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Reading behaviors and text-to-speech technology perceptions of people with aphasia

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Abstract

People with aphasia often have reading impairments that affect participation in daily activities. Text-to-speech (TTS) devices are technology-based supports that can facilitate processing of written materials. The purpose of this study was to gather information about the reading behaviors and TTS technology perceptions of people with aphasia who had first learned about system features and options. Sixteen people with chronic aphasia participated in single, one-on-one instructional and guided practice sessions using TTS systems. They answered close-ended questions about current reading behaviors and materials and ways they believed these would change given TTS system access. Participants reported reading at home and community locations. Most read calendars, newspapers, magazines, and mail. Participants who did not read lengthy materials – such as newspapers, magazines, and novels – indicated their interest in these materials would likely increase given TTS support. Although participants did not predict substantial comprehension changes given TTS support, most expressed interest in the technology after learning about it. Thus, people with aphasia perceive TTS systems as helpful for comprehending lengthy materials. Given modest predictions about comprehension benefits, presenting TTS as one of several support strategies is an appropriate recommendation.

Keywords

aphasia; assistive technology; comprehension; reading; text-to-speech

Adequate decoding and comprehension of written content is important for accessing and transferring information, engaging in leisure activities, and participating in social exchanges. For people with aphasia, impaired reading can hinder participation in many life activities (Webster et al., 2018a, 2020). Consequently, speech-language pathologists

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implement interventions to facilitate literacy restoration and teach strategies to compensate for persistent impairments (Bernstein-Ellis & Elman, 2003; Dietz et al., 2011; Purdy et al., 2019; Webster et al., 2018b). One compensatory strategy involves using text-to-speech (TTS) systems to present auditory and written content simultaneously. Currently, however, little information exists about the perceptions of people with aphasia about using this type of assistive technology. Gaining this information will help reduce the "evidence-to-practice gap" (Douglas et al., 2015, p. S1833) regarding reading interventions for people with aphasia. Our purpose was to explore the social validity of TTS system adoption by examining perceptions of people with aphasia about potential uses for the technology and changes foreseen in personal reading behaviors given implementation.

Reading supports

Many researchers have sought to understand the reading experiences of people with aphasia (Kjellén et al., 2017; Knollman-Porter & Julian, 2019; Knollman-Porter et al., 2019, 2015; Webster et al., 2020, 2018b). For example, Knollman-Porter et al. (2015) interviewed six people with post-aphasia changes in reading proficiency, motivation, and preferred materials. Despite continued desires to read, difficulty with lengthy content often prompted selection of short passages and infrequent or no attempts to read lengthy material. Participant-reported strategies for improving reading included selecting passages with images, scanning texts for easily understood words, and relying on previous knowledge. Seeking assistance from others was also a strategy but conflicted with a reported desire for independence. Although all participants noted the potential for using assistive devices, only one routinely used a TTS system. Similarly, Webster et al. (2018b) interviewed 10 people with chronic aphasia about strategies aiding reading comprehension. Even though some participants indicated using technology devices such as computers and mobile phones, albeit inconsistently, none reported using any technology-based strategies – such as text-to-speech systems – to support reading efforts. Yet another, more recent survey of reading support strategies used by 82 people with chronic aphasia revealed comparable findings (Webster et al., 2020). Participants cited rereading content, slowing reading speed, receiving support from others, and using images as compensatory strategies; however, technology use of any sort was endorsed by only 17% of respondents.

Examined collectively, extant research findings suggest that some people with aphasia are beginning to explore or use TTS technology to support reading, but implementation remains limited (Knollman-Porter et al., 2015; Webster et al., 2020, 2018b). This is in contrast to the growing use of TTS technology among other people both with and without reading challenges. For example, educators acknowledge the importance of TTS technology for providing students with reading challenges or visual impairments access to print (Guha, 2017; Hodapp & Rachow, 2010; Parr, 2013); among readers without disabilities, the popularity of TTS technology is evident in its inclusion as a standard feature on tablets and e-readers. Despite these endorsements, expanding the use of TTS technology as a reading support for people with aphasia has lagged. Given the potential benefit afforded, exploring the perceptions of people with aphasia that may be inhibiting their adoption of TTS technology is warranted. Also, consideration of anticipated changes in reading

behaviors given access to TTS technology may be informative to practitioners assisting people with aphasia to increase reading independence.

