"That's the Way Sighted People Do It": What Blind Parents Can Teach Technology Designers about Co-reading with Children

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ABSTRACT

Co-reading (when parents read aloud with their children) is an important literacy development activity for children. HCI has begun to explore how technology might support children in co-reading, but little empirical work examines how parents currently co-read, and no work examines how people with visual impairments (PWVI) co-read. PWVIs' perspectives offer unique insights into co-reading, as PWVI often read differently from their children, and (Braille) literacy holds particular cultural significance for PWVI. We observed discussions of co-reading practices in a blind parenting forum on Facebook, to establish a grounded understanding of how and why PWVI co-read. We found that PWVIs' co-reading practices were highly diverse and affected by a variety of socio-technical concerns – and visual ability was less influential than other factors like ability to read Braille, presence of social supports, and children's literacy. Our findings show that PWVI have valuable insights into co-reading, which could help technologies in this space better meet the needs of parents and children, with and without disabilities.

Author Keywords

Co-reading; blind parents; literacy; assistive technology.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

The rise of digital technologies has caused fundamental shifts in societal reading habits [51], and emerging technologies like e-books, audiobooks, and conversational agents continue to expand where, when, and how we may read. This raises new concerns that electronic media may affect reading comprehension [55], hinder sustained

Figure 1. Sighted adults reading with visually impaired children, as depicted here, is commonly how "co-reading" and "visual impairments" are conceptualized together. Rarely are needs of blind adults and sighted children considered in the design of interventions.[1]

reading [37], and even redefine the role of literacy for future generations [8]. Co-reading – when parents read aloud with their children – has been shown to be an effective activity for developing literacy skills and interests in young children [57]. HCI has begun to explore how digital technologies might support co-reading (e.g. [17,18,72,73]). Yet, there has been little empirical work toward identifying how and why parents co-read, or understanding the cultural significance of co-reading as an activity. Here, we contribute to this growing body of work, by examining the practices used in, and significance of, co-reading amongst people with visual impairments (PWVI) and their children.[1]

For many parents, co-reading with their young children is a simple and routine aspect of daily parenting activities. More than half of children under eight years of age read, or are read to, for 30 minutes or more per day [19]. Co-reading is widely identified as a fun bonding activity by both parents and children [80]. But, for PWVI, co-reading with their children presents unique difficulties; gaining access to Brailled media (like the Braille book being used in Figure

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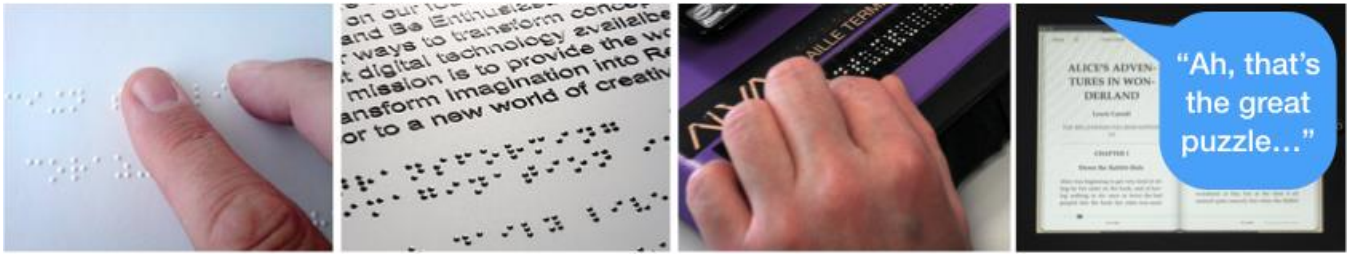
[1] Art courtesy of Andrew Tumang.

Figure 2. Examples of how PWVI might read a book. From left to right: (a) Traditional Braille books are written as raised characters on high-quality paper, (b) Twin-vision books are written in both print and Braille, which, here, appears beneath the printed text, (c) Refreshable Braille displays dynamically raise Braille characters to display digital text, and (d) Text-to-audio technologies, like audiobooks, or e-books read by the iOS native screen-reader VoiceOver, can be used to vocalize digital texts.[2]

1) can be challenging, and even then, fewer than 10% of blind adults read Braille [86]. PWVI may therefore adopt fundamentally different strategies for co-reading than their sighted peers. Many advocacy groups express growing concerns about the long-term effects of Braille illiteracy for PWVI – only 32% of blind adults in the U.S. are employed, and 93% of blind adults who are employed read and write Braille [27]. The stakes of designing reading technologies are disproportionately high for PWVI. Yet, people with disabilities are often not included in the beginning stages of design [16,81].

Here, we examine the co-reading experiences of PWVI, not only to forefront accessibility in the design of future technologies – but because the creative workarounds used by PWVI, and their perspectives on literacy development in a time of declining Braille education, offer unique insights into the diversity of co-reading practices, and the cultural significance of parent/child co-reading.

