Design of Accessible Digital Picture Books for People with Print Disabilities

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Abstract
This research examined the design of accessible digital picture books (e-books) for people with print disabilities. Accessible e-books can be presented in a simplified layout, with suitable fonts, or audio synchronized with word highlighting. Previous studies have established that children show curiosity about recordings of unfamiliar natural voices that are different than their mother's voice when reading an e-book on a tablet PC, but reactions to text-to-voice synthesized speech have not yet been tested. We investigated the effects of natural versus synthesized voices on ease of listening. Eight adults (2 males and 6 females) took part in this study. Five versions of a digital picture book were created, with different voice conditions (natural voice of girl and an adult, synthesized voice of a girl and an adult, animated voice of a boy). The study was set up on a tablet computer (iPad). First, participants listened to the picture books being read in each of the voices. Then, they were asked to rate the ease of listening for each reading voice using 4 items evaluated on a five-point Likert scale. In addition, the participants were interviewed and asked to comment on the digital picture books. The results showed that participants preferred digital picture books with speech synthesis rather than natural voices. The synthesized child's voice was suitable for the digital picture book in which a girl was a character, suggesting that speech synthesis might be suitable for character voices in picture books.

Keywords: Accessibility, digital picture book, print disability, text-to-speech

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Introduction

A picture book is designed so that illustrations are as important as text when telling a story. Reading picture books to young children is seen as beneficial for fostering language abilities (Aram, 2006). Technological innovations have led to inherent changes in how individuals read; several book publishers and periodicals have abandoned print in favor of digital media. Numerous digital picture books are versions of classic children's stories that were once published in a traditional printed form. In most cases, text and illustrations are presented in a similar format as the printed version, but multimedia features, such as word pronunciation, narration, sound effects, and animations, are incorporated. Multimedia formats for picture storybooks offer various ways for supporting story comprehension and other aspects of literacy (Smith, 2001). Grimshaw et al. (2008) reported that the main benefit digitized storybooks have for children's reading abilities, compared to printed versions, are narration provisions that are accompanied by animated pictures and sound effects that relate directly to the storyline. Reading electronic picture books might facilitate children's cognitive development, as well as their picture book reading ability. In accordance with these changes, e-readers with advanced accessibility options are now available to aid people with print disabilities.

People with print disabilities are unable to read standard printed material because of a visual, physical, perceptual, developmental, cognitive, or learning disability. Individuals with poor vision as a result of advanced age are also included within this category. Print disabilities prevent a person from gaining information from printed material in a standard way, requiring them to utilize alternative methods, such as technological or personal aids, to access that information (Learning Ally, n.d.).

Digital picture books are widely available and can be accessed with a portable electronic device. However, while several digital picture books are available for individuals with normal reading acumen, availability is limited for individuals with print disabilities. Moreover, little is known regarding the impact of artificial or natural voice text-to-speech functions in the context of reading digital picture books.

Previous studies have established that children show curiosity regarding unfamiliar natural voice recordings (that differ from their mother's voice) when reading an e-book on a tablet PC (Ikeshita-Yamazoe et al., 2012). However, reactions toward text-to-voice synthesized speech have not yet been tested. To fill this gap, the present study examined the design of accessible digital picture books (e-books) for people with print disabilities. The goal was to develop universally accessible e-books. As a first step, we evaluated the effects of natural versus synthesized voices on the ease of listening e-books in a sample of individuals without print disabilities.

Methods

Participants

Eight adults (2 males and 6 females) between 20 and 50 years of age took part in this study. All participants were native Japanese speakers; and all participants except one had never read e-books before. Written informed consent was obtained.

Materials

The study used a picture book (Kore wa Mahou kana; Sakura Maeda, 2013) intended for both children and adults. The book tells the fantasy story of a girl and a magical store. None of the participants had ever read this book before. To create the e-book, illustrations were scanned (but not the text). All text was converted into text data. The digital picture book was created in EPUB 3.0 format. The digital picture book was presented in a simplified layout, with suitable fonts or audio synchronized with highlighted words. Illustrations that are central to comprehending the story include a text alternative using a text-to-speech synthesized voice. The digital picture book was created in several formats, with and without the embedded reading voice (see Table 1). Five versions of the digital picture book were created, with different voice conditions. Two versions used natural voices (either a female adult or a girl) and two used synthesized speech (either a girl or a boy anime character). These voices were created using text-to-speech software (AITalk Plus, AI Inc.). This software enabled us to provide the listener with more natural, higher-quality human-like voices than a conventional machine sound. The final version of the digital picture book did not have the embedded reading voice. Instead, the reading voice was a voiceover (female adult) recorded through the iPad's (Apple) accessibility functions. The e-books were read using the Apple reader application iBooks on a 9.7-inch Apple iPad.

Table 1. Characteristics of each of the five versions of the digital picture book.