TTS systems for people with aphasia

Researchers have established that combining written and auditory content presentations via TTS systems improves reading comprehension and/or efficiency for some people with aphasia (Brown et al., 2019; Caute et al., 2016, 2018; Hux et al., 2020; Knollman-Porter et al., 2019; Wallace et al., 2019). Differing outcomes across studies and participants likely reflect either unique residual reading abilities or differences in written stimulus characteristics (e.g., text length, sentence complexity, assessment procedures). These outcome disparities are not surprising given the variability of reading materials available and the heterogeneity of reading preferences, strategies, and abilities among study participants. Still, people with aphasia generally report liking content presented via TTS systems. Specifically, at sentence and paragraph levels, most people prefer combined auditory and written modalities to either modality in isolation (Brown et al., 2019; Knollman-Porter et al., 2019; Wallace et al., 2019); however, this preference does not consistently align with the modality yielding the best comprehension.

Social validity of text-to-speech systems

All people, regardless of disability status, engage in reading activities as a means of accomplishing unique personal and social goals (Parr, 1995). These goals are not generalizable across the population, and, instead, reflect wide variability regarding social roles, responsibilities, and interests (Parr, 1995). As such, expecting all people with aphasia to endorse a desire to read independently is not realistic or appropriate. Similarly, people with aphasia are likely to be unique in their preferences regarding support strategies, and practitioners need to take individualized goals and support strategy preferences into consideration when exploring reading interventions.

Understanding perceptions of and acceptance by people considering assistive technology adoption is critical for functional use. Various models exist to support practitioners in matching assistive technology options to individuals (e.g., Guner & Acarturk, 2020; Holden & Karsh, 2010). Central to all such models is the notion that assistive technology use is likely to persist only when a person finds it helpful and useful when engaging in functional activities. Assistive devices that require substantial effort to use, are not readily available when needed, or do not accommodate a person’s preferences and abilities are most likely to be rejected. Regarding TTS devices, features influencing acceptance and, hence, warranting investigation include the rate of speech output, the options available regarding highlighting, and the quality and acceptability of speech output voices.

Previous researchers examining TTS technology have examined how variations in some salient TTS features affect comprehension and reading efficiency (e.g., Hux et al., 2020; Knollman-Porter et al., 2019); however, they have not sufficiently addressed how these features affect perceptions and acceptance by people with aphasia. As such, results from extant research have yielded some information about preferences for specific TTS features

(e.g., voice, speech rate; e.g., Hux et al., 2020), but have not explored the technology's social validity for people with acquired reading challenges. Furthermore, opinions expressed about TTS technology have resulted from single experiences participants have had while performing research procedures controlled by investigators (e.g., Brown et al., 2019); participants have not had opportunities to adjust or compare TTS settings and features across multiple systems to understand fully the adaptability and potential benefit possible by using the technology.

Current study

Few people with aphasia have experience using TTS systems in daily life (Knollman-Porter et al., 2015; Webster et al., 2020) even though technology advances have resulted in greater system availability and flexibility regarding user-adjustable settings. As a first step to address this situation, people with aphasia need opportunities to explore, manipulate, and comment about TTS technology. Allowing engagement in this type of process can inform clinicians about how TTS technology can assist people with acquired reading challenges and whether it has sufficient flexibility to accommodate the unique reading desires, preferences, and goals of a particular person. We sought to illustrate this process by providing people with aphasia with guided practice using, modifying features, and comparing TTS systems. We followed this experience with an opportunity for our research participants to express their concerns and beliefs about TTS technology feasibility and potential use. Our intent was to (a) expand existing literature about current reading experiences and behaviors of people with aphasia and (b) understand the perceptions of people with aphasia about TTS technology and how access to it might influence future reading preferences and behaviors.

Methods

We obtained institutional review board approval at both institutions at which data collection occurred before recruiting participants and implementing study procedures. We used aphasia-friendly strategies (e.g., frequent comprehension checks, pointing to written text while speaking aloud) to promote comprehension of the study purpose and procedures. All participants signed an informed consent document after having demonstrated adequate comprehension of planned activities.

Participants

The 10 male and 6 female participants ranged in age from 35 to 78 years ($M = 63.63$; $SD = 11.51$) and were between 2.17 to 22.83 years ($M = 10.69$; $SD = 7.31$) post-onset of aphasia. All were Caucasian, and all but one had acquired aphasia from a left hemisphere stroke; the remaining participant acquired aphasia from non-progressive encephalopathy. We selected participants as part of a convenience sample from university clinics, local support groups, and registries of people interested in research related to aphasia. We only included participants who spoke American English as a primary language, were literate, and were right-hand dominant prior to acquiring aphasia; their educational achievement ranged from 12 to 19 years ($M = 15.19$; $SD = 2.43$). Furthermore, we sought to include people with a wide range of reading abilities and aphasia types and severities so we could obtain varied

perspectives regarding TTS systems. All participants had completed vision and hearing screenings within the past year. Additional demographic data appear in Table 1.