To establish a grounded understanding of PWVIs' co-reading experiences, we observed authentic discussions of co-reading practices, by parents with visual impairments, over a 16-month period, in a blind parenting group on Facebook. While we found that visual impairments were often the catalyst for adopting *some* alternative co-reading strategy, the choice of a *specific* strategy was influenced by a variety of factors other than the parents' visual (dis)abilities. Additionally, we found that co-reading is a particularly complex collaborative activity. Co-reading practices change frequently, as abilities evolve over time, parents' and children's roles are renegotiated, and external social supports contribute to the practices of the parent/child dyad. Successful designs aimed at supporting accessible co-reading practices should account for these nuances, while observing the significance of co-reading for

this group. More importantly, our findings show that parents with visual impairments have unique perspectives on the practice of co-reading. We share their key insights and identify new avenues for designing interactive technologies to support co-reading that are more attentive to needs of parents and children, with and without disabilities.

BACKGROUND: CO-READING AND LITERACY
The literacy benefits of parents reading printed books to their children have long been recognized – a 2011 meta-analysis of 99 studies on children's leisure time reading associated early print exposure with improved reading comprehension, technical reading and spelling skills, oral language skills, and lifelong academic achievement [60]. Reading together offers unique opportunities for parents to model reading behaviors, and for dialogic engagement (when parents ask additional questions, and prompt discussions about a story external to its content) [90], which helps children to connect with, and make sense of, texts [26].

But recent shifts in reading, from paper to digital media, have raised new concerns about young children's literacy development amongst literacy scholars. Today, children's in-home literacy development involves engagement with a wide variety of interactive technologies [56]. While many scholars hail the opportunities afforded by emerging technologies like the iPad [29], others argue that interactive technologies remove children from the benefits of traditional methods of teaching literacy [38]. How digital technologies may affect co-reading has also been a point of debate. Several studies have examined how the literacy development benefits of co-reading may be impacted by introducing digital media [15,28,47,48], with mixed results.

These same concerns that digital media may impact literacy are particularly salient for PWVI. Though Braille has been the principle reading format for PWVI for over 200 years [64], the availability of consumer-grade assistive technologies (ATs) for PWVI have created new opportunities for making printed information more accessible. Figure 2 shows only a few examples of variety of tools available to PWVI, for reading in the digital age. Screen-readers, which read aloud textual content of

personal computer windows are becoming increasingly common – Apple's screen-reader VoiceOver comes standard on their devices. Advances in automated character recognition even allow mobile applications, like SeeingAI, to interpret and translate real-world text to synthesized speech. Some ATs incorporate Braille in their outputs, like refreshable Braille displays which can convert digital text to Braille on a flexible membrane display. But the increasing availability of text-to-audio technologies has contributed to views that Braille is obsolete [40], and a consequent decline in Braille education [27] and Braille literacy rates [76].

However, the notion that PWVI should rely primarily on auditory channels to obtain information has led prominent advocacy groups, like the National Federation of the Blind (NFB), to sound the alarm on the "Braille Literacy Crisis in America" [64], and call for specific action to increase Braille education for children and adults with visual impairments. Text-to-audio technologies are not solely responsible for declining Braille literacy rates. But the Braille Literacy Crisis speaks to extant concerns that text-to-audio technologies may affect the nature of literacy and emphasizes the particular significance of such debates for PWVI [1]. The importance of literacy for sighted people has long been recognized – and should be for PWVI, too. Put succinctly [40]:

> If we were to propose that sighted children no longer needed to learn to read and write, that they could get all their information from radio, television, or tapes, the idea would be rejected immediately.

Despite growing views that literacy for PWVI is optional or obsolete in the digital age, Braille literacy has long been associated with positive outcomes for PWVI. A 2015 survey of more than 1,000 legally blind adults found that those who read Braille on a weekly basis had an increased likelihood of being employed and receiving a higher salary than those who do not read Braille [4]. Similarly, a survey of 443 legally blind adults found that Braille readers had higher self-esteem and life satisfaction than those who had never learned Braille [84].

While our work, here, does not directly address *Braille* literacy, the perspectives on literacy development through co-reading shared by PWVI in our sample cannot be removed from the social context of the present Braille Literacy Crisis, or the importance of literacy for PWVI.

RELATED WORK

Digital Reading Technologies
The use of digital reading technologies for educational purposes has been discussed extensively by literacy scholars (see [59] for a recent review). The use of digital technologies in *co-reading* has been the subject of a smaller, but still substantial, body of work in the domain of education. Often, such studies of digital technologies and co-reading, like those of Fisch et al. [28] and Kim and Anderson [47], examine parent-child interactions, across

digital and print formats, where no disability is present. Several literacy scholars, like McClanahan et al. [58], and Peppler and Warschauer [67], have rightly identified the potential for digital reading technologies to support the educational needs of people with disabilities. But they focus primarily on *children* with disabilities, rather than *parents* with disabilities. More broadly, and in contrast to our work, studies of digital technologies in education-oriented disciplines concern evaluating the educational efficacy of reading technologies as they are presently designed. We focus instead on examining current co-reading practices, to consider how digital technologies might support these activities.

In HCI and Interaction Design, supporting co-reading has been the subject of a small, but growing, body of literature. Recent work by Cingel and Piper [18] investigated the use of haptic feedback in parent-child co-reading practices. They found integrating haptic feedback into e-reading technologies increased dialogic engagement, but may reduce parents' narrative expressivity. Similarly, Raffle and colleagues [72,73] have explored familial co-reading at a distance, by designing augmented teleconferencing systems like StoryVisit. They describe design implications for shared family activities, like creating a playful UI, allowing single users to take ownership over other family members' accounts, and using a story's content to structure co-reading activities. But studies have not yet examined how parent-child co-reading practices may differ for parents with disabilities or, more specifically, visual impairments.

