The Added Challenge of Digital Reading

Exploring Young Children's Page Turning Behaviors

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ABSTRACT

Electronic books (e-books) with audio narration are often touted as enabling pre-literate children to read independently, which, indeed, is the most common way children utilized e-books in the U.S. However, young children may have trouble navigating e-books, as their cognitive and fine motor skills are still developing. Compared to print-books, e-books lack the tactability and tangibility of print books and thus may pose additional challenge to book navigation. To examine this issue, we randomly assigned 174 children aged 3-5 to be read either a print book by an adult ($n = 85$) or an e-book with audio narration ($n = 89$) and compared their page-turning behaviors, including disruptive turning (i.e., turning before narration ends), delayed turning (i.e., being inattentive for over one minute after the narration ends), and incorrect page-turning motions. We found that screen-based reading imposes additional cost to children's navigation of the book, especially for children under four years old and those who are less experienced with tablet devices. The learning curve to navigate e-books appears to be steeper than that for print-books. Future e-book design may want to provide scaffolding for young users and those lacking familiarity with touchscreen technologies.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Touch screens**; • **Social and professional topics** → **Children**.

KEYWORDS

Reading; Tablets, Touchscreen; Young children; Interaction with digital media

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1 INTRODUCTION

Young children are introduced to mobile technology at an early age, with many using touchscreen tablets and smartphones on a daily basis. By 2017, children in the United States averaged 48 minutes of daily touchscreen use [21]. The popularity of touchscreen use among young children has led to digital reading becoming increasingly common. Research finds that although print books were still the dominant reading format for preschoolers, twenty-eight percent of this age group had engaged with an e-book on a tablet device [21]. E-books are usually equipped with audio narration and are thus often touted as enabling pre-literate children to “read” independently [22]. Indeed, children in the U.S. most commonly use e-books with minimal adult supervision. In a survey of 462 parents of 2- to 6-year-olds, approximately 83% reported that they frequently (18%) or sometimes (65%) gave children e-books to read by themselves [25].

When compared to print-books, e-books lack the tactability and tangibility of print books and thus may pose additional challenges to navigation for children reading alone. The fine motor skills of navigating e-books are different from those for print books. While children use their hands and fingers to flip the pages of a print book, they need to tap and swipe to progress through an e-book. Print books also have visible and tangible pages, but e-books obscure the notion of pages by reconfiguring the entire book into one “black box,” the mobile device itself. Therefore, researchers have argued that e-books may be less natural and intuitive for readers to control the reading medium [26]. If children struggle with the navigation of the e-book, they are prone to allocate their already limited cognitive resources to the page-turning task, rather than to the narration [11, 13]. More

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importantly, children may miss critical plot lines in the story if they have troubles in navigating the book properly [4, 14]. As such, it is important to understand the possible challenges associated with screen-based reading in order to design e-book interfaces that best facilitate learning. However, we are not aware of any studies using an experimental design to compare young children's book navigation across reading formats. By examining the impact of e-books might have on children's page turning behaviors, our work uncovers the challenges children may encounter when reading digitally and subsequently provides important implications for the design of e-books that can better scaffold emergent readers.

2 RELATED LITERATURE

There has been a heated debate in the research community and popular press as to whether children's learning from e-books is comparable to that from print books. A large body of research has compared children's reading comprehension, emergent literacy, and vocabulary growth between the two formats. The results are mixed, with both positive and negative e-book effects [6, 16, 18, 20, 23, 27, 29]. Our work is situated within this line of literature but examines the differences or similarities between reading e-books and print books from the interaction, rather than cognitive, perspectives [15]. Specifically, we view e-book as an interactive product [2] and focus on how reading formats afford different page-turning behaviors.

