Title: Rekindling the love of books - a pilot project exploring whether e-readers help people to read again after a stroke

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Abstract

Background

E-readers may facilitate reading in aphasia through "aphasia-friendly" features such as altering text size and formatting (Worrall et al, 2005), and text-to-speech functions. However, no previous research has examined whether e-readers help people with aphasia to read.

Aims

This project explored:

- whether people with aphasia can learn to use e-readers following a brief period of training
- whether e-reader training improves reading comprehension
- whether e-readers increase participation in and enjoyment of reading activities

Method and procedures

In phase one, available e-readers were compared using an expert evaluation against a set of criteria, to identify the model with optimum accessibility features and fewest potential barriers. The Kindle Keyboard 3G ™ (Amazon) was selected for trialling in phase two.

Four people with self-reported reading difficulties post-stroke participated in phase two. All had mild or mild-moderate aphasia. Four one-hour training sessions aimed to trial accessibility features, identify helpful features, and teach independent operation of these.

A repeated measures design was used. Outcome measures assessed reading comprehension (Gray Oral Reading Tests, Bryant & Wiederholt, 2001) and confidence and emotions associated with reading (Reading Confidence and Emotions Questionnaire, Cocks et al., 2013). Matched texts were used to compare reading comprehension using printed texts and the e-reader. Usability evaluations explored independence in e-reader use and acceptability of the technology. Participation in reading activities and reading enjoyment were explored using qualitative exit interviews.

Outcomes and results

Participants' reading comprehension on the Kindle, as measured by the GORT-4, did not improve following training and did not exceed comprehension of printed texts. However, reading confidence improved significantly for three of the participants (RCEQ: $p<.05$, $p<.01$ and $p<.005$).

Analysis of exit interviews and usability evaluations indicates that three out of four participants preferred reading on the Kindle to printed texts. These participants read more frequently on the Kindle than they had done before the training, and the technology enabled them to access more challenging texts (e.g. novels). They appreciated different features of the Kindle. Two participants experienced difficulties operating the technology, one of whom would have benefited from a longer training period.

Conclusions

This pilot study suggests that a short block of e-reader training led to improvements in reading confidence, participation and enjoyment. E-readers were not shown to enhance reading comprehension. Larger-scale investigations are warranted to further investigate whether and how e-readers facilitate reading for people with aphasia.

Keywords:

Aphasia, acquired dyslexia, e-readers, assistive technology, training

Acknowledgements

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Introduction

Reading is a fundamental skill required to participate fully in society. Difficulties with reading are common in aphasia (Leff, 2008). Historically, disturbances of reading after left hemisphere damage were considered as alexia with or without agraphia (Cherney, 2004). More commonly, they are considered psycho-linguistically, with four main syndromes of phonological, deep, surface, and semantic dyslexia (see Cherney, 2004). As well as being apparent at the single-word level, reading difficulties may manifest at sentence and text levels. For example, people with aphasia may have difficulties understanding verb argument structures in written sentences, while comprehension of paragraphs and longer texts may be affected by cognitive and memory impairments (Coelho, 2005).

Regardless of type, reading difficulties can have a dramatic and devastating effect on everyday reading activities, such as reading a story to a child, reading emails, or joining in a conversation with friends about a newspaper article, with associated consequences for a person's social, work and leisure roles (Parr, 1996). The increasing prevalence of technology-based written communication, including email, texting, and Facebook™, suggests that the communication gap between people with aphasia and the rest of the world will continue to expand (Dietz et al., 2011). Assessment and intervention of everyday reading, and treatment that empowers people with aphasia to use electronic media, is greatly needed (Dietz, Ball and Griffith, 2011).

Whilst literacy is considered a general life skill, reading assessment and intervention is substantially under-researched in aphasia. Publically available evidence maps indicate a paucity of synthesized evidence for reading assessment and treatment in general (see National Center for Evidence-based Practice in Communication Disorders: ASHA Evidence Maps Aphasia Reading Treatment). Reading comprehension is recognized as important. However, the synthesized evidence focuses almost exclusively on single word reading, recommending analyses of orthographic, phonological, and semantic processing of written words, with treatments targeting these deficits (RCSLT, 2005). Sentence level comprehension is considered under sentence processing, but primarily as auditory

processing. Sentence and paragraph reading assessment is clearly advocated even though there are limitations to existing reading assessments (Cherney, 2004; Webster, Morris, Connor, Horner, McCormac and Potts, 2013).

Regarding intervention, there is a clear evidence base for single word reading treatment (Aphasia Treatment Evidence Tables: Written Language – Reading; Cherney, 2004), but more evidence for sentence or paragraph/ text level treatments is needed. Clinical guidelines have framed aphasia interventions as restorative, compensatory, and alternative and/or augmentative (RCSLT, 2005). Restorative interventions for dyslexia syndromes are relatively well understood and include tasks such as grapheme parsing, phoneme blending, repeated reading, and word to picture matching (Cherney, 2004; Academy of Neurologic Communication Disorders and Sciences website). These have been shown to produce gains in understanding of treated words under test conditions with some evidence of generalisation to untreated items (e.g. Friedman & Lott, 2002), but there is little evidence that they lead to improvements in everyday reading. Occasionally, treatment takes a cognitive approach using attention process training (e.g. Coehlo, 2005). Treatments that target broader functional reading abilities are considered compensatory and/or augmentative, and include text level reading approaches known as Multiple Oral Rereading (Beeson & Insalaco, 1998) and Oral Reading for Language in Aphasia (Cherney, 2010). Research into these treatments has shown gains in reading speed or reading aloud, but changes in reading comprehension and generalisation to everyday reading have not been established.

