figure 4**:** A negative association was found in the Standard Condition and Text Only Condition, but not for the Streamlined Condition

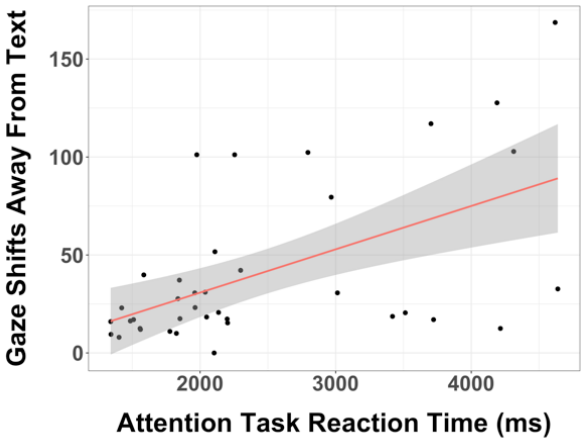

Figure 5: Scatterplot of the positive association between Gaze Shifts Away from Text and Attention Task Performance in the Standard Condition

Association between Eye Gaze Patterns and Attention Task Performance We then examined the association between mean gaze shifts away from the text and performance on an independent measure of attention. It is possible that children's gaze shifts away from the text in the Standard Condition are indicative of children attempting to use the illustrations as a strategy to help determine the meaning of unknown words, or of children enjoying looking at engaging pictures rather than resolving attentional competition. As per preregistered analyses, the main attention task variable of interest was mean test trial reaction time on the Conjunction Visual Search Task.

Gaze shifts away from the text in the Standard Condition, $r(38) = .55$, $p = .0004$ were positively associated with children's mean attention task reaction time (see Fig. 5). Gaze shifts away from the text were not associated with attention task performance in the Streamlined Condition, $r(35) = .19$, $p = .280$ or Text Only Condition, $r(37) = .199$, $p = .237$. Thus, as children's attention task reaction time increased, looks away from the text increased, but only while reading in the Standard Condition. The association of children's eye gaze patterns while reading in the Standard book condition in which extraneous illustrations were intermixed with relevant illustrations and performance on an independent measure of attention supports the hypothesis that children's eye gaze patterns while reading are associated with attention regulation skills.

Enjoyment Outcomes, by Condition A chi-square test of independence was performed to examine the relation between book enjoyment and condition. The relation between these variables was significant, X^2 (8, $N = 117$) = 48.21, $p <$ .001. When asked how much children enjoyed reading the book using a Smileyometer 5-point likert scale, children rated enjoyment similarly between the Standard and Streamlined Conditions (Somewhat and Very much), while children's enjoyment ratings of the Text Only Condition were evenly distributed and the only book Condition in which children rated the book negatively as "Not at all" and "Not really." Importantly, these findings indicate that removing extraneous illustrations does not reduce children's book enjoyment, as ratings of enjoyment between the Standard and Streamlined Conditions did not differ significantly (see Fig. 6).

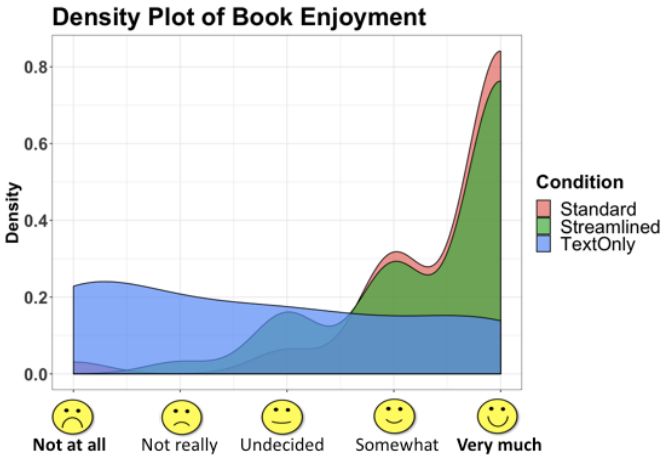

Figure 6: The plot displays similar ratings of enjoyment between the Standard and Streamlined Conditions.