Some studies have noted that children's page-turning is "one important sensorimotor experience" associated with reading tablet-based e-books [15], because when children use an e-book, the majority of their haptic interactions with the screen occurred when they manipulated the pages [5]. Another study found that children enjoyed being able to control the pace of reading and turned pages on e-books spontaneously [7]. This control not only brought about a feeling of agency but also enabled children to read at a pace that fit their understanding of the book's content. Other studies, however, documented issues young children had related to the page-turning on tablets. For example, children reported that it took some time to familiarize themselves with the touching motion required to swipe the page [12]. Children were also observed to be confused about the appropriate timing to turn pages [19]. Nevertheless, these troubles may be associated with children's still developing skills and limited experiences in reading, rather than merely caused by the characteristics of e-books. Indeed, studies have also described page-turning difficulties when children read in print. For example, a study, in which children encountered page-turning troubles with print books, was mostly due to the pages being stuck together [19]. In conclusion, previous literature has recorded some extent of page-turning issues among young children in both e-book and print formats. However,

studies that solely focus on page-turning behaviors in one format cannot clarify whether screen-based reading induces additional challenges on page-turning.

3 RESEARCH QUESTIONS AND HYPOTHESES

Two questions were explored:

- **RQ1** Do children's page turning behaviors (i.e., motion and timing) vary by medium?
- **RQ2** Is the effect of medium on page-turning behaviors (if there is any) moderated by age and prior tablet experience?

Despite the lack of empirical evidence, the medium materiality theories have led to a hypothesized difference in page-turning behaviors that are afforded by the different material characteristics of print- versus screen-based media [8, 9]. Page-turning in e-books requires different sets of motor abilities (point-press-slide-lift) than in a print book (grasp-lift-place). In addition, the concept of pages is more obscure in e-books than in print, which may impede children's awareness of page-turning (i.e., decision of timing to turn). Given this, we hypothesized that the schema of navigating e-books may demand more cognitive load from the reader and thus induce challenges to young children as they also need to allocate their cognitive resources to processing the story content. Nevertheless, how much cognitive load a child may need to perform page-turning tasks on print or on screen may depend on their developmental state as well as format-specific reading experiences [17]. As such, we hypothesized that older children may find it easier to adjust to different reading formats given their more developed cognitive and fine motor skills. Also, children who have more experiences reading in a particular format may navigate their familiar medium more smoothly.

4 METHOD

Participants

We recruited a total of 200 children aged 3-5 years old in a suburban area in California. We selected children in this age range because preschool years are a critical period for the development of emergent literacy, and our study is specifically concerned with how digital technologies might impact this age group's early reading experiences. These children were randomly assigned to be read either an e-book or a print book. Our analytic sample consisted of 174 children whose parents granted permission to video-tape the reading session. Fifty percent of the sample were female. The mean age was 48 months. The parent questionnaire also inquired about children's technology experiences. The majority of children were reported to use tablets at least 3 days a week. Details of demographics and technology use information are presented in Table 1.

Table 1: Participant Information by Experimental Condition

	Full sample	E-book	Print book
Age (in months)	47.9 (9.2)	48.2 (9.4)	47.5 (9.1)
Female	50.0%	52.9%	47.2%
<i>Race</i>			
White	52.3%	49.4%	55.3%
Asian	18.4%	18.0%	18.8%
Hispanic	5.2%	6.7%	3.5%
Multi-race/ethnicity	17.2%	16.9%	17.6%
Other	4.6%	5.6%	3.5%
Black	1.1%	2.2%	0.0%
Decline to report	1.1%	1.1%	1.2%
<i>Household income</i>			
Below 75k	19.0%	13.5%	24.7%
75k-125k	12.6%	15.7%	9.4%
125k-150k	14.4%	14.6%	14.1%
Above 150k	46.6%	48.3%	44.7%
Decline to report	7.4%	7.9%	7.1%
<i>Weekly tablet use</i>			
Never	6.3%	7.9%	4.7%
Occasionally (1-2d)	22.4%	21.3%	22.4%
Sometimes (3-5d)	45.4%	46.1%	44.7%
Almost daily (6-7d)	26.4%	24.7%	28.2%
N	174	89	85

Study Procedure

The participants were randomly assigned to be read a print book by an adult ($n = 85$) or an e-book with audio narration ($n = 89$). All baseline demographics and technology use variables were comparable between the two conditions.

The procedure was similar across the two experimental conditions except for the reading format. Children met individually with a trained adult experimenter in a designated quiet area at their preschool. Prior to the reading session, children were verbally assented and then instructed how to operate the device or the book. Specifically, how to use the correct motion to turn the page after the narration of a particular page was complete was modelled for all children. The experimenter in the print-book group pointed at the text while reading whereas the text was highlighted automatically in the interactive storybook. The adults did not initiate conversation with the children, and did not elaborate on children's questions, so as to ensure that all children received similar treatment. The experimenter interfered only when children were completely off-task (e.g., failure to remain seated, not attentive to the reading for a long period of time). The reading sessions were video-taped with children's assent, and they ranged from 5-10 minutes, typically lasting 8 minutes.