Digital picture book	Reading voice	
Book 1	Natural voice	Female adult
Book 2	Natural voice	Girl
Book 3	Speech synthesis	Female adult (voiceover)
Book 4	Speech synthesis	Girl
Book 5	Speech synthesis	Boy anime character

Procedure

The study was set up on a tablet computer (iPad). First, participants listened to the picture books read in each of the voices. Then, participants were asked to rate the ease of listening for each voice using 4 items evaluated on a 5-point Likert scale (see Table 2): 1 = "strongly disagree," 2 = "disagree," 3 = "neutral," 4 = "agree," and 5 = "strongly agree." In addition, participants were interviewed and asked to comment on the digital picture books.

Table 2. Questionnaire Items.

	Question
1	Have you ever read digital picture books?
2	Which voice of the five digital picture books did you find most easy to listen to?
3	What do you think are the differences in readers' story comprehension when different voices are used?
4	Do you think digital picture books will be used in the future?

Results

None of the participants had previously read a digital picture book (Q1). When asked which picture book was the easiest to listen to (Q2), 5 respondents chose Book 4 (synthesized voice of a girl), one respondent chose Book 1 (natural voice of a female adult) and one respondent chose Book 2 (natural voice of a girl) (see Figure 1). Non-responses were eliminated.

The average evaluation provided for Q3 and Q4 were 4.3 ± 0.7 and 3.4 ± 0.5 (see Figure 2). Participants made several comments regarding the digital picture books. The comments included "I thought about it, and I wonder if this is something that the world will like since a lot of people can share in the new book because it's digital." "I think this is a new form of entertainment for people who like to hear the story and the representation of the sounds." "I think digital picture books will definitely change our worldview." "Voiceovers and synthetic speech are difficult to listen to."
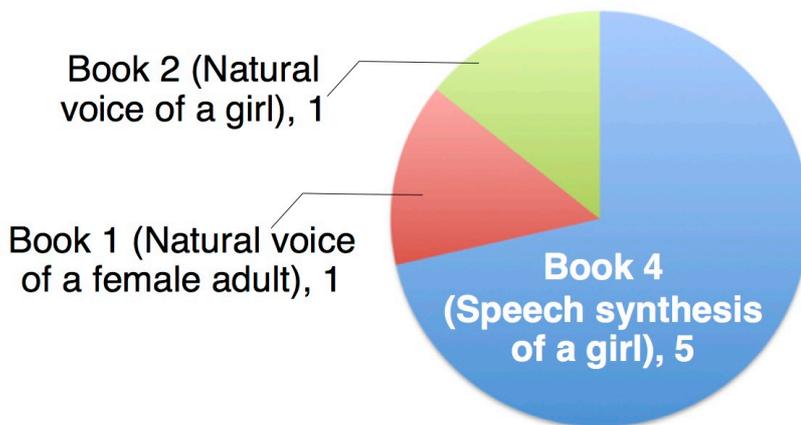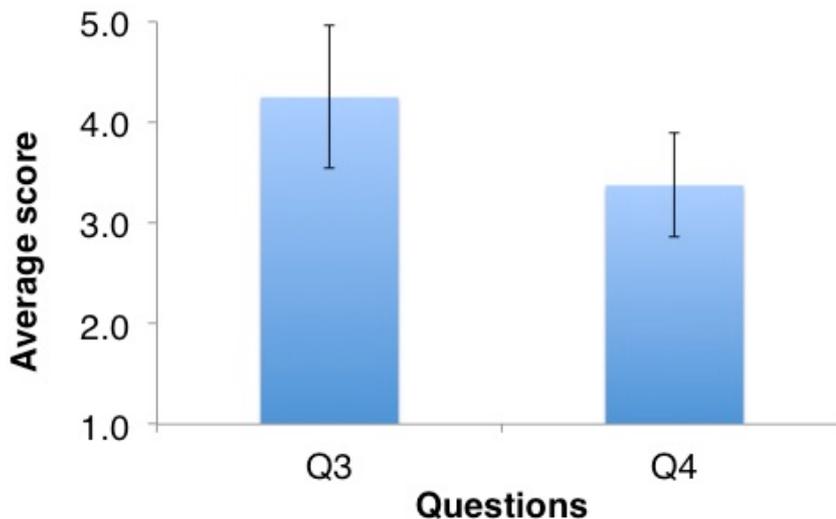
Figure 1. Results of evaluation for Q2.

Figure 2. Average response for comprehension of the different digital picture book forms (Q3) and the desire to use these picture books in the future (Q4). Error bars represent standard deviations.

Discussion

The current study showed that adult readers prefer digital picture books with synthesized speech rather than natural voices. The synthesized child's voice was suitable for the digital picture book in which a girl was the main character (see Table 1). Otsuka and Toyama (2014) reported that speech synthesis might influence human emotional reactions. Our results suggest that appropriate speech synthesis of natural, high quality human-like voices might affect reader comprehension and story enjoyment. Accessible digital picture books hold the possibility for substantially increasing access to material among people with print disabilities.

A slight advantage was identified for synthesized speech compared to a natural voice using the tablet computer. This suggests that appropriate synthesized speech might help people with print disabilities read picture books. Since the sample size in this study was rather small, future studies will include a larger sample size to better understand how reading with electronic media affects text recognition among people with print disabilities. This will help determine the optimum display method and settings for maximizing visual information processing. Developing a picture book that anyone can enjoy is difficult, but our research will help provide equal access to this form of information.

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