Designing for Familial Intimacy
We approach co-reading technologies from the perspective of designing not just to meet educational ends, but also to facilitate intimate family connections. There is a large body of work in HCI, exploring interactive technologies for family coordination [21,22], and investigating shared digital resources, like home networks, as technological [33] and sociological [20] objects.

Bell et al. identified the potential for Ubiquitous Computing technologies to facilitate personal relationships, under the larger umbrella of intimacy, in [5]. Kaye and colleagues explored the role of communications technologies in facilitating intimacy in romantic relationships, at a distance [42–44]. Branham and colleagues [9,10] brought this mediated romantic intimacy back home, with a Diary Built for Two, a design concept for facilitating intimacy of collocated partners. While "intimacy" carries different connotations in parent-child relationships than in romance, studies in designing for mediated *familial* intimacy, like [3,23,45,92] and our work here, build upon these findings.

Designing for Mixed-Ability Collaborations
Despite decades of foundational research on assistive technologies for PWVI [7,39,41,49,63,65], the vast majority of prior work addresses scenarios where disabled users are acting alone. Accordingly, several recent projects have pursued design of technologies for collaborative

settings with mixed-ability teams – where some members have a disability, and some do not.

Branham and Kane [11] explored accessibility as a collaborative practice, in the homes of PWVI and their sighted companions. They used the term *collaborative accessibility* to describe the ways these mixed-ability teams work together to create an accessible home environment, like maintaining consistent orientation of shared objects which are tactilely indistinguishable (e.g., shampoo and conditioner bottles). They found that accessibility challenges in the home sometimes displace important intimate bonding opportunities. Similar studies in collaborative workplace [12] and collaborative indoor navigation [91] settings find that even the assistive technology and well-meaning sighted companions can lead to accessibility breakdowns. Finally, Thieme et al. [87] explore (dis)ability as it is constructed and negotiated through interactions between a person's body, and the social and environmental features of their environment. Through in-depth observations of athletes and spectators at the Rio Paralympics, the authors show how social connections contribute to negotiations of ability for PWVI.

To design interfaces supporting collaboration between blind and sighted users, Savidis and Stephanidis [79] explored the integration of visual and non-visual interface elements. Plimmer et al. [70] designed a multimodal interface for sighted teachers to guide blind students' handwriting, through haptic and auditory feedback. Piper and colleagues have explored user interfaces for facilitating communication between people with disabilities and their healthcare providers [68,69]. In this vein, our work considers the design of interactive technologies in a setting where PWVI are working collaboratively with their children who, in many cases, are sighted.

At a more general level, our approach to understanding and exploring the lived experiences of people with disabilities is heavily influenced by Disability Studies and aligns closely with the perspectives shared with the Assistive Technology community by Mankoff, Hayes, and Kasnitz [54]. As such, our analysis considers larger socio-technical factors influencing the co-reading practices identified, and privileges sharing the direct perspectives of our informants.

METHODS
We observed authentic conversations in a Facebook group dedicated to discussions of blind parenting. To preserve anonymity, we refer to this group as Blind Parent Forum (BPF). We use the term "blind," from here forward, to describe this forum and its members, as it is aligned with the way that this group identifies itself. However, this should not be interpreted as indicating any one member's specific identities or abilities, as the visual acuity of the parents described was observed to be highly diverse, and the insights shared speak to a wide range of visual abilities.

BPF has more than 1,500 members and is a very active community, with new posts daily. Because BPF is a closed Facebook group, two members of the research team requested access to the group and were admitted. The second author messaged the moderators to describe the study and request permission to observe the discussions occurring on this page. Two admins responded granting permission, and BPF members were informed of the presence of our research team in multiple public posts to the group. We note that it is not typical for this particular group to admit sighted members. So, the posts we observed were written primarily *by* blind parents, *for* a blind parenting audience. This allowed us to identify aspects and difficulties of co-reading which are particularly salient, from the perspective of the blind parenting community.

We used Facebook's integrated search feature to query all posts containing the keyword "read". We reviewed each of these posts and all comments posted in reply to them. Posts returned by this search that were not related to co-reading with children were removed from further analysis (e.g. Adults reading Braille alone, children playing with sticker books). We gathered and analyzed data in one-month intervals, moving backward through time until we achieved data saturation [31]. In total, we compiled a corpus of 497 unique posts and comments, from 229 unique users, during the 16 months from June 2017 to September 2018. For anonymity, we refer to these users here as BPs (blind parents) 1-39, and use singular they/them pronouns to refer to both parents and their children.

We conducted a thematic analysis of this data [13], following an inductive approach, using iterative comparisons of the themes and codes (sub-themes) applied. We refined our themes and codes until they accurately encompassed the structure and details of all data in our corpus.

FINDINGS
Our analysis was guided by three primary research questions: 1) Which practices, strategies, and methods do blind parents use to co-read with their children? 2) How do blind parents determine which specific co-reading methods to use? 3) How does blind-parent/child co-reading, as an activity, inform the design of ATs, more broadly? These research questions structure our discussion, here.