Participants performed selected subtests of standardized assessments; their scores appear in Table 2. Subtests used for assessing language and cognition were from the Western Aphasia Battery – Revised (WAB-R; Kertesz, 2006), the Comprehensive Aphasia Test (CAT; Swinburn et al., 2004), the Reading Comprehension Battery for Aphasia – 2nd edition (RCBA-2; LaPointe & Horner, 1998), and the Cognitive Linguistic Quick Test+ (CLQT+; Helm-Estabrooks, 2017). We administered these assessments with the intent of including research participants who were heterogeneous regarding aphasia severity and reading comprehension, auditory comprehension, and cognitive abilities. A diverse sample was appropriate for our purposes because it reflects the highly individualized nature of reading and technology preferences among adults regardless of disability status.

We also were purposeful in our selection of participants who did not use TTS systems in their daily lives. All participants reported having tried TTS technology at least once prior to study participation, but none used it routinely. For all but one participant, previous TTS exposure was from engaging in research with TTS simulations created by our team of researchers; for the remaining participant (i.e., P16), experience was limited to other, unspecified TTS system exposure. Previous research experience involved participation in structured experimental procedures requiring engagement with TTS simulations that varied single, distinct TTS features (e.g., speed of auditory presentation, presence or absence of text highlighting); these experiences did not allow participants to explore commercially available TTS devices. Our inclusion of participants who had limited TTS system exposure minimized the influence of previous experiences on perceptions arising from performance of the experimental tasks.

We gathered information about participants' current technology use because of our interest in their perceptions about TTS systems as a technology-based support and because experience with and frequency of use of certain technologies could influence perceptions about TTS systems. We asked technology use questions by employing aphasia-friendly interview techniques, supportive conversation procedures, and external supports (i.e., written text and images). Questions targeted the type and frequency of use of various forms of technology (e.g., computer, smart phone, electronic readers, smart home devices). We specifically probed for information about technologies with computer-generated voice output. Summarization of the obtained data appears in Table 3.

Materials

Study materials included a Reading Behaviors survey, a PowerPoint© presentation about TTS technology, and TTS devices.

Reading behaviors survey

The researcher-generated Reading Behaviors survey included a closed set of Likert scale, yes/no, or multiple-choice questions (see Appendix A). The first questions probed which of 10 types of materials a participant read post-aphasia acquisition (e.g., "Do you read newspapers?"), the location of reading activities, and the strategies employed to facilitate

decoding and comprehension. All participants answered the same questions presented in the same manner and order. Whenever a participant endorsed reading a specific material, we proceeded by asking a follow-up, 4-point Likert scale question about comprehension (e.g., "My understanding of newspaper articles is . . . "). The two remaining multichoice questions queried participants about any prior attempts and any prior consideration to use TTS technology. Another set of questions probed for predictions about engagement with each of the 10 materials types if the person had access to TTS technology (e.g., "Would you read newspapers with TTS technology?"). We asked follow-up questions regarding material comprehension whenever a participant endorsed use (e.g., "My understanding of newspapers articles with TTS technology might be . . . "). We presented all questions in written and spoken form with written formatting incorporating aphasia-friendly principles (e.g., ample white space, large font size, simple syntactic structures, and images). For example, the question about reading newspapers was accompanied by two photographs – one contextualized of a person reading a newspaper and one decontextualized of a newspaper in isolation – along with the written word *yes* with a checkmark in a green box and *no* with an X in a red box. See example image in Appendix B showing a contextualized photograph. Each written question appeared on a separate page for each material about which we asked.

PowerPoint© presentation

We created a 14-slide presentation about TTS and a written script mirroring slide content. The presentation introduced TTS technology and provided brief education about various options (i.e., cost, voice, rate, device platforms, highlighting, and pausing and replaying content) to provide participants with an overview of TTS technology before they had the opportunity to explore the systems. Embedded audio and video examples provided demonstrations of system options. Questions probing participants' possible future use of TTS technology were included in the PowerPoint© presentation with the question text appearing at the top of the slide (i.e., "*Do you think you might use text-to-speech?*") and four answer options (i.e., *yes, no, maybe*, and *I don't know*) appearing in a grid below it. Asking questions about potential TTS use before and after the presentation allowed us to understand how participants' perspectives changed with provided information. Appendix C shows an example question slide from the presentation.