Figure 1: Child participants reading a print book (left) and an e-book (right)

Materials

The book “Chris P. Bacon: My Life So Far,” authored by Len Lucero and Kristina Tracy, was selected as the reading material for the study because it was published in both traditional print version and e-book for touch screen devices. The content of the e-book and print versions were identical. We also considered that the story had appropriate length and narrative complexity for this age group as well as potential story interest. The design of the e-book followed the convention of print books. It required right-to-left swiping motion to progress to the next page. We were thus enabled to explore whether the e-book intended to simulate page turning following print conventions may induce similar or different behaviors for navigation.

Measures

We analyzed children's page-turning behaviors both quantitatively and qualitatively.

The quantitative coding was aimed at comparing children's page-turning behaviors between the reading formats. In both conditions, children's page turning behaviors were coded from the video-taped reading sessions. The videos were divided into 10-second segments, and each segment was coded for three page-turning behaviors described below [27, 29]. On average, children's videos contains 53 segments, ranging from 40 to 90, representing their page-turning behaviors every ten seconds. Two coders, who were blinded from research objectives, performed the coding. During a two-month training session, coders met once a week and practiced with videos taken from the pilot sessions of the study. They then compared their codes and negotiated the discrepancy to reach a mutual agreement. The actual coding did not start until the two coders were able to obtain a reliability over 0.90 for the training videos. The entire coding took approximately seven months. Twenty percent of the videos were double-coded. The inter-rater reliability was over 0.85 for each variable.

The first page-turning variable was whether children had difficulty in turning page, which was coded as present if a child attempted to turn the page but failed to successfully

turn to the next page as intended. The second variable was whether children turned pages too early, which was coded as present if a child attempted to turn or turned a page before the narration of the current page was complete. The third variable was whether children turned pages too late, which was coded as present if a child did not turn a page nor did they engage in task-related activities in any form for one minute. The researcher did not intervene during the one minute and, after that, prompted or assisted the child to turn the page. Given that the variables of page-turning behaviors frequencies were all right-skewed, we employed rank-based methods that do not require normality assumption for all our analyses.

In addition, we also used open-ended field notes to gain a deeper description of navigation challenges associated with reading e-books. From the video recording, we took detailed notes on how children handled the page-turning task for every page of the e-book, including their facial expressions, hand movements, and verbal comments. Researcher's actions and comments were also recorded per page. Figure 2 displays a field note excerpt of one child. Based on the notes, we generalized common page-turning patterns using an inductive approach [24]. Specifically, we derived trends across participants based on detailed reading of the field notes and interpretations made from the reading.

Page	Description of page turning			Researcher	
	Hand movements	Facial expressions	Verbal comments	Actions	Comments
1A	Swiped backwards	Looked at the screen. No expression.	NA	Prompted the child to swipe by making a swiping motion in the air with her finger above	"Now that Chris is done reading, all you have to do is swipe the screen and it'll turn the page."
	Swiped backwards to the previous page. Used his finger to point to the screen and moved his finger from one side to the other in a swiping motion	Looked at the screen, and then looked the researcher. Slightly frowned.	"Is this how you do it (turning the page)?"	Researcher modeled how to swipe twice.	When child asked the researcher how to do it, the researcher said, "oh yeah just swipe". Then research said "there you go" after the child turned the page
1B					

Figure 2: Fieldnote excerpt of one child participant

5 RESULTS

Format Effects on Page-turning Behaviors

The frequencies of page-turning behaviors in both conditions are presented in Table 2.