Co-reading Practices
In our data, we identified 312 references to specific co-reading practices. These include seeking advice, providing tips, sharing personal methods, and debating the merits of a particular co-reading strategy.

We use this analysis only to identify the range of practices discussed by blind parents, rather than to indicate preferences for any specific method. That some practices appeared in our data more frequently than others shows that those practices are more widely *discussed* by blind parents, but not necessarily more widely *used*. We note that the

practices identified are not discrete, nor are they exclusive of each other. Often, a combination of these methods was used to co-read. We provide an overview, here, of the diverse methods identified.

Braille

Braille was by far the most referenced method for co-reading in our data. In total 137 comments discussed using Braille for co-reading, comprising nearly half of all references to specific practices identified. Strategies for co-reading using Braille included; using two copies of the same book in Braille and in print, using twin-vision books in which Braille is written alongside print, reading digital materials with an external Braille display, and applying Braille overlays to print books. Despite the low and declining number of people who read Braille (discussed above), Braille is often the default recommendation for blind parents seeking advice for co-reading. A large portion of advice-givers first inquired "Are you a Braille reader?" before offering other options to advice-seekers.

Text-to-Audio Technologies

Text-to-audio technologies were a frequently identified strategy for co-reading (99 comments), but the individual technologies used varied. Audiobooks were most commonly discussed, likely because of the mixed opinions on these technologies. Audiobooks are frequently recommended because they are particularly accessible. But many BPF members feel they are "just not the same" as paperback books. Similarly, borrowing books-on-tape or CD-ROM from the local library, or using interactive e-books, were often viewed as subpar options. Text-to-Audio technologies were perceived negatively for a variety of reasons – many parents found the presence of a narrator is obtrusive to parent-child bonding, others felt being able to read to one's own child is an important part of their self-efficacy, and some simply found certain narrators' voices irritating. Some clever parents, like BP1, augmented these technologies by listening to audiobooks through a headphone, and repeating the words they heard to their child, noting the importance of allowing "*your* [children to] hear *your* voice and *your* interpretation" (emphasis added).

Other text-to-audio technologies have significant technological barriers, in addition to being "just not the same." For instance, Voiceover (Apple's integrated screen reader) and SeeingAI (a 3rd party mobile application, which vocalizes text in an image) are only able to determine the semantic content of texts written in certain fonts. Children's books, in particular, use a wide variety of unusual fonts to engage children's attention. BP2, a veteran user of SeeingAI, expressed disappointment that the app cannot read many books' contents, though it can "at least read the cover of the book."

Alternative Methods

Though Braille and text-to-audio comprised the vast majority of comments concerning specific co-reading methods, several other strategies were shared, and regularly portrayed more positively in discussions.

Often, expectant and new parents perceived the impetus of co-reading to be solely upon themselves – but more experienced parents suggested *having the sighted child read*, instead (17 comments). BP3, replying to a parent concerned about their ability to co-read with their first, newly literate child, soothed their fears suggesting, "I think your [child] will be more helpful than you realize. Once [they] learn the letters, [they] will be able to read them back to you, so that you know what the word is… This works well for my [child]."

While blind people are often perceived as a homogenous group, defined by their visual impairments, many BPF members (16 comments) identified using *eyesight* as a technique for co-reading, or for scaffolding other co-reading methods. For instance, BP4 listens to audiobooks on headphones, repeating the story back to their child, using their partial vision to support this practice. They state, "I can see pictures fairly well, so… I can stay on the right page!"

Frequently, parents indicated the benefits of *telling imagined stories* (14 comments). This practice, too, was often scaffolded by blind parents' partial vision. For instance, BP5 suggests "if you can see the pictures… just make up a story corresponding to [them]." Though it could be debated whether fabricating a story can be considered co-reading, this practice was identified as central to many parents' co-reading methods. Some parents even flipped the pages of a book while telling oral stories, to mimic reading the words printed on the page.

Because children's stories are relatively brief, many parents found it easiest to *memorize* the story, and repeat it verbatim to their child (12 comments). These parents may listen to an audiobook version of their child's printed book, or have a sighted companion recite the book to them, until they have memorized its contents. BP6 jokingly noted, "My eldest is twenty-three [years old] and I could still recite some of [their] board books!"

Several parents suggested finding *read-aloud videos on YouTube* (12 comments). This strategy is particularly advantageous for engaging young children because "[the reader] will show you the pictures [in] the book while they read it" (BP6). Still, some parents were skeptical of YouTube read-alouds, including BP7, who stated "it's just not the same as sitting down on the side of [my child's] bed, tucking [them] in, and reading a good old hardcopy book."

Lastly, the least common method identified in our data, was *deferring co-reading responsibilities* to a sighted companion (5 comments). It is not insignificant that this method was the least frequently discussed. Co-reading with one's own child holds a particular significance for many parents, and likely for those in our group – evidenced by

BP1's (and others') insistence on having their child hear their own voice and interpretation, as described above.

Combining Methods
Most frequently, these methods were used in combination with each other to perform co-reading. For example, many parents indicated listening to audiobooks, until they are memorized. They may then recite the story to their child, while turning through a printed copy. If they have partial sight, they may be able to use the pictures on the page to scaffold their memory. Too, parents of literate children may have their children remind them of the first words on the page. So, it is reasonable to imagine that *one* parent's co-reading practices, in *one* co-reading session, may involve 1) text-to-audio, 2) memory, 3) eyesight, and 4) having the sighted child read. In this way, co-reading practices were found to be highly personalized, and comprised of unique configurations of specific techniques which were accessible for the parent-child team.