TTS systems

We used three TTS software systems on three hardware platforms to demonstrate user-adjustable features. We selected systems representing a range of features and options. Specifically, we selected systems that afforded demonstration of six key features on different platforms and with commercially available TTS systems representing a range of prices. On an iPad Pro, we demonstrated voice and speaking rate options using Natural Reader©; on a Macintosh laptop, we demonstrated uploading documents and pausing TTS output using Read&Write™; and on a Windows Surface™, we demonstrated replaying and highlighting options using Kurzweil 3000®. Using multiple TTS systems and platforms allowed us to minimize any potential effect of familiarization with a specific platform and to focus on demonstration and exploration of targeted features.

Procedures

Participants completed a single one-on-one experimental session lasting up to 90 minutes. We used Supported Conversation techniques such as pointing to images and reading written text aloud (Kagan et al., 2001); reliance on a script ensured procedures were consistent across participants. Response modes used by participants included pointing to images, gesturing, writing, and speaking; whenever uncertainty existed about a participant's communicative intent, we confirmed our understanding by asking yes/no questions. Participants first answered all questions included in the Reading Behaviors survey as we read them aloud. We then used the PowerPoint© presentation slide showing four answer choices to ascertain a participants' willingness to consider using TTS technology if it were available to them. Next, we provided information about TTS technology using the PowerPoint© presentation. We then repeated the previous procedure to ask participants a second time about their willingness to consider using TTS technology. We followed this with a demonstration of user-adjustable and standard features on TTS systems. Demonstrations were done in-person using a standard script and procedure. This standardized procedure included opportunities for participants to adjust demonstrated features independently or with verbal and gestural support as needed. Subsequently, we asked participants about their interest and predicted use of TTS technology with various reading materials. We also had participants predict whether any changes would result in their reading comprehension by using a TTS device; this allowed us to consider how estimations about comprehension changes influenced participants' decisions about using TTS technology with specific reading materials. We concluded by asking once again whether a participant would consider TTS technology as a reading support; as done previously, we presented this question with four answer choices appearing on a PowerPoint© slide. Following completion of all sessions, we computed frequency counts, means, and response ranges across participants.

Results

Reading behaviors with and without TTS support

All participants reported reading at home; many also read during speech-language therapy sessions and with clubs or groups. Participants acknowledged benefitting from various reading strategies. As shown in Table 4, some strategies reflected reading material selection, some reflected dependence on others, and some could be implemented independently. The most frequently reported strategies were relying on previous knowledge, looking for keywords, and referencing images. Five participants endorsed TTS technology as a reading support strategy despite not regularly using this accommodation functionally or independently.

Perceived/potential TTS technology use pre- and post-instructional training

Nine participants indicated, prior to viewing the educational presentation, that they would consider using TTS technology; six participants were willing to consider use or were unsure, and one participant (i.e., P1) would not consider TTS technology use. Following the presentation but prior to guided system manipulation, three people changed their willingness to consider TTS technology use; P10 initially said he would consider using the technology

but switched to being uncertain, and P2 and P15, who initially were undecided, expressed willingness to consider TTS technology use.

Expected changes in reading materials given TTS support

Participants reported reading calendars, newspapers, e-mails, mail, and magazines frequently. They predicted reading similar materials given TTS access; hence, calendars, newspapers, and magazines were again frequently cited materials. Some changes in reading materials also appeared given the presumption of TTS system access. Particularly noteworthy was that four participants (P3, P8, P11, and P16) predicted increased interest in reading novels and short stories. Five participants (P2, P3, P4, P12, and P14) predicted decreased interest in reading magazines given TTS support. Social media, mail, calendars, and recipes were other materials frequently identified by participants as those they would be less likely to read when incorporating TTS support. Details about predicted changes regarding each reading material appear in Table 5. Examination of reading material expectations with versus without TTS support reveals that, as a group, participants expressed greater likelihood of reading lengthy materials (e.g., novels and newspapers) with the aid of TTS output, but they did not anticipate using a TTS system to read short materials (e.g., text messages, calendars).

Expected reading comprehension changes given TTS support

Participants used 5-point Likert-type scales to rate their perceived current reading comprehension of materials and estimated comprehension if TTS support were available. As shown in Table 6, the greatest change occurred for magazines, novels/short stories, and social media posts. As a group, participants predicted a negative change in reading comprehension only for calendars.

Final perceptions about TTS technology

Most participants expressed willingness to consider using TTS technology as a reading support after learning about it and manipulating system features; only P1 and P13 – neither of whom currently used applications with computer-generated speech – were ultimately not open to this possibility. P13 reported rejecting TTS technology use after the guided practice session because of operational concerns given paresis of her dominant hand; still, she acknowledged the technology would likely improve her reading comprehension. P1 was consistent in not wanting to consider a TTS system because of cost, voice output, and potential technology problems as well as satisfaction with his current, unsupported reading ability.