Strategy-based treatments generally address cognitive and memory processes required for reading paragraphs and longer texts. They may target comprehension and recall through, for example, identifying and highlighting key words; paragraph summaries; mind-mapping topics; and obscuring text to reduce visual crowding (Cocks et al., 2013; Webster et al., 2013). These have been shown to be effective in improving paragraph-level comprehension for several individuals with mild or moderate reading difficulties (Cocks, Pritchard, Cornish, Thompson and Cruice, 2013; Webster et al.,

2013), but with varying patterns of generalisation to everyday reading. Spontaneously used strategies have also been documented (see Lynch, Damico, Abendroth and Nelson (2013) for an overview of 28 strategies noted to serve efficiency, contextualization, comprehension and socialization functions when reading).

"Low tech" and "high tech" alternative and augmentative communication (AAC) has been used with individuals with acquired and progressive neurological disorders. In aphasia, however, technology has been traditionally presented as a platform for supporting linguistically-based treatment rather than as AAC (RCSLT, 2005). The emphasis of this paper is not on specialist technologies and computer-supported therapy, but rather on mainstream technologies such as e-readers. There is some evidence that new technology developments, such as voice recognition software, can be successfully employed by individuals with post-stroke acquired dysgraphia with aphasia (Bruce, Edmundson and Coleman, 2003; Caute & Woolf, in press). Currently, there is only anecdotal evidence that e-readers may have application for people with aphasia (see Milwaukee Journal Sentinel, 2011).

E-readers have great potential to enable reading despite acquired dyslexia. They incorporate aphasia-friendly text principles, such as text size adjustment and key word highlighting (Rose, Worrall and McKenna, 2003). Some have text-to-speech functionality, providing multimodality input capitalizing on auditory comprehension strengths, or circumventing the reading impairment entirely (Dietz et al., 2011). Manipulating text layout and white space may assist comprehension (Worrall, Rose, Howe, Brennan, Egan, Oxenham and McKenna, 2005). Other assistive features include dictionary functions for semantic and lexical support, and text annotation functions, specifically highlighting, electronic post-it notes, and bookmarking to track particular elements of a book (e.g. where a character is introduced). Finally, difficulties with physical manipulation of printed books caused by hemiparesis or hemiplegia may be overcome by e-reader one-handed operation.

Learning to use technology independently is complex and not universally achieved (Egan, Worrall and Oxenham, 2004). E-readers may pose challenges for people with aphasia due to linguistic demands in understanding menu options and inputting text searches, as well as reading manuals. Cognitive demands include multistep operations and cognition involved in learning new technology (e.g. Egan et al., 2004). Furthermore, there is additional cognitive load associated with integration of memory, decision making, and visual processing associated with an interactive interface. A study comparing comprehension of printed versus digital text found comprehension scores superior for print (Mangen, Walgermo and Brønnick, 2013). Finally, fine motor control is required for buttons and touchscreen use. Concurrently, cognitive, motor or visual impairments will influence individual success with technology.

It is not known whether people with aphasia can benefit from training to use e-readers, and whether this results in improved reading ability and engagement with reading. The current study piloted an e-reader training intervention with four people with acquired reading difficulties, to investigate whether:

1. people with aphasia can learn to use e-readers following a brief period of training
2. e-reader training improves reading comprehension
3. e-readers increase participation in and enjoyment of reading activities.

Methodology

Ethical approval

City University London's research ethics committee granted approval.

Phase 1: Evaluation of e-reader accessibility features

Accessibility features and potential barriers of all e-readers available on the market at the time of the study were explored to identify the most suitable e-reader to pilot. SLT and human computer interaction (HCI) researchers investigated accessibility features, including a text-to-speech function, and text size, word and line spacing modification. Potential barriers were identified by evaluating against a set of criteria. The criteria were grounded in previous work on the design and usability of technologies for people with aphasia, summarised as eight interaction design principles for people with aphasia and initially reported in Galliers, Wilson, Muscroft, Marshall, Roper, Cocks and Pring (2011). These high level principles include for example, the benefits of direct mappings, minimal distractions, and minimal use of language. Thus some of the criteria against which the devices were measured included the number of steps required to complete simple tasks, the potential distractions such as multiple buttons, and the minimal use of textual instruction. The presence of a keyboard with small keys and needing to connect to a local Wifi network (rather than 3G wireless that would connect automatically to a mobile network) were identified as additional potential difficulties.

Selection was challenging due to the fast pace of change in the e-reader market. Only e-readers including a text-to-speech feature were short-listed for selection, which limited the choice to Amazon's Kindle e-readers. Initially a Kindle Touch model was selected, because it had text-to-speech and an intuitive touchscreen rather than a keyboard. However, this model was discontinued prior to purchasing. The Kindle Keyboard 3G was selected as the second choice model, as it had text-to-speech and could connect to the mobile network rather than requiring password entry to connect to a wireless network. However, the HCI researcher identified potential barriers: small keyboard keys; 4-way direction key for making a selection; and numerous steps required for functions such as purchasing books from the Kindle store.

Phase 2: Piloting of assessment and training procedures

Design

This study used a repeated measures single-case design, with four cases forming a case series. Outcome measures were administered at two pre-training baselines (Times 1 and 2) conducted four weeks apart. Post-training assessment (Time 3) was followed by maintenance assessment (Time 4) four weeks later. Participants received four training sessions, conducted once a week between Times 2 and 3. Background assessments were administered between T1 and T2, while qualitative assessments were carried out between T3 and T4.

Assessment and training sessions were conducted by two research speech and language therapists (Friede and Caute) and two speech and language therapy students under their supervision.