Kruskal Wallis rank-based ANOVA suggested that, compared to the print-book group, i) children reading an e-book more frequently turned page both disruptively ($\chi^2(1) = 13.11$, $p < 0.01$, $ES(\epsilon^2) = 0.08$) and with delay ($\chi^2(1) = 10.64$, $p < 0.00$, $ES(\epsilon^2) = 0.06$); and ii) children reading an e-book showed more instances of incorrect motion ($\chi^2(1) = 27.95$, $p < 0.001$,

Table 2: Mean and Standard Deviation (SD) of Page-turning Behaviors per 10-second Increments by Format

	E-book		Print book	
	Mean	SD	Mean	SD
Disruptive page turning	0.02	0.03	0.01	0.02
Delayed page turning	0.11	0.13	0.06	0.06
Incorrect motion	0.04	0.04	0.02	0.03

$ES(\epsilon^2) = 0.26$). These results suggested significant format effects on children's page-turning timing as well as page-turning motion, with e-book posing more challenges on young children's navigation.

The Moderating Role of Age and Tablet Use

Do the negative effects of e-books on page-turning timing and motion depend on children's age and tablet usage? We conducted subsequent rank-based two-way ANOVA to determine whether there were significant interaction effects between i) format and age and ii) format and prior tablet experiences, respectively. In terms of the interaction between format and age, we found that e-books interfered with younger children's decision on page-turning timing more so than older ones. Specifically, e-books appeared to induce more disruptive page turning ($F = 7.01$, $p < 0.01$) and more delayed page turning ($F = 7.17$, $p < 0.01$) for younger children than for older ones (see Figure 3 and Figure 4). However, age was not shown to moderate the negative effects of e-books on page-turning motions ($F = 0.40$, $p = 0.67$). In other words, children from 3- to 5-years-old experienced similar levels of difficulties in using the appropriate motion to turn pages on the e-book.

Figure 3: Interaction effects between format and age on instances of disruptive page-turning

In terms of the interaction between format and prior tablet experience, we found that children lacking prior technology

Figure 4: Interaction effects between format and age on instances of delayed page-turning

experiences had more difficulty in using the correct motion with the e-book as compared to their more experienced peers ($F = 11.64$, $p < 0.001$). See Figure 5. However, prior tablet experiences did not appear to moderate the negative effects of e-books on page-turning timings ($F = 0.24$, $p = 0.87$ for disruptive page-turning; $F = 0.42$, $p = 0.74$ for delayed page-turning). With that said, e-books seemed to induce more challenges on children's page-turning timing regardless of their tablet experiences.

Figure 5: Interaction effects between format and prior tablet experiences on instances of incorrect page-turning motion

E-book Navigation Challenges

The qualitative field notes corroborated the results from the quantitative coding. The majority of children had issues related to page-turning motions at least some point of the reading episode ($n = 73$), including swiping too firmly or too delicately, swiping in the wrong direction (backward instead

of forward), tapping instead of swiping, and repeatedly swiping thereby turning more than one page. In particular, children had difficulty using the appropriate pressure to swipe. We observed that 10 children required several rounds of trial and error before they could apply the appropriate amount of pressure to turn the page. For example, a four-year-old turned the page on his fourth attempt. On the first attempt, he applied too much pressure and the page did not turn. On the second attempt, he swiped slowly and applied even more pressure. The researcher then prompted him to swipe more softly and she modeled the motion in the air. The boy was still unsuccessful however on the third attempt, as he barely touched the screen and then moved his finger away too quickly. On the fourth attempt, he finally applied the appropriate amount of pressure and succeeded in turning the page. In addition to the issue of appropriate pressure, another common problem with page-turning motions involved children accidentally activating interactive areas within the e-book (i.e., hotspots) by pressing on them as they attempted to turn the page.

In terms of issues related to page-turning timing, many children ($n = 76$) showed delays in turning the page: they either appeared to anticipate narration even after it was complete, or they simply sat idle. For example, we observed that one four-year-old child did not initiate any action after the narration of a page was complete, rather, he looked at the researcher and seemed to seek prompts for what he should do the next. In addition to delays in turning, some children also disrupted the narration by turning pages too soon and did not attempt to go back to the unfinished page. Although this behavior was less common (observed among 43 children) compared to delayed page-turning.

Interestingly, although most children ($n = 80$) encountered at least one type of page-turning obstacles early on in the reading session, some children appeared to be more determined to overcome these difficulties. These children frequently readied themselves to turn the page before the narration had ended. Specifically, they positioned their fingers just above the screen as the narration progressed and immediately swiped once the narration ended. As these children were very focused on the book navigation itself, they may have been distracted from attending to the story's actual content. On the other hand, some children appeared to not be willing to further attempt to turn the page after their initial failure. They frequently relied on the researcher to perform the page turning task. Some children also explicitly confirmed with the researcher the appropriate timing or motion required to turn the page, and only turned the pages after receiving confirmation.