Discussion

The results of this study replicate the findings reported by Eng et al. (2020) and extend these findings in several ways. First, this study replicates the findings of increased gaze shifts away from the text and reduced comprehension in the Standard Condition compared to the Streamlined condition. Second, the results of this study show a *Goldilocks Effect* (Kidd, Piantadosi, & Aslin, 2012) in storybook design: children learned the most in the "just right" condition where the visualizations were neither too busy nor eliminated. Children exhibited the highest comprehension scores in the

Streamlined Condition compared to the Standard Condition *and* Text Only Condition. Illustrations in books for beginning readers can be helpful in understanding the text, providing additional information, and motivating readers (Carney & Levin, 2002). This study suggests that illustrations can support reading comprehension, but they need to be well designed by taking into account individual differences in attention. Third, gaze shifts away from the text induced by extraneous illustrations are due to increased attentional competition, based on the correlation between gaze shifts and an independent measure of attention in the Standard Condition only. Lastly, extraneous illustrations increase attentional competition and decrease reading comprehension; however, removing extraneous illustration details did not have a strong negative effect on enjoyment. Children expressed more enjoyment when reading the book with illustrations compared to the book with no illustrations, but there was no further gain in enjoyment from including extraneous illustrations alongside relevant illustrations.

One limitation of this study is that it remains unclear whether the effects of extraneous illustrations on reading comprehension may change with age. We are currently exploring this question by including a sample of third grade children. We hypothesize that the inclusion of extraneous illustration details will have a greater negative effect on the comprehension and attention of first- and second-grade children compared to third-grade children, who are more proficient readers and have better developed attention regulation. Another limitation to this study is that the comprehension measure focused on the recall of key story events; therefore, both the understanding and memory of the story were assessed. Although this is a common approach, in future research, it will be important to incorporate assessments of comprehension that have lower memory demands.

In the present study, children showed higher reading comprehension when extraneous illustration details were removed. These findings are in line with prior work with adults which also found learning benefits from removing extraneous details from educational materials (e.g., textbooks, lectures; Rowland et al., 2008; Sanchez & Wiley, 2006). The benefit of streamlining illustrations on children's reading comprehension may stem in part from reducing the extraneous load on children's working memory. When books combine relevant and extraneous illustrations, children may divert attention away from the text to explore the illustrations. However, this exploration may result in children encoding irrelevant details that do not support, and may conflict with, comprehension of the story. In contrast, the inclusion of illustrations that are closely aligned with the text may help children integrate these sources of information and develop a better representation of the story.

Modifying the design of beginning reader books such that they only contain relevant illustrations may be particularly beneficial for younger children who have difficulty regulating their attention and may struggle to inhibit extraneous information. Indeed, prior research has found that attentional control not only predicts children's reading achievement at school entry but also their subsequent reading achievement (Guo et al.,2011; McClelland, Acock, & Morrison, 2006).

In summary, this work highlights the importance of considering attentional control when designing books for beginning readers. This work in combination with the prior literature can help optimize the design of beginning reader books in which engaging illustrations are created specifically to support–rather than interfere–with learning.

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References

Beck, D. M., & Kastner, S. (2009). Top-down and bottom-up mechanisms in biasing competition in the human brain. *Vision research, 49*(10), 1154-1165.

Cain, K., & Oakhill, J. (2006). Profiles of children with specific reading comprehension difficulties. *British journal of educational psychology*, *76*(4), 683-696.

Carney, R. N., & Levin, J. R. (2002). Pictorial illustrations still improve students' learning from text. *Educational psychology review, 14*(1), 5-26.

Clark, R. C. & Mayer, R. E. (2012). *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*. 3rd edn. Pfeiffer.

Clay, M. M. (1985). The early detection of reading difficulties.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20,* 37–46.

Coldstein, R., & Underwood, G. (1981). The influence of pictures on the derivation of meaning from children's reading materials. *Journal of Research in Reading, 4*(1), 6-16.

Downing, P., & Dodds, C. (2004). Competition in visual working memory for control of search. *Visual Cognition, 11*(6), 689-703.

Dykman, R. A., & Ackerman, P. T. (1991). Attention deficit disorder and specific reading disability: Separate but often

overlapping disorders. *Journal of Learning Disabilities*, 24(2), 96-103.

Eng, C. M., Godwin, K. E., & Fisher, A. V. (2020). Keep it simple: streamlining book illustrations improves attention and comprehension in beginning readers. *npj Science of Learning, 5*(1), 1-10.