Choosing a Practice
We found that a wide variety of factors affect which techniques are desirable, accessible, and eventually incorporated into parent-child co-reading practices. For many blind parents, we found that parents' *motivation to co-read* determined which methods were perceived as desirable and effective. Which methods were feasible depended on both the *parents' abilities,* and socially-supportive *others' abilities* to scaffold parent/child co-reading practices. However, which methods were ultimately implemented was primarily determined by the *availability of reading materials* from commercial publishers – and the choice of a publisher was itself influenced by a variety of consumer concerns.

Motivation to Co-read
The motivation for engaging in co-reading determined which co-reading practices were seen as desirable, and how the effectiveness of these practices was evaluated. Sometimes the motivations of parent and child conflict. The parents in our sample were most often driven to co-read to 1) contribute to their child's pre-literacy skill development, or 2) partake in an intimate, bonding activity with their child. Their children, unsurprisingly, often just wanted to have fun.

Parents primarily motivated by developing their child's pre-literacy skills often used methods which prioritize the accurate coupling of the book's written content, and the words spoken by the reader. For instance, read-aloud videos posted on YouTube were a common suggestion for parents concerned about their child's ability to read. BP8, giving advice to another parent, suggested to "search for 'read aloud' or 'story time' on YouTube and [you'll find] videos of people reading kids' books aloud, and they show the [book]… Tons of parents of print learners do this and they learn to read just fine." BP9, too, noted that "videos on YouTube of other parents reading picture books to kids… got me through the phase where they needed to see the

book as we read." Similarly, these parents were more likely to defer their child's co-reading activities to someone else, like BP8, who suggested parents "have sighted friends or family read books to [their child] over Facetime."

But, many of these methods proposed by parents motivated by pre-literacy development were viewed unfavorably by parents seeking bonding time with their child. BP10 voiced reluctance, stating "I've been having to resort to those read aloud books on YouTube, which is just not the same." Even parents who deferred the bulk of their child's co-reading time to a sighted other often wanted to personally co-read with their child. BP11 shared, "[my spouse] is sighted and usually will read the books, but it is something that I would like to do, also."

While audiobooks were a frequently suggested method for co-reading, they were perceived negatively by both parents aiming to develop their child's literacy skills, as well as parents seeking bonding time with their child. BP12, an expectant parent, stated, "I would absolutely love to read to my child when they get here, but I don't feel like putting in an audiobook is appropriate at all. It doesn't give *that intimate vibe* to me" (emphasis added). Conversely, BP13 expressed skepticism of the educational merits of audiobooks, saying, "I don't know about using too much that is only audio in the early years. They could miss out on a lot of fundamental visual learning that way."

In contrast, the advantages of simply making up a story were advocated by both types of parents. BP1 suggested parents make up a story, while performing reading behaviors, like flipping pages. While they note "this really only works with really small children who don't yet understand that the words on the page meant anything… it does allow you to teach your child some valuable pre-literacy skills, like learning what books are, how to turn pages, how to read from left to right in a sequence… etc." Similarly, BP14 notes the advantages of oral stories for bonding, suggesting that it is "the communication between parent and child that matters most. So, go ahead and make up your own words to the book. Your baby will love it!"

Braille was also perceived as meeting both parents' pre-literacy and bonding goals, especially using twin-vision books, which closely resembles the co-reading practices of sighted parents with sighted children. Some parents, especially expectant parents, like BP15 expressed concern about "being able to point at the words" while reading twin-vision books, where Braille and print are spatially separated. But more experienced parents, like BP16 reminded them that simply because "that's the way *sighted* people do it, that doesn't mean it's the *only* way to do it, by any means" (emphasis added). Additionally, children's desire to be entertained often complicated reading Braille in twin-vision books. BP17 shared, "[my child] was always pushing my hands out of the way to see the pictures, so I gave up." Likewise, BP18, a professional Braille teacher, notes "I've been able to read one-handed and upside-down

for some time… but I've never had a little reader steal pages from me!"

Parents often make the final determination of which co-reading practices to use. But, in this way, children's motivation to be entertained by a book may prevent parents from choosing strategies which meet only their own goals. The effectiveness of a particular co-reading technique, then, depends on how well it meets both parents' and children's individual motivations for co-reading.

Parents' Abilities

Perhaps surprisingly, we found eyesight was a frequently identified component of co-reading – emphasizing that blind people do not have uniform disabilities, or necessarily total visual impairments. For example, some parents who can see book illustrations used pictures as reminders of a story's content, while they recited a book from memory.

In the context of co-reading, ability to read Braille was far more significant than parents' vision impairments in determining which co-reading techniques were feasible. Several parents noted the importance of reading Braille for gaining access to the sizable selection of Brailled children's books. Providing advice to a parent concerned about the limited selection of accessible books that do not require Braille skills, BP19 stated, "These [other methods] are all very good suggestions, but this is a very good reason to learn Braille… Ultimately, I think Braille is the best solution for this dilemma [of finding accessible reading materials]."