Additionally, participants who expressed a willingness to consider using TTS also differ in their current use of technology. For example, P1 used many types of technology on a daily basis but was not interested in exploring TTS technology as an option for reading; in contrast, P15 did not use any technology regularly but was interested in TTS technology.

Discussion

We examined reported reading behaviors of people with aphasia, their willingness to consider use of TTS technology as a reading support, and their predicted engagement and potential comprehension changes with reading materials given TTS support. Results confirmed that people with aphasia engage in reading despite persistent language challenges. Overall, the study participants endorsed the belief that TTS technology would improve their comprehension and the diversity of materials read; however, perception differences among participants also emerged. Acknowledging the presence of individual differences is important because it is consistent with technology acceptance models suggesting people only adopt assistive technology solutions for routine use when they are helpful and useful for performing functional activities (e.g., Guner & Acarturk, 2020; Holden & Karsh, 2010).

Current reading behaviors & perceptions of strategies

All participants reported reading primarily at home, although some also endorsed reading in other settings and contexts (e.g., therapy sessions, social clubs, groups). Although we did not explore potential TTS use in specific contexts, information about locations in which people with aphasia read can help clinicians design intervention programs. Society's current reliance on text-based materials across multiple settings makes having universal access available to people with aphasia important. The possibility of TTS technology and other support strategies increasing the variety of locations in which people with aphasia can pursue reading activities warrants exploration.

Study participants endorsed several strategies to improve reading comprehension. Most reported benefiting from careful material selection or reliance on existing knowledge and skills; several also relied on other people for support. These results are similar to those reported previously (Kjellén et al., 2017; Knollman-Porter et al., 2015; Webster et al., 2020) and highlight the individualized nature of strategy use during reading tasks. Future researchers should further explore this topic by determining the frequency with which people use each strategy, strategy implementation across settings and contexts, and strategy use when engaging with various reading materials.

Reading materials

Interest in TTS technology may vary in part on the reading materials a person with aphasia wishes to access. Similar to previous findings (e.g., Kjellén et al., 2017; Knollman-Porter et al., 2015), our participants preferred short materials when not using supportive technology. This preference likely reflects comprehension and working memory difficulties typical of people with aphasia (Sung et al., 2009; Wright & Fergadiotis, 2012). Interest in TTS technology related primarily to accessing longer materials than participants currently could read. Given that people with aphasia comprehend long paragraphs better with TTS support than without such support (Wallace et al., 2019), success reading lengthier and more difficult content than currently attempted may be possible. TTS support may also boost independence and efficiency when reading long materials. Participants' recognition that TTS support may not be necessary or helpful for short materials (e.g., recipes), materials with abundant supplemental images (e.g., social media), or materials with formatting not conducive to the

technology (e.g., calendars) was noteworthy. Their observations about materials for which they would want TTS support were likely enhanced by the educational presentation and the opportunity to practice using the technology. Providing comparable activities in clinical practice settings is important.

Predicted comprehension changes

We asked participants to predict comprehension changes associated with using a TTS device to provide information about how expected comprehension influences material selection preferences. Participants' interest in using TTS technology occurred despite relatively modest predicted comprehension gains. This suggests people with aphasia are not overly optimistic about the comprehensive benefits likely with TTS support. The realism conveyed by this perspective is positive in that it suggests people with aphasia may not become discouraged by a mismatch between expectations and actual benefits realized. Past researchers have found that up to 25% of adults with aphasia change their opinion about TTS technology use when shown their comprehension accuracy data with versus without TTS support (Hux et al., 2020). However, this observed change also followed repeated exposure to TTS technology, so performance feedback may not have been the sole factor in prompting reconsideration. These findings, in combination with those of the current study, confirm the importance of having multiple opportunities to learn about and engage with assistive technology. Further exploration of factors other than perceived or real comprehension improvements (e.g., independent system use, reading efficiency) may also drive TTS technology acceptance by people with aphasia and should be addressed in future research.

Interest in TTS technology

Technology availability as well as the frequency and predictability with which a person performs an activity affects judgments about the relative usefulness of an assistive device. TTS technology is now readily available through commercial vendors, and the frequency with which people rely on text to perform daily activities suggests frequent TTS device use might occur if access were not a problem. Given this, the interest reported by current and former study participants (Kjellén et al., 2017; Knollman-Porter et al., 2015) regarding TTS use is encouraging. In fact, following an opportunity to learn about and engage with TTS technology, 87.5% of current study participants indicated interest in using TTS technology to support reading efforts. This contrasts markedly with reports about the frequency with which people with aphasia currently implement TTS technology (Knollman-Porter et al., 2015; Webster et al., 2020). Practitioners need to address this mismatch to determine whether insufficient exposure to and instruction about the technology is a primary hindrance to system adoption or whether other barriers – such as concerns about operational competence, cognitive demands, or mobility – prevent implementation. Interest in and adoption of TTS technology may align better if practitioners provided adults with aphasia instruction to facilitate independent use. Similarly, results of this study highlighted a potential disconnect between participants' reported current technology use (i.e., five participants endorsed TTS support as a potential reading strategy but admitted to not using this particular strategy regularly) and interest in potentially using TTS technology as a reading support. Interest in TTS technology as a potential support appeared to grow

as participants received education regarding the technology and were provided opportunities to engage with software. These findings give further credence to the need for individual consideration of and exposure to potential TTS system implementation regardless of previous or current technology use practices.