Participants

Four participants were recruited through City University's aphasia clinics and a local aphasia group. All participants self-reported reading difficulties following stroke. Participants with any severity of reading impairment were included, as the accessibility features of e-book readers (e.g. text-to-speech) might facilitate reading comprehension even among people with severe reading impairments. However, participants had to score at least 70% on auditory comprehension subtests of the Comprehensive Aphasia Test (CAT, Swinburn, Porter and Howard, 2004), to ensure that they could benefit from the training sessions. Participants were minimum six months post-stroke and were fluent pre-morbid users of English (established via self-report). They had no diagnosed cognitive impairment, such as dementia, and received no other speech and language therapy during the study. Table 1 shows demographic information about the participants, for whom pseudonyms have been used.

[Insert Table 1 here]

Background assessments

Tests of spoken language, writing, reading, and cognition were administered once at baseline. These informed the strategies used in training for each individual and explored factors that might be predictive of outcomes.

Six subtests from the CAT (Swinburn, et al, 2004) were administered, along with eight subtests from the Reading Comprehension Battery for Aphasia (RCBA-2, LaPointe and Horner, 1998), a criterion-referenced assessment of silent reading comprehension. These probed comprehension of written words, sentences, paragraphs and functional reading. The Cognitive Linguistic Quick Test (CLQT, Helm-Estabrooks, 2001), assessed attention, memory, executive function, language and visuospatial skills. Background and screening assessment scores are presented in Table 2, together with ceiling scores and control data for the CAT and the CLQT. No control data was available for the RCBA-2. However, the manual suggests that normal performance should be at ceiling.

[Insert Table 2 here]

Summary of assessment results and self-reported reading difficulties

Bethany

Bethany presented with moderate non-fluent aphasia characterised by word finding difficulties and impaired sentence production. She produced simple SVO sentences but had difficulties producing more complex sentence structures. She had mild difficulties reading sentences and paragraphs. The

CLQT indicated a mild cognitive deficit in areas of memory and language. Attention, executive functions and visuospatial skills were within normal limits.

At baseline Bethany reported she read short stories and novellas, but took up to five weeks to read a story. She was unable to read longer texts, including novels that she enjoyed before her stroke, due to fatigue, slowness in reading, and consequent difficulties remembering the plot and characters. She was keen to read longer novels by her favourite authors, Jodi Picoult and Cecelia Aherne.

Edward

Edward presented with mild receptive and expressive aphasia. His spoken output was fluent, characterised by word finding difficulties and circumlocutions. He had severe dysgraphia and mild dyslexia, with good comprehension of single written words and sentences but impaired reading at a paragraph/text level. The CLQT indicated cognition overall was within normal limits, but with mild memory impairment.

Edward found it difficult to read printed text. He used ClaroRead™ (Claro Software Ltd) software's text-to-speech function to listen to online news, recipes and short stories. He was only able to read once or twice a week for 10 minutes because he fatigued easily, even when using ClaroRead™.

Kathleen

Kathleen had mild expressive aphasia. Spoken output was fluent, grammatical and syntactically well-formed, with occasional word finding difficulties and reduced rate. She had moderate receptive aphasia, with auditory comprehension difficulties becoming more pronounced when she was tired. Reading was mildly impaired at paragraph level. The CLQT indicated a mild cognitive deficit overall,

with a moderate deficit in memory and mildly impaired language. Attention, executive functions and visuospatial skills were within normal limits.

Before the study, Kathleen tried to read letters, cards, bank statements and utility bills, but had difficulty understanding these. She tried reading newspapers and magazines, but usually only understood the main headlines. She was unable to read books, but keen to be able to do this again, as she had previously enjoyed reading.

She reported that reading was harder with small font sizes (e.g. in newspapers). She found reading tiring and had difficulties remembering what she had read. She found it easier to read in the morning when she was less tired, without background noise, when pictures accompanied an article, and when she could discuss what she had read.

Rosa

Rosa's first language was Portuguese, but she had lived in the UK for a decade and spoke fluent English pre-stroke. She presented with mild receptive and expressive aphasia. Her speech was fluent, with word finding difficulties and a slightly reduced pace of speaking. She had moderate dysgraphia and dyslexia, with reading difficulties at a single-word, sentence and paragraph level. The CLQT indicated a moderate level of cognitive deficit with difficulties across all subtests, especially in memory, executive functions and language.

Before training, Rosa reported frequently reading fashion and lifestyle magazines. However, she was only able to read the headlines and a few keywords, making use of pictures to support understanding. She attempted to read gas bills, bank statements and letters from her daughter's school, but reported difficulties understanding these. She tried to ascertain important information by identifying keywords.

Factors that made reading harder for her were small font size, complex sentence structures, background noise and distractions. She found it more difficult to read when tired, so preferred reading in the morning.

Outcome measures

At each assessment point, the Gray Oral Reading Tests (GORT-4; Bryant & Wiederholt, 2011) and the Reading Confidence and Emotions Questionnaire (RCEQ; Cocks et al., 2013) were administered.

GORT-4 is a text-level assessment of reading comprehension requiring participants to read a series of passages increasing in length and complexity. Multiple-choice comprehension questions assess literal, inferential, critical and affective comprehension. Reading was timed with reading rate and comprehension recorded.

GORT-4 includes two sets of 14 passages (Forms A and B), matched for difficulty. Both forms were administered at each time-point, with Form A presented as printed texts, and Form B presented on the e-reader. This enabled comparison between presentation methods of reading rate (in seconds) and comprehension (number of questions answered correctly), both before and after therapy. For both forms, comprehension questions were presented on paper and read aloud by the therapist. Participants were not permitted to refer back to the passages when answering the comprehension questions.

When administering Form B on the Kindle, each text was presented with the font size and line spacing adjusted to look as similar as possible to the paper version. At post-therapy assessment, participants were reminded that they could use the text-to-speech feature and change the size and layout of the text if they wished to, but they were not given specific prompts or facilitated to do so.