However, reading Braille is far from a universal skill amongst people with visual impairments. In particular, for people whose visual impairments were not present at birth, Braille reading may be a relatively new skill. The present importance of Braille for finding accessible co-reading materials inspired some parents to learn Braille. BP20 shared, "I've had to learn [Braille] as an adult and it's never been that easy. Each month, when [my child and I] get a new book, I see it as a chance for me to practice… it's been beautiful how both of us have the chance to learn to read together." For other parents, reading Braille is unfeasible for other reasons, like BP21 who indicated, "even though I learned Braille, due to a nerve condition, it is very tedious for me to read, even preschool books." Despite the many reasons a parent with visual impairments may not be able to read Braille, much of the currently available "accessible" reading material privileges this skill.

Others' Abilities

Which co-reading methods were available was not determined solely by the abilities of the blind parent – but also by the abilities of others who might participate in, and support, accessible co-reading practices.

Most directly, as children's literacy skills developed, they were able to either scaffold their parent's reading by spelling the first words on a new page, or children may take the primary role in performing most of the reading themselves. BP22 suggested, "when they know how to read a little bit, have them read it with you and make it a game," to continue advancing children's literacy.

As children's literacy developed further, some parents facilitated their child's education by performing co-reading tasks in everyday settings. BP23, for instance, attributed their child's advanced literacy to their visual impairments, saying, "I was always getting [my child] to spell things to me so that I could know what it said and then eventually [they could] read to me short, little things, like in the grocery store." Similarly, BP24 shared, "[my child] reads the numbers on the doors to find [their] doctor's office. [They] also spell out signs to us when we are in a car," adding jokingly, "[they're] really good at reading the Toys'R'Us sign!" While co-reading, here, has a different connotation than co-reading a book, it shares many of the same practices. Parents facilitate their child's learning by encouraging them to read real-world materials, and can correct their child's reading, when they feel a misidentified food item, or hear a well-known retail chain's name mispronounced.

However, children's developed literacy did not always *increase* the number of methods available to the parent-child team. Sometimes, it obsolesced previously used methods. For instance, BP25 indicated, "when my [child] was younger I [could] read Braille to [them], but now, since I've learned Braille as an adult and I'm not very proficient, [they are] much more fluent in print than I am in Braille and [they tire] of my slow reading rate."

External to the parent-child team, other socially supportive adults may also contribute to making co-reading accessible. Sometimes, social supports contribute directly, by reading to the child books which are otherwise inaccessible to the blind parent. For instance, BP26 shared, "I can't read the books [my child] brings home from the library, but we have family and friends who come over and read those books for [them, so they're] still getting exposed to literature and reading."

External social supports may additionally perform preparatory tasks to make co-reading accessible for the parent-child team. Applying custom Braille to children's books ensures any book children may want to read is accessible to their parent. But this process is time consuming, and often requires a sighted companion to read and label the book. So, parents who used this method, like BP27, often suggested it is best saved for "when maybe you and your [spouse] have some time."

In these ways, the co-reading methods available to the parent-child team, partly depended upon the abilities of the child and supportive others.

Availability of Reading Materials

Motivation for co-reading and the presence of social supports determined which co-reading techniques were desirable and feasible. But which techniques were

ultimately implemented depended primarily upon the reading materials available from commercial publishers. Each of the strategies identified (with the exception of making up stories), in some way, relied on the features of the printed or electronic materials used. Seeking a specific book or reading material format often led parents to initially consider certain publishers. However, selecting a source for purchasing reading materials was shown to be a complex decision affected by a number of common consumer concerns, and considerations specific to blind parents.

Some common consumer concerns, like quality and cost of the materials offered, affected parents' decision to purchase books from a publisher. Quality of the book's material was of particular concern for parents with young children. BP28 noted that they were looking specifically for "board books, because [my child] is only 15 months [old], and any paper [becomes] crumpled or torn."

Cost, too, is a concern for most consumers, but especially for blind parents of young children. Often, accessible formats, like twin-vision books, are more expensive than children's books written only in print. The cost of accessible books is prohibitive for many parents, like BP29 who expressed, "I glanced through [a well-known, twin-vision book publisher's] selection a while ago, but gave up pretty quickly based on the prices I saw." Also, as young children age and their literacy skills develop, their interests and reading levels change rapidly – meaning parents with young children buy new books frequently. BP30 noted, "even [for] those of us who [already] have a handful of books, kids get bored after a while."

The cost of acquiring materials was unreasonable for many parents, even leading some parents in this group to propose taking collective actions. Some shared their contact information, to form a book exchange club. One of these parents, BP31, noted, "we do probably have a lot of the same [books, but] even so, being able to borrow back and forth prevents each parent from having to actually buy each book new themselves." Others suggested submitting collective requests to publishers for specific accessible books. BP32 indicated, "I am thinking, maybe if we all requested some certain books, it would be more likely to be Brailled, [which might be cheaper than] how much more it costs to request a special Braille."

In addition to concerns about the quality and cost of book materials, many parents expressed concerns with the accessibility of *acquiring* books from certain sources. For instance, local libraries were frequently suggested as sources for free books. But, as BP33 noted, "it's not like sighted parents who can go to the library and refresh their supply easily." For many blind parents, especially in areas with limited public transportation, traveling to the library is difficult, and may involve the support of a sighted companion.