Limitations and future research

The current findings highlight the importance of exposing people with aphasia to TTS systems and obtaining their individual perspectives about its adoption as a reading support. Engaging people with aphasia in such activities may help clinicians design functional, person-centered reading interventions. However, practitioners need to exercise caution about assuming the types of reading supports a person with aphasia may wish to explore, and limitations with the current research prevent widespread generalization of the results.

One limitation was that we examined only TTS systems as a reading support strategy; other types of reading support strategies may have greater appeal to some people. Regarding this possibility, our presentation only of TTS systems as a possible reading support strategy may have biased participants; inclusion of multiple support strategies for exploration may have yielded different results.

Another limitation concerns our desire to explore how perceptions about TTS technology varied based on estimated changes in comprehension. In soliciting this information, we did not take into consideration that some people with aphasia struggle to estimate accurately their performance on language tasks. Despite this caveat, however, participants' responses allowed us to consider potential connections between estimated reading comprehension and the desire to use a specific support strategy such as TTS technology.

Another limitation is that we solicited information about broad categories of reading materials (e.g., newspaper, magazines) rather than probing for information relating to specific material characteristics such as length, reading level, and match to personal interests– some of the factors that have been identified as important in previous research (e.g., Webster et al., 2018a). Asking questions with greater specificity regarding material characteristics and the use of various support strategies across materials and settings may yield salient information about the clinical adoption of compensatory strategies.

Conclusion

People with aphasia generally report an interest in using TTS systems to support reading of certain materials. This interest is present despite relatively modest predicted changes in comprehension. Clinicians may wish to provide guided practice opportunities to expose people with aphasia to TTS systems as one of several reading support strategies.

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Disclosure of interest

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Appendix A.

Sample Text from the Reading Behaviors Survey

(Images not included because of copyright issues)

1. **I am going to ask you some questions about READING. Do you read**:

Newspapers	Yes/No
Magazines	Yes/No
Religious Materials	Yes/No
Novels & Short Stories	Yes/No
E-Mails	Yes/No
Social Media	Yes/No
Texts	Yes/No
Mail & Personal Letters	Yes/No
Calendars	Yes/No
Recipes	Yes/No

(If a participant answered yes to any of the items above, a follow up question about that material was asked as provided in the example below)

My understanding of newspaper articles is

Poor Fair Good Excellent

2. Where do you read **since** you had a stroke?
   - Home
   - Work
   - Coffee Shop
   - Library
   - Speech-Language Therapy
   - Religious Buildings
   - Clubs/Groups
   - Other:_____
     _
3. What makes it easier to understand what you read?
   - Help from other people

- Pictures
- Shortened text
- Previous knowledge/familiarity
- Looking for key words
- Text-to-speech
- Anything else:_____

4. Have you tried using text-to-speech to help with reading?
   - **Yes** If yes, explain:
   - **No**

   If “no,”
5. Have you considered using text-to speech to help with reading?
   - **Yes**
   - **No**
   - Explain:_____

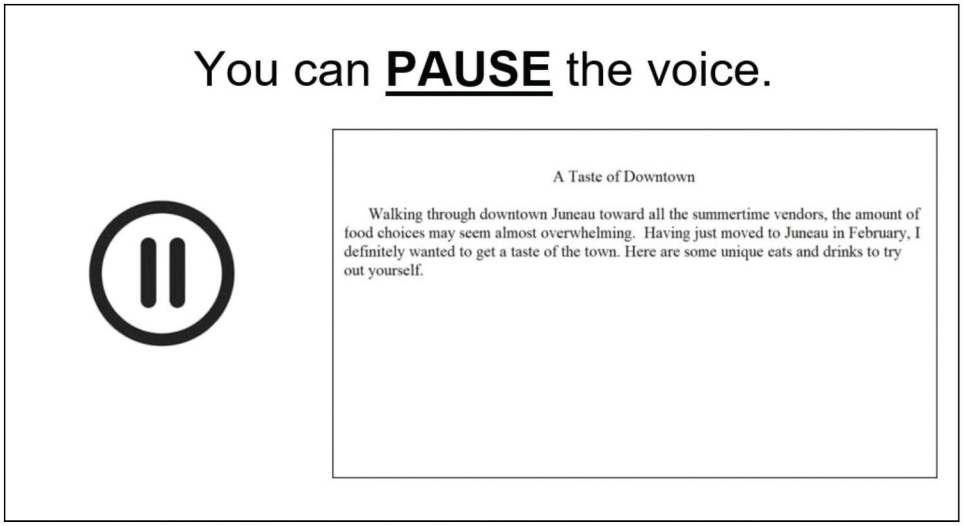
Appendix B.