Participants scored a maximum of 5 points for each passage, with higher scores indicating better comprehension and faster rate. Order of administration was alternated between assessment time points and participants, i.e. two participants started reading from printed texts at Time 1 and two started with the e-reader. The order was alternated at each assessment point.

RCEQ assesses confidence and emotions associated with reading using a ten-point self-rating scale. Participants rate their confidence carrying out different reading-related tasks in different contexts, confidence in remembering and understanding what they have read, and enjoyment and emotions (frustration, anger, upset, anxiety). See Cocks et al. (2013) for further details. Participants completed the questionnaire with support from the SLT researchers and/or students who read the questions aloud and clarified where necessary.

Qualitative evaluation

Semi-structured exit interviews and usability evaluations took place between post-therapy and maintenance testing. Interviews took place at the University. Exit interviews probed satisfaction with the project, changes attributed to participation, and difficulties encountered (see Appendix 1). They were carried out by two project advisors (Cruice and Woolf) who had not been involved in the training or assessments. Interviews were video recorded and transcribed verbatim. Utterances where the target was unclear were transcribed phonetically and omitted from the analysis.

Data analysis used descriptive content analysis to identify initial themes and concepts, to subsequently construct the framework to index the interview data (see Appendix 2). Transcripts were analysed thematically using the Framework approach (Ritchie and Lewis, 2003). We are presenting those themes that are particularly illuminating for each individual participant.

Usability evaluations were conducted by another researcher (Galliers), who asked participants to complete a series of tasks on their Kindle, starting with switching the Kindle on. Tasks were tailored

to the personalised practice each participant had undertaken during training. Participants were observed and videoed performing the tasks, with observations analysed according to the degree of support required. After each task, the participants were invited to rate how easy or hard they found the task using a five-point Likert scale (see Appendix 3).

Training sessions

Participants attended four one-hour training sessions, once a week at the University or at home. The first training session included discussion about reading habits and preferences pre- and post-stroke. Participants also reflected on factors that helped or hindered reading, including characteristics of the reading material (e.g. font size) and influences of the environment (e.g. background noise). They were asked to think about authors they liked and reading material they wanted to download to the Kindle. The therapist helped participants to download their selected reading material, typically one or two books and a subscription to a newspaper. Participants were provided with a Kindle Keyboard 3G for the remaining duration of the study. In addition, they received a £20 Amazon voucher to download reading material of their choice.

Participants were given an individually tailored manual. This contained step-by-step instructions for the Kindle functions, illustrated with photographs. Manuals followed aphasia-friendly text principles (Worrall et al., 2005), using large text, wide spacing of lines and key words highlighted in bold (see example in Appendix 4).

Basic Kindle functions were explained and practiced several times during sessions, until the participant felt confident they could operate these independently. Basic functions included: charging; switching on/off; navigating using buttons; modifying text formatting; using text-to-speech. If participants encountered difficulties, they were encouraged to refer to their manual.

Home practice

Participants were encouraged to use the Kindle between training sessions and practise the newly learned functions. They were asked to record in a diary what they read each day and for how long.

Each training session started with reviewing the diary together, discussing what had been read, how long it took, whether comprehension problems occurred, and whether the reading material was at the right level and of interest.

Once participants had mastered basic functions, more advanced features were explored, including use of bookmarks, highlighting, and notes. Participants kept their Kindle during the four weeks between post-therapy and maintenance testing.

Results

The results for each participant are presented below, and summarised at the end of this section.

Bethany

Exit interviews and usability evaluations

Bethany found the Kindle easy to use and operated 17 functions of the Kindle independently during the usability evaluation (see usability evaluation results in Appendix 3). Although able to read short stories and novellas before the project, Kindle training enabled her to read faster and hence access longer novels by her favourite authors. She increased her reading speed by decreasing text size and using the text-to-speech function. She reported a great sense of achievement and satisfaction in being able to understand longer texts:

> *"reading it and .. following the story .. so much detail .. with .. the character and the (.) plots and so much better and (.) interesting (.) twists and (.) maybe the bad guys done it"*

She reported reading avidly with her Kindle:

"completely (.) addicted to this Kindle [laughs] … yes so much better .. but .. amazing"

She liked the Kindle's portability and bought headphones so she could use text-to-speech on the train.

GORT-4

Bethany's scores for comprehension and rate are shown in Figures 1 and 2 below. Results were analysed visually, as there were insufficient data points to conduct a statistical analysis. Bethany's comprehension was markedly inferior with the Kindle than with printed presentation at B1. While her printed scores remained broadly stable across the four time-points, comprehension on Kindle presentation increased at B2 and again at PT1 (see Figure 1 below). At PT1 Bethany employed her preferred strategies for reading with the Kindle (using text-to-speech and decreasing font size) and her comprehension scores for printed and Kindle presentation were very similar. Her performance at PT2 dropped markedly, seemingly due to a distracting incident during the assessment session when the person accompanying her to the appointment left the room. This affected the latter part of her paper assessment and the Kindle assessment. She did not use her usual strategies on the Kindle at PT2.

At baseline assessments, Bethany read very slowly in both formats, but was slower on the Kindle. Speed on the Kindle increased at PT1, exceeding her reading speed on paper, despite her listening to many of the passages (7/11) twice using text-to-speech. At PT2 Bethany did not employ her usual strategies on the Kindle and her reading speed fell back to the level at baseline.