6 DISCUSSION

By examining how preschool-aged children navigated e-books and compared their page-turning behaviors in e-book and print-book formats, this study makes at least two contributions to the field of child-computer interaction.

First, our study suggested that screen-based reading (or being read on screen) imposed additional cost on children's navigation compared to print-books. Children seemed to struggle with the page-turning timing. This lessened awareness of page-turning timing may be due to having pages that were conceptually more abstract in e-books than print books, thus discouraging children from proceeding the book by swiping to the next "page". The signal to indicate page completion in the particular e-book in our study - word highlighting that accompanies the narration - may be too subtle, leaving children who cannot yet decode unsure when the narration was complete. Children also appeared to struggle with using the appropriate motion. This may be due to that the fine motor skills required by e-book page-turning are more unfamiliar for young children than those needed for print books. In addition, the learning curve for navigating an e-book also appears to be steeper than for print-books. Specifically, younger children (those who were three-year-old) as well as those who lacked experience in operating tablets appeared to find navigating an e-book especially challenging.

Second, children's page-turning timing in e-books appeared to be related to their developmental state, while their turning motion was related to their experiences with specific devices. Younger children had more difficulties in determining the appropriate page-turning timing, and this was probably due to their less developed print knowledge [3]. In addition, children who never used tablets had more trouble using the correct motion; however, among tablet users, more frequent tablet use did not seem to improve book navigation. We speculate that children over three years of age may possess sufficient fine motor skills to perform the swiping motion, but some exposure to screen technologies is necessary to evoke the schema needed to operate e-books properly [1].

The differential page-turning behaviors associated with reading format calls for researchers' attention on the clarification of "concepts of print" when digital reading is prevalent. Digital reading may require different convention of reading, which have not been included in the traditionally defined concepts of print [4]. Indeed, in the popular presses, we have been exposed to many anecdotes where children attempted to "swipe" the page as they were given a print book to read. It would be worthwhile to explore how this concept may have been changed due to the reading format.

Our findings also offer several design and interaction implications. First, e-book designers may want to provide scaffolding for young users and those lacking familiarity with technologies. For example, e-books could display animated page-turning instructions in the cases when users are not detected to proceed to the next page. Indeed, in the market, some e-books display figure-moving animation with the purpose of modeling page-turning. But this kind of instruction usually only appears at the beginning of book and thus may not be effective in scaffolding children's page-turning during their reading. Second, while it is a common practice that e-books replicate the reading conventions provided by print book, such design, at least in our study, appears to fail to create a similar experience. As managing the appropriate swiping motion appeared to be challenging to children, e-book designer may want to consider other features, such as voice control [28]. In addition, embodied interaction that involves using the whole body, not just hands and eyes, may also be worthwhile to investigate [10]. Third, in addition to optimization of the medium itself, support from caregivers or older siblings may also be important. Although most e-books are to some extent designed for individual use, external scaffolding may ease the interaction obstacles.

7 CONCLUSION

Many young children now read e-books with audio narration on mobile devices independently. However, the tactile and tangible aspects of print books differ from those of e-books, thus preventing children from applying the page-turning schema developed from print reading to an e-book. This experimental study uncovered the possible challenges touchscreen media introduced to the reading experiences. Children appeared to struggle to use the appropriate motion and determine the appropriate timing for page turning, especially for children under four years old and those less experienced with tablet devices. These findings suggest a need to design e-books that are more developmentally supportive and thus make such interaction more beneficial to children's literacy development.

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9 SELECTION AND PARTICIPATION OF CHILDREN

This study was reviewed and approved by the University Institutional Review Board. Children were recruited from local preschools during school drop-off and pick-up hours.

A researcher explained the study procedure to the parents caregivers and answered any questions. If interested, parents/caregivers signed informed consent. Prior to the reading session, a researcher orally asked children if they were willing to participate the study, and children gave oral assent. Children were also orally informed that they could discontinue the study anytime if they wished to do so. Both parental/caregiver written consent and the child's explicit assent were necessary for the study to proceed.

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