Eng, C. (2020). Optimization of Visual Materials in Storybooks for Beginning Readers: An Eye Tracking Study. Retrieved from https://osf.io/8q9ux/?view_only=f579ec4d79d44d3098eb95a115195cff.

Fenesi, B., Kramer, E., & Kim, J. A. (2016). Split-Attention and Coherence Principles in Multimedia Instruction Can Rescue Performance for Learners with Lower Working Memory Capacity. *Applied Cognitive Psychology*, 30(5), 691-699.

Fisher, A., & Kloos, H. (2016). Development of selective sustained attention: The role of executive functions. *by APA edited volume on Executive Functions*.

Frye, E. M., & Gosky, R. (2012). Rapid word recognition as a measure of word-level automaticity and its relation to other measures of reading. *Reading Psychology*, *33*(4), 350-366.

Guo, Y., Connor, C. M., Tompkins, V., & Morrison, F. J. (2011). Classroom quality and student engagement: Contributions to third-grade reading skills. *Frontiers in psychology, 2*, 157.

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of educational psychology*, *90*(3), 414.

Harp, S. F. & Maslich, A. A. (2005). The consequences of including seductive details during lecture. *Teaching of Psychology*, 32, 100–103

Jacobson, L. A., Ryan, M., Martin, R. B., Ewen, J., Mostofsky, S. H., Denckla, M. B., & Mahone, E. M. (2011). Working memory influences processing speed and reading fluency in ADHD. *Child Neuropsychology*, *17*(3), 209-224.

Kendeou, P., Van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of educational psychology*, *101*(4), 765.

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learn. Instr*. 12, 1–10.

Kidd, C., Piantadosi, S. T., & Aslin, R. N. (2012). The Goldilocks effect: Human infants allocate attention to visual sequences that are neither too simple nor too complex. *PloS one, 7*(5), e36399.

Lehman, S., Schraw, G., McCrudden, M. T., & Hartley, K. (2007). Processing and recall of seductive details in scientific text. *Contemporary Educational Psychology*, *32*(4), 569-587.

McClelland, M. M., Acock, A. C., & Morrison, F. J. (2006). The impact of kindergarten learning-related skills on academic trajectories at the end of elementary school. *Early childhood research quarterly, 21*(4), 471-490.

Melby-Lervåg, M. Lyster, S.A., & Hulme, C. (2012). Phonological skills and their role in learning to read: a meta-analytic review. *Psychological Bulletin*, *138*(2), 322-352.

Morris, D. (2013). *Diagnosis and correction of reading problems*. Guilford Publications.

Morris, D., Bloodgood, J. W., Perney, J., Frye, E. M., Kucan, L., Trathen, W., Ward, D., & Schlagal, R. (2011). Validating craft knowledge: An empirical examination of elementary-grade students' performance on an informal reading assessment. *The Elementary School Journal*, *112*(2), 205-233

Paris, A. H., & Paris, S. G. (2003). Assessing narrative comprehension in young children. *Reading Research Quarterly*, *38*(1), 36-76.

Rayner, K., Ardoin, S. P., & Binder, K. S. (2013). Children's eye movements in reading: A commentary. *School Psychology Review*, *42*(2), 223.

Read, J. C., & MacFarlane, S. (2006). Using the fun toolkit and other survey methods to gather opinions in child computer interaction. In *Proceedings of the 2006 conference on Interaction design and children* (pp. 81-88).

Rowland, E., Skinner, C. H., Davis-Richards, K., Saudargas, R., & Robinson, D. H. (2008). An Investigation of Placement and Type of Seductive Details: The Primacy Effect of Seductive Details on Text Recall. *Research in the Schools, 15*(2).

Sanchez, C. A., & Wiley, J. (2006). An examination of the seductive details effect in terms of working memory capacity. *Memory & cognition, 34*(2), 344-355.

Sweller, J. (2005). Implications of Cognitive Load Theory for Multimedia Learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (p. 19–30). Cambridge University Press.

Team, R. C. (2018). R: A Language and Environment for Statistical Computing. http://dx.doi.org/10.1007/978-3-540-74686-7

Woods, A. J., Göksun, T., Chatterjee, A., Zelonis, S., Mehta, A., & Smith, S. E. (2013). *The development of organized visual search. Acta psychologica*, *143*(2), 191-199.