Figure 1. Bethany's GORT-4 comprehension scores on paper and Kindle

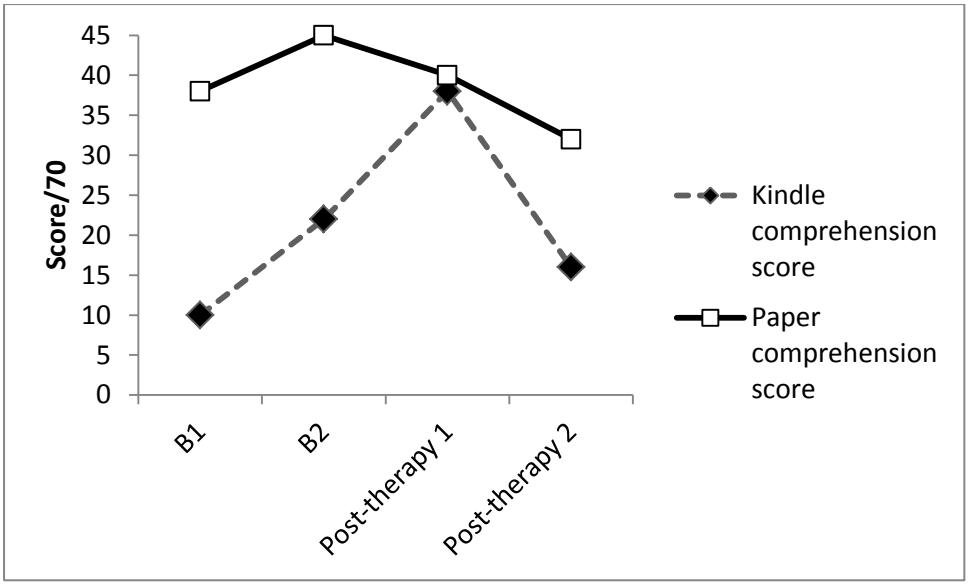
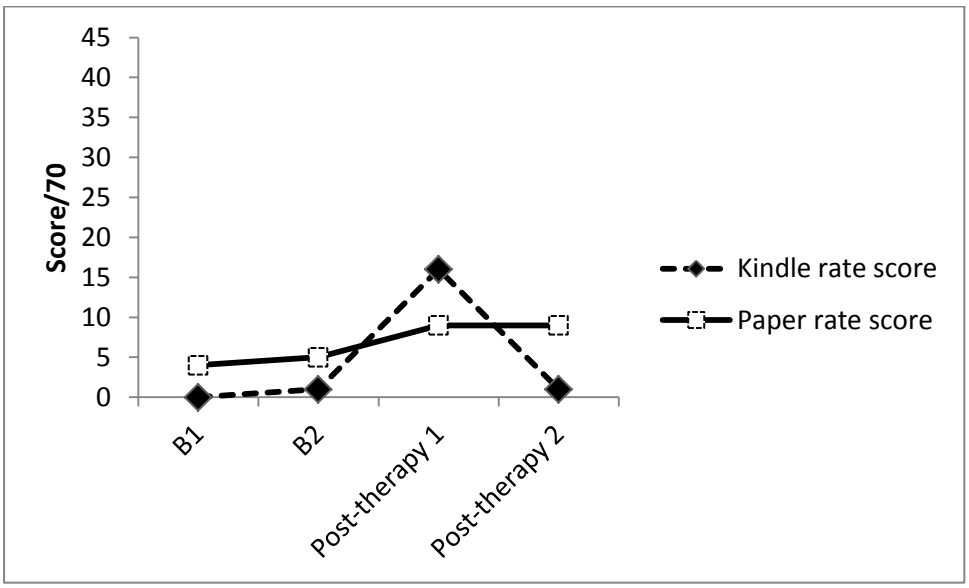


Figure 2: Bethany's GORT-4 rate scores on paper and Kindle



RCEQ

Scores were analysed using Friedman and Wilcoxon signed ranks tests. Only questions relating to post-stroke confidence and emotions were included in the analysis, while those relating to pre-morbid confidence and emotions were removed.

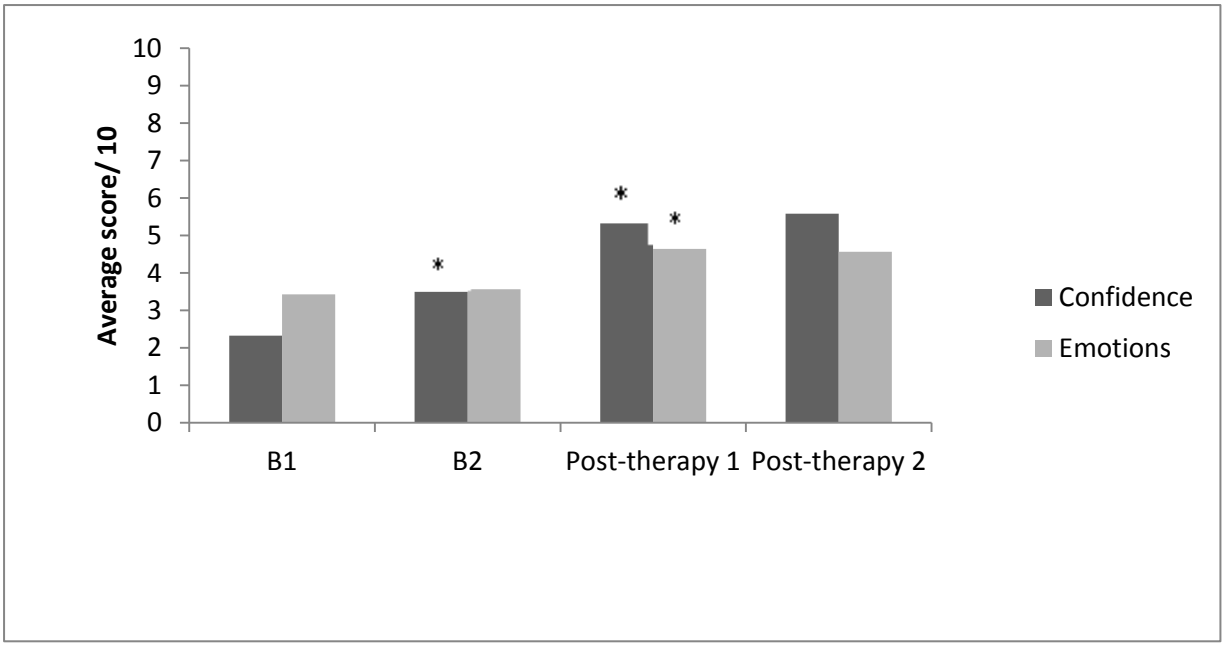
The Friedman test showed a highly significant change in confidence and a significant change in emotions during the project (Confidence: $\chi^2(3)= 29.70$, $p=.000$), Emotions: $\chi^2(3)= 7.98$, $p<.05$, two-tailed). See Figure 3.