Example contextualized image

Newspapers

Appendix C.

Example Slides from Educational PowerPoint Presentation



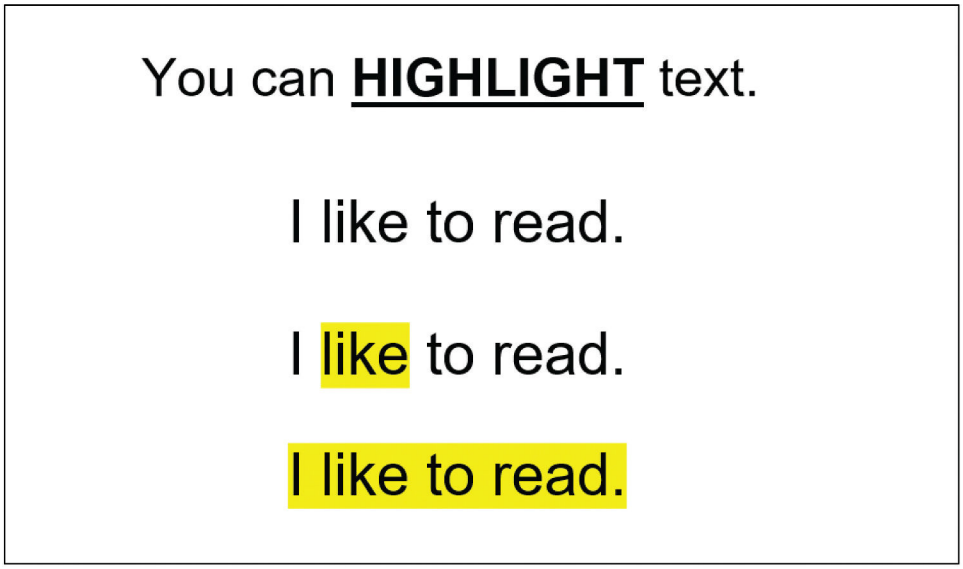


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Table 1.

Demographic information about individual participants.

Participant number	Gender	Age (years)	Education (years)	Months post-onset	Currently receiving SLP services	Employment status	Living status
1	M	72	19	274	No	Retired due to CVA	Independent
2	F	74	16	248	No	Retired due to CVA	With spouse
3	F	65	14	249	No	Retired due to CVA	With spouse
4	F	35	18	59	No	Retired due to CVA	With spouse
5	M	69	18	43	Yes	Retired	With spouse
6	M	52	13	166	No	Retired due to CVA	Independent
7	F	55	18	96	No	Retired due to CVA	With spouse
8	F	74	12	85	No	Retired	With spouse
9	M	65	16	26	Yes	Retired	With spouse
10	M	66	16	32	Yes	Retired due to CVA	With spouse
11	M	61	12	198	Yes	Part Time	Independent
12	M	56	12	171	Yes	Volunteer	With family
13	F	78	12	32	Yes	Retired due to CVA	Independent
14	M	74	15	53	No	Retired	With spouse
15	M	72	16	212	No	Retired due to CVA	With spouse
16	M	50	16	108	No	Retired due to CVA	With parents

F = Female; M = Male; CVA = cerebrovascular accident.

Table 2.

Participant standardized test scores.