Recognizing this issue, several non-profit organizations offer programs which deliver twin-vision children's books to the homes of registered members. However, these programs typically have strict qualifications for who may register. Most often, these qualifications limit this service to blind *children,* rather than blind *parents.* Despite this, some parents worked around these qualification requirements to register. For example, BP34 stated, "I [registered] through a phone call, explained my situation, [and] they signed us right up!" But other parents felt a responsibility to the wider blind community, in observing these qualification requirements, like BP35 who indicated, "I just don't want to take [resources] from blind *children*, as a blind *parent*, if you know what I mean" (emphasis added).

Many parents indicated a similar allegiance and responsibility to the blind community when considering the rapport of a specific source. In particular, parents specifically sought accessible book publishers who have rapport with the blind community – operated by blind people or owned by known friends and allies. For example, one publisher was recommended by BP36, because "it was set up by a dad who is blind [who] wanted to read stories independently with his children." Similarly, another publisher who was a member of the BPF at the time of our observation, was frequently recommended *because* they are identified as a friend to the blind community and a personal friend of many BPF members. This publisher was recommended in 26 separate posts, by 17 unique BPF members, during our observational period.

While many of the considerations addressed above were identified in relation to acquiring printed books, purchasing electronic books involved many of the same considerations. In fact, purchasing electronic books presented unique considerations, in addition to those of acquiring printed books. For instance, some parents were irritated by the style of some e-book narrators. BP37 shared, "audio books are great, but I hate some voices and I hate paying for books, [when] I can't listen to the narrator's voice." Consequently, many parents preferred to use the familiar narration of Apple's integrated screen reader, VoiceOver. But VoiceOver is not a perfect solution – "not all books are compatible with VoiceOver" (BP38), often due to unrecognized fonts, and some parents simply "have trouble with understanding VoiceOver" (BP39).

Parents must consider each of these factors when seeking a source from which to purchase accessible reading materials. The availability of materials which are 1) of good quality, 2) affordably priced, 3) accessible to acquire, 4) produced by reputable publishers and, often, 5) compatible other ATs, affects which co-reading techniques can be used. While motivations for co-reading influence which techniques parents *prefer* to use, and the abilities of the parent and other social connections affect which techniques are *feasible,* we found the format and features of available

materials most directly determined which techniques were *implemented.*

DISCUSSION

To our knowledge, this study is the first academic exploration of how blind parents co-read with their children. We found that the co-reading techniques blind parents implemented often differed from those which they preferred, suggesting that this area is worthy of further exploration and innovation. Below, we revisit our findings in light of prior work to propose future directions.

Including Disabled Parents in Technology Design

The vast majority of previous HCI and design work in this space has focused on supporting collaborative activities between adults [24,25,36,75], and supporting childhood learning [2,35,46,74,77]. Few works have focused on collaborations between adults and young children [72,73,93,94], especially where one of these actors has a disability. Explorations of mixed-ability collaborations between adults and young children have exclusively considered *children* with disabilities [70,71]. Our work charts new ground by examining intergenerational, mixed-ability collaborations between *adults* with disabilities and their young children – and suggests that there is ample opportunity for design in this space.

Our focus on blind parents reveals a significant gap in technological and material supports for this population. For example, our finding that accessible children's book subscription services are available only to blind children mirrors similar trends in design research, which has considered either designing for blind children (e.g., [46,52,88]) or blind adults outside the presence of children (e.g., [7,41,53]). This gap in knowledge is particularly salient as set against the backdrop of a society which often devalues or denies the parenting capabilities of people with disabilities. Despite the absence of empirical investigations into the parenting strategies and skills of people with disabilities, 70% of American states may legally deny the fundamental parental rights of people with disabilities, strictly on the basis of their having some disability [66]. By contrast, our findings suggest that parents with disabilities are not only capable, they have valuable insights into parenting which would likely improve the design of technologies and services for *all* parents and children, regardless of their abilities.

Additionally, we argue a need to include blind parents in the design process because many blind children become blind parents – and perhaps more importantly – many blind adults were sighted children. Numerous parents in our observation had learned Braille as an adult, or were newly inspired by their child's emerging literacy to learn Braille. It cannot be assumed that supporting blind children's learning of valuable skills, like Braille, will "trickle up" to all blind adults. Designs aimed at supporting people who are blind should be inclusive of a diversity of ages, while recognizing that blind users' proficiencies in the *skills of being blind* do not necessarily depend upon their age.

Our work challenges traditional ideas about *who* is in need of technological support during parent/child and mixed-ability collaborations, extending findings from recent work in AT which highlights social aspects of accessibility [6,82,83,87]. Traditional approaches to mediated co-reading in both the design and education domains [28,47,78], assume only the child benefits from technological support in reading a printed text. Interventions targeting parents' role in co-reading, focus on auxiliary tasks like dialogic questioning [18], or providing structure to reading activity [73]. Similarly, traditional approaches to AT design have been critiqued for their tendency to put the impetus of creating access on people with disabilities [11]. When we consider BP23's child, who spells words on the labels of food items to BP23 while grocery shopping, we note that neither BP23 nor their child can "read" the labels individually. But, through the combination of the child's sight and BP23's sense-making, the pair can read together. In this situation, designers could equally consider either, both, or neither actor as being "in need" of technological intervention. Our findings thus expand the possible sites of intervention from simply the child, to also include the parent and the parent-child unit.