Analysis of confidence ratings using Wilcoxon signed ranks tests indicated a significant improvement between B1 and B2 ($Z= -2.75$, $p<.01$, two-tailed), a highly significant improvement between B2 and PT1 ($Z=-2.83$, $p=.005$, two-tailed), with improvement maintained between B2 and PT2 ($Z=-2.83$, $p=.005$, two-tailed).

Analysis of emotions ratings indicated no change between B1 and B2 ($Z=-1.00$, $p=.317$, two-tailed), a significant improvement between B2 and PT1 ($Z=-2.06$, $p<.05$, two-tailed), but this improvement was not maintained at follow-up (B2 v PT2: $Z=-1.55$, $p=.121$, two-tailed).

Figure 3: Bethany's confidence and emotions scores on the RCEQ

N.B. *= significant improvement from previous time point



Edward

Exit interviews and usability evaluations

When reading on the Kindle, Edward adjusted the settings to increase both text size and line spacing. He was able to operate these functions independently but did not use the more advanced features, such as writing notes or placing bookmarks, and was unable to use the Kindle store independently (see Appendix 3). These functions were challenging for Edward due to his severe dysgraphia. Edward disliked the appearance and feel of the Kindle, finding the small keys particularly difficult to use. He indicated a strong preference for reading books on paper, and conveyed that he liked the familiarity and memories associated with these.

Edward was the only participant who reported no benefits from using the Kindle. Before taking part in the project he had become proficient in using ClaroRead™ software on a PC, which offers similar accessibility functions to the Kindle. He reported preferring ClaroRead™ to the Kindle at the end of the project. He reported difficulties operating the Kindle, for example, when navigating between newspaper articles. He strongly disliked the Kindle's text-to-speech function, which he found "mechanical". In contrast, he regularly used ClaroRead's™ text-to-speech, which he found to be of better quality, including more choice of different voices and speeds.

GORT-4 results

Edward's comprehension was markedly better on paper than Kindle at baseline assessments and at maintenance assessment, but fell below his Kindle score at PT1 (see Figure 4 below). His rate was consistently lower on the Kindle than on paper, but reading was very slow in both modalities (see Figure 5). Whereas Edward typically read on the Kindle with large font and increased space between

the lines, he did not make these adjustments to the text at post-therapy assessments, instead reading the passages as they were presented to him.