	Western Aphasia Battery – Revised			Comprehensive Aphasia Test			RCBA-2		Cognitive Linguistic Quick Test +					
Participant Number	**Aphasia Quotient (Max = 100)**	**Aphasia type**	**Aphasia severity**	**Spoken Sentence (Max = 32)**	**Spoken Paragraph (Max = 4)**	**Written Sentence (Max = 32)**	**Paragraph Factual (Max = 10)**	**Attention (Max = 215)**	**Memory (Max = 185)**	**Executive function (Max = 40)**	**Language (Max = 37)**	**Visuospatial (Max = 105)**	**Nonlinguistic Cognition (Max = 49)**	**Linguistic/ Aphasia (Max = 56)**
1	82.6	Anomic	Mild	26	4	28	9	170	140	18	24	11	33	42
2	37.1	Broca’s	Severe	19	3	20	9	168	68	16	6.5	78	33	23.5
3	70.0	Anomic	Moderate	28	4	16	9	194	150	26	25	92	42	44
4	91.5	Anomic	Mild	27	4	26	10	204	161	29	28	100	44	47
5	61.7	Broca’s	Moderate	30	4	24	8	186	118	18	21	88	35	40
6	56.0	Broca’s	Moderate	20	3	14	7	126	121	25	22	79	33	38
7	14.8	Global	Very severe	8	0	6	4	149	46	14	1	69	29	16
8	56.9	Transcortical sensory	Moderate	24	1	24	8	189	132	24	15	90	39	33
9	78.9	Conduction	Moderate	18	2	26	10	179	181	30	33	91	40	51
10	14.5	Global	Very severe	2	0	3	4	81	50	21	0	63	28	9
11	65.1	Broca’s	Moderate	18	1	17	6	76	58	22	11	66	25	26
12	44.4	Conduction	Severe	8	2	4	6	171	70	21	5	84	36	23
13	74.4	Transcortical motor	Moderate	26	3	26	8	149	125	12	22	63	28	38
14	49.4	Broca’s	Severe	19	3	24	10	178	117	21	10.5	86	38	27.5
15	81.3	Anomic	Mild	24	2	25	8	181	111	23	22	84	36	38
16	42.4	Broca’s	Severe	12	2	12	7	148	63	13	8.5	72	27	20.5

Western Aphasia Battery–Revised Severity Scores are: 0–25 = very severe, 26–50 = severe, 51–75 = moderate, 76+ = mild.

Table 3.

Participants' frequency and type of technology use.

Participant	Frequency of technology use (days per week)	Frequency of computer–generated speech use (days per week)	Tablet	Smart phone	Electronic reader	Smart home device	Laptop computer	Desktop computer
1	7	0	✓	✓	✓		✓	✓
2	7	1–3	✓	✓			✓	
3	7	7	✓	✓	✓		✓	✓
4	7	0	✓	✓	✓		✓	
5	7	4–6	✓	✓	✓	✓	✓	✓
6	7	0	✓					
7	7	0	✓	✓			✓	✓
8	7	0	✓					
9	7	0		✓				
10	4–6	0	✓	✓				✓
11	1–3	0		✓				
12	7	0	✓	✓			✓	
13	1–3	0	✓					
14	7	7	✓		✓			✓
15	0	0						
16	7	7	✓	✓	✓		✓	

Table 4.

Reading locations and strategies endorsed by participants.

Reading locations	**Number of participants**
Home	16
Speech-language therapy	9
Clubs/groups	7
Coffee shops	5
Libraries	4
Religious buildings	3
Other (e.g., bars, restaurants)	3
Endorsed strategies	**Number of participants**
Material features	
Pictures	12
Short text	8
Dependence on others	
Help from others	5
Independent strategies	
Implement previous knowledge	13
Look for keywords	12
Use TTS technology	5
Re-read	1

Table 5.

Number of participants reporting reading various reading materials.

	Newspapers	Magazines	Religious materials	Novels and short stories	E-Mails	Social media	Texting	Mail and personal letters	Calendars	Recipes
Read currently	11	12	7	8	9	9	8	10	16	7
Response change given access to TTS	+3/−2	+2/−5	+0/−3	+4/−0	+1/−3	+1/−4	+2/−3	+1/−4	+0/−4	+2/−4
Total with TTS access	12	9	4	12	7	6	7	7	12	5

Eleven participants reported reading newspapers without TTS support; given TTS technology, three additional participants indicated they would read newspapers, but two who currently read them said they would not do so with TTS technology.

Table 6.

Participants' average predicted reading comprehension scores across materials with and without TTS.

	Newspapers	Magazines	Religious materials	Novels and short stories	E-Mails	Social media	Texting	Mail and personal letters	Calendars	Recipes
Number of participants	9	7	4	8	5	5	5	6	12	3
Average current comprehension estimation	2.25	2.43	2.25	2.00	2.40	2.33	2.25	2.00	1.58	2.00
Average comprehension prediction with TTS	1.88	1.86	2.25	1.50	2.00	1.80	1.92	1.83	1.75	2.00
Percent change in comprehension with TTS	7.4%	11.4%	0.0%	10.0%	8.0%	9.0%	6.6%	3.4%	−3.4%	0.0%

Participants provided comprehension ratings only if they indicated via the Reading and Technology Experiences questionnaire current reading of that material. Lower scores indicate better predicted comprehension on a 5-point Likert-type scale than higher scores.

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