Expanding Our Definition of Co-Reading

Most academic literature concerning co-reading, particularly in Education, conceptualizes co-reading as oriented around a printed book, which is read aloud to children by a parent, in order to develop children's literacy [61]. But, our findings suggest that co-reading is artifact agnostic (e.g., Braille books and audio books are also used). In addition, vocalizing text is not strictly the responsibility of the adult, such that the interaction is educational for *both* children and their parents.

We found that views of co-reading which are strictly focused on children's education may unnecessarily formalize this process – over-emphasizing the presence of a digital or analog book, and the intentionality of developing children's literacy. Parents in our sample frequently co-read with their children incidentally, using real-world materials, on-the-go. BP23's co-reading activities, described above, occur in the mundane setting of a grocery store, as a method for identifying food. Similarly, BP24 and their child co-read publicly displayed signage, to pass time in the car, and to navigate a maze of doors at the doctor's office. In contrast to previous design solutions for digital co-reading [17,18,72,73], our findings suggest that augmenting reading materials, to support specific educational outcomes, in designated instructional settings, is not the only avenue for technologically scaffolding co-reading.

Strictly educational perspectives of co-reading may also ascribe undue importance to the role of parents in reading and vocalizing the text. The belief that parents will, or should, be primarily responsible for reading aloud is

prevalent amongst Educational co-reading scholars, who have even focused specifically on "mothers" [14,47]. Interestingly, this belief was also prevalent in our observational group, especially amongst new and expectant parents. More experienced parents, though, were aware of how quickly children become useful assets in co-reading, like BP3, who reassured an expectant blind parent, "I think your [child] will be more helpful than you realize." Some parents even attributed their children's advanced literacy skills to giving their children a primary role in reading books, and other everyday textual items. Highlighting children's active roles in co-reading levels traditional hierarchical perspectives which position children as passive recipients of expert knowledge from an adult teacher.

In fact, our findings suggest that conceptualizing children and parents in static student/teacher roles may wrongly indicate that children are the only people learning through co-reading. Parents in our observation also viewed co-reading as an opportunity to learn, themselves. Most directly, many parents – especially those who developed a visual impairment later in life – saw developing their child's *print* literacy as a valuable opportunity to develop their own *Braille* literacy. Other parents acquired, or improved, skills in support of co-reading with their child, like learning how to perform the actions of reading a book to demonstrate for their child, how to commit relatively long texts to memory, and how to apply custom Braille to a printed book. Perhaps most importantly, parents and children learned *together* how to effectively perform collaborative reading– which transferred into other real-world tasks, like navigation and object identification (as discussed above in the cases of BP24 and BP23, respectively).

Our observation that children are active participants in co-reading and that both parties are engaged in learning is an exemplar of the types of interdependence described by Bennett et al. [6]. This frame highlights the non-hierarchical and simultaneous relations between people with and without disabilities. When we consider collaborative reading as an interdependent interaction, we make visible the labor performed by both blind parents and their children. Through this lens, parents are not simply interactive objects for facilitating children's passive acquisition of literacy – nor are children simply the "eyes" for their blind parents. Rather, the frame of interdependence highlights the mutuality and relationship building involved in the parent/child co-reading process. Recent works in interactive co-reading technologies, which design intelligent agents to replicate parents' role in co-reading [30,34,62,89] or evaluate digital tools' efficacy on specific literacy metrics, like story comprehension [32,50], may neglect these more nuanced benefits of the activity. Our findings emphasize the importance of keeping both children and their parents in-the-loop, by demonstrating that co-reading is not a strictly unidirectional, educational activity –

but also an intimate and social process for collaboratively creating access to literature and literacy.

LIMITATIONS AND FUTURE WORK

Though we obtained and analyzed a significant amount of data (497 posts) from a large number of people (229 users), a limitation of this work is that we observed only one blind parenting group. It should not be expected that the findings shared here are representative of other blind parenting forums. Norms and perspectives of disability vary significantly between different communities, and different blind advocacy groups (e.g. amongst the National Federation of the Blind, as compared to The American Foundation for the Blind). There is space for future work observing another, or multiple blind parenting forums, to understand these differences. Future studies of the topics discussed here, using other methods like qualitative interviews which allow for probing specific topics more deeply, would also be beneficial. Lastly, the phrase "young children" has specific connotations in literacy development research (often meaning children ages 10 and younger [59]). Here, we adopt a flexible definition of "young children," 1) because we cannot determine the ages of children identified, and 2) to distinguish our findings from intergenerational collaborations between adult children and their older-adult parents.

CONCLUSIONS

We conducted a qualitative, thematic analysis of 497 posts, from 229 users, from authentic discussions of co-reading practices in a blind parenting forum. To develop an understanding of this under-explored domain, we described the variety of techniques used by blind parents to co-read with their children. We identified factors affecting parents' choice of specific co-reading techniques, including 1) motivation, 2) individual abilities of parents and children, 3) the presence of social supports, and 4) the availability of accessible reading materials. We used these findings to suggest considerations for the design of ATs supporting co-reading between blind parents and their children, and to share blind parents' valuable insights, as they inform the design of interactive co-reading technologies, more broadly.

ACKNOWLEDGMENTS

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