Figure 4: Edward's GORT-4 comprehension scores on paper and Kindle

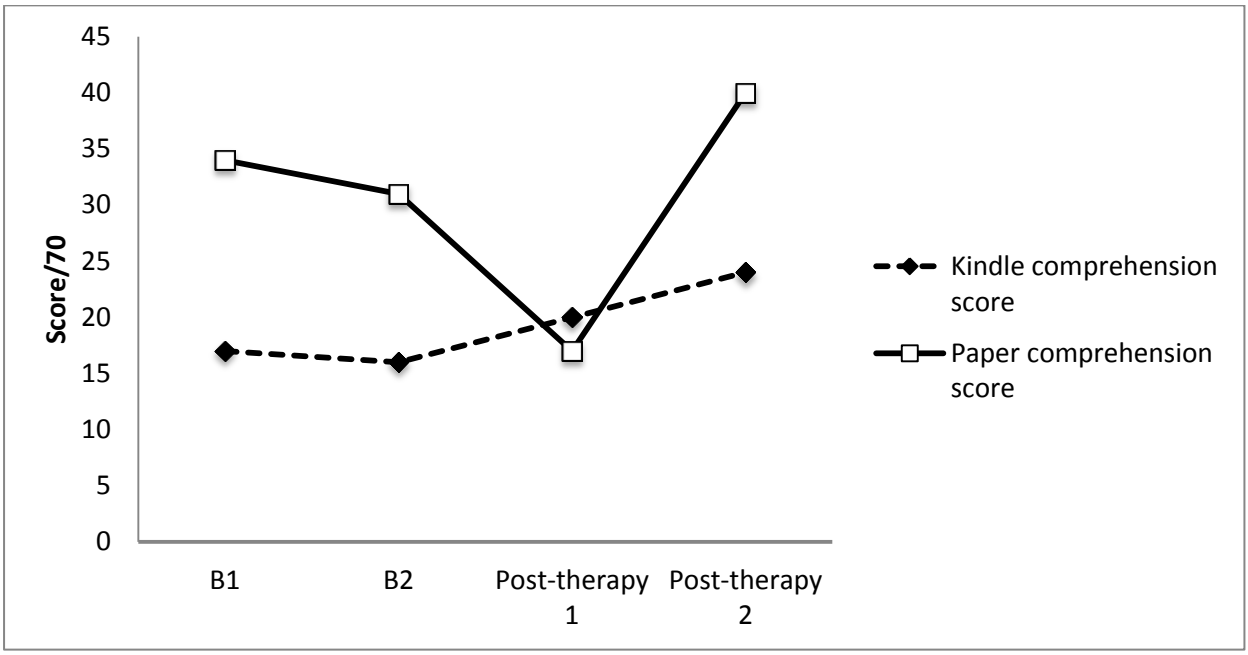
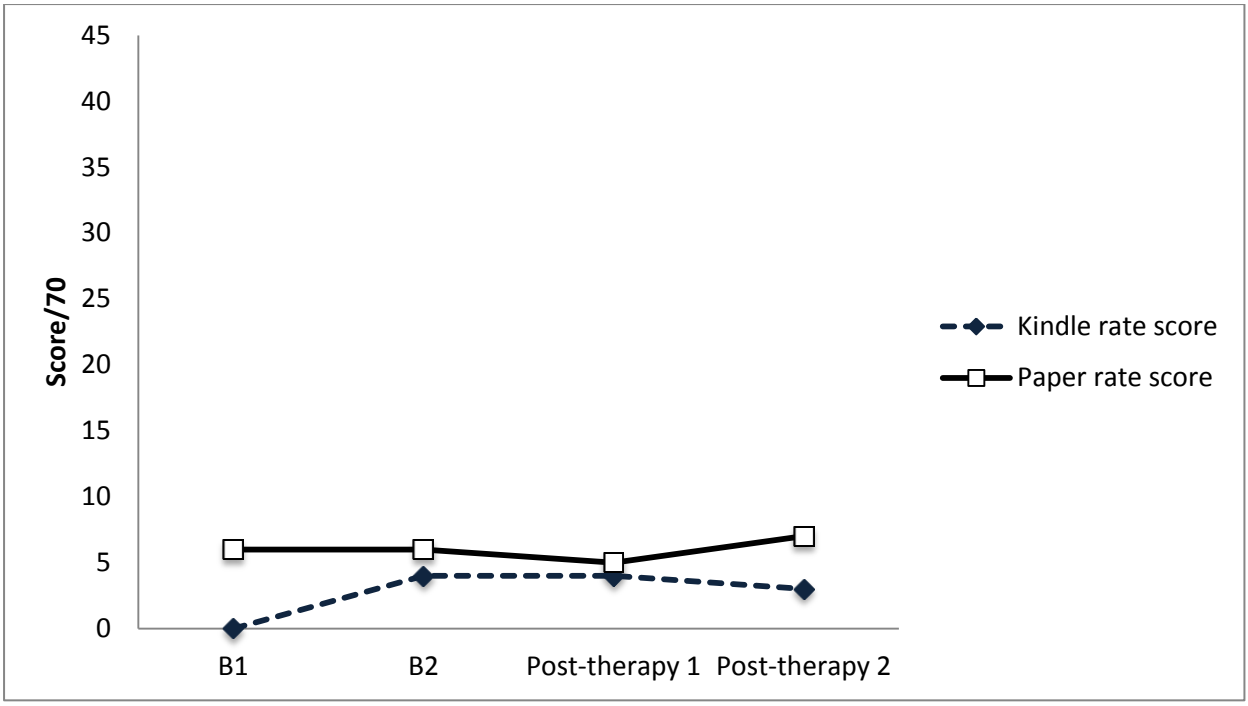


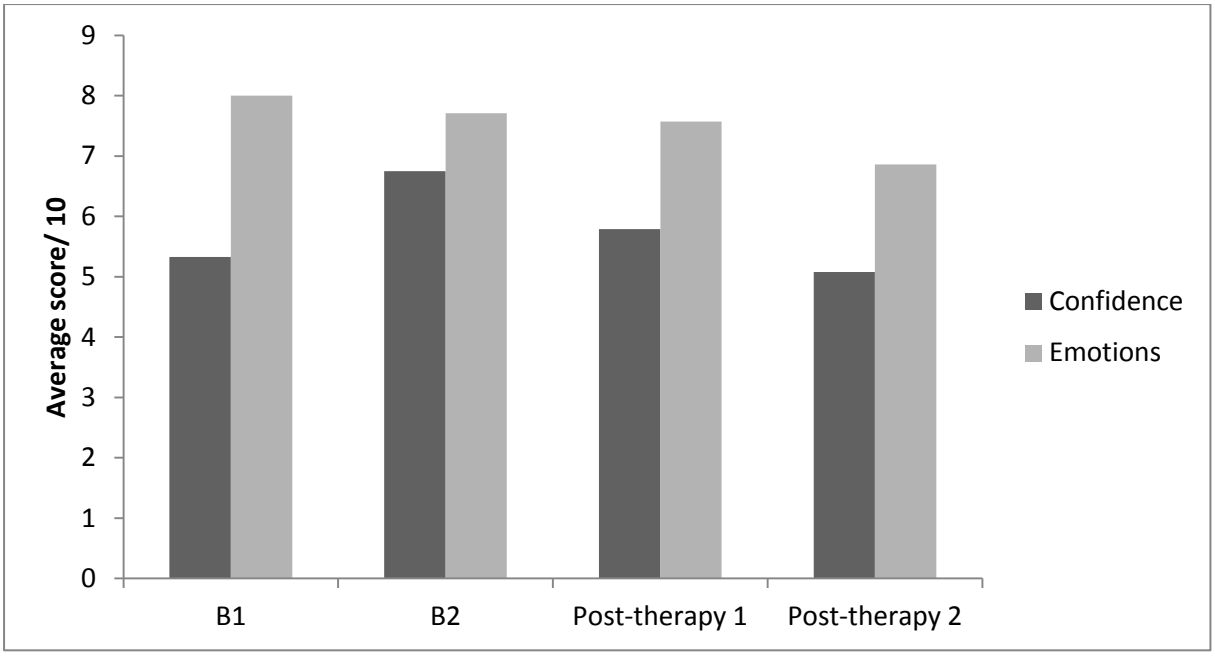
Figure 5: Edward's GORT-4 rate scores on paper and Kindle



RCEQ

Before training, Edward was the participant with the highest self-rating of confidence and emotions related to reading, reflecting his high level of satisfaction with using ClaroRead software to read on his computer. His scores did not change after training (Confidence: $\chi^2(3)= 3.595$, $p=.309$; Emotions: $\chi^2(3)= 2.186$, $p=.535$, two-tailed). See Figure 6.

Figure 6: Edward's confidence and emotions scores on the RCEQ



Kathleen

Exit interviews and usability evaluations

Kathleen was delighted that she learnt to operate the Kindle and used numerous features, including enlarging the text, increasing spacing, using bookmarks and writing notes. During the usability evaluation she completed 13/16 tasks independently (see usability evaluation results in Appendix 3). Kathleen reported that she found the font size in paper books too small, making it difficult to remember what she had read. In contrast, the Kindle enabled her to read for pleasure again:

> "*I love my Kindle. It's the best thing I've had. I didn't think I could read but I can read. I used to read all the time before my stroke and I missed it*."

She found she could read books and short stories, which she did prolifically. She liked the Kindle's portability and the ease of purchasing books through the Kindle store. She reported that she could understand humour in books again, having previously been unable to. She found the experience so

positive that she purchased an e-reader before the project ended. Kathleen talked eloquently about her experience and it was clear she had gained much from the project, specifically personal insights into her own reading, language, and learning, as well as finding a sense of herself again:

> *"yea I think so im more (..) I'm (.) happy now to do things now not that I never did I always did like like doing what I'm doing I lost quite a lot of my me myself (.) so its brought me out into myself now I can have a conversation now".*

GORT-4

Overall Kathleen's comprehension was better on paper than on Kindle presentation (see Figure 7). There was little change in score in either presentation across the four time-points (with the exception of reading comprehension on paper dropping markedly at B2), despite Kathleen employing her preferred strategies on the Kindle at PT1 and PT2 (enlarging font and increasing white space).

Kathleen's reading rate was very similar on paper and the Kindle (see Figure 8). She showed a very slight improvement in her reading rate in both modalities at PT1, which further gains on paper at PT2.

Figure 7. Kathleen's GORT-4 comprehension scores on paper and Kindle

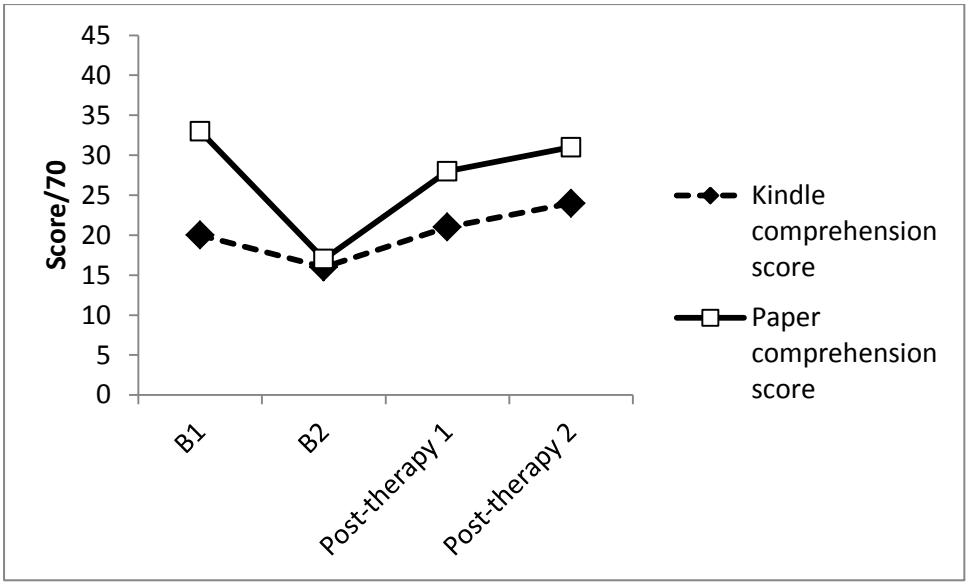
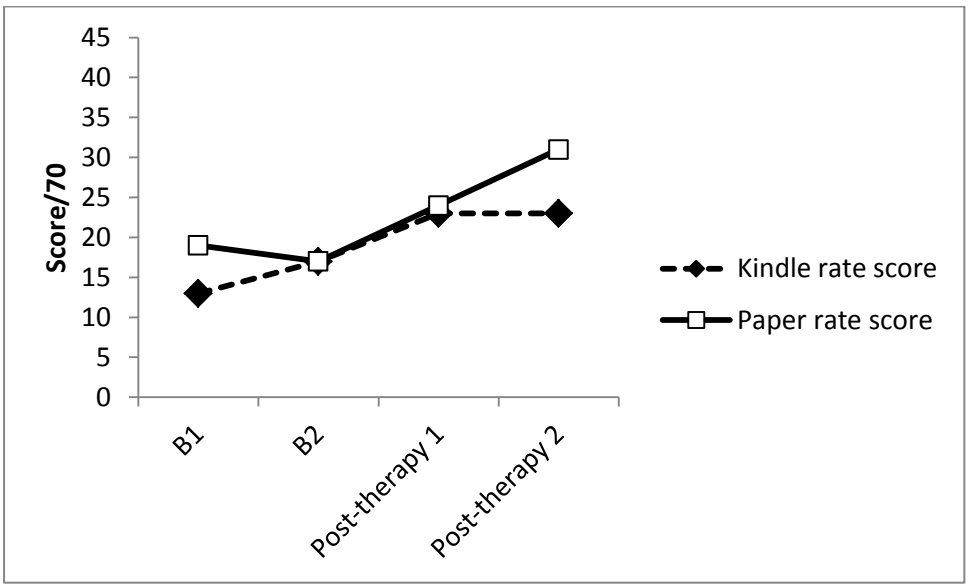


Figure 8: Kathleen's GORT-4 rate scores on paper and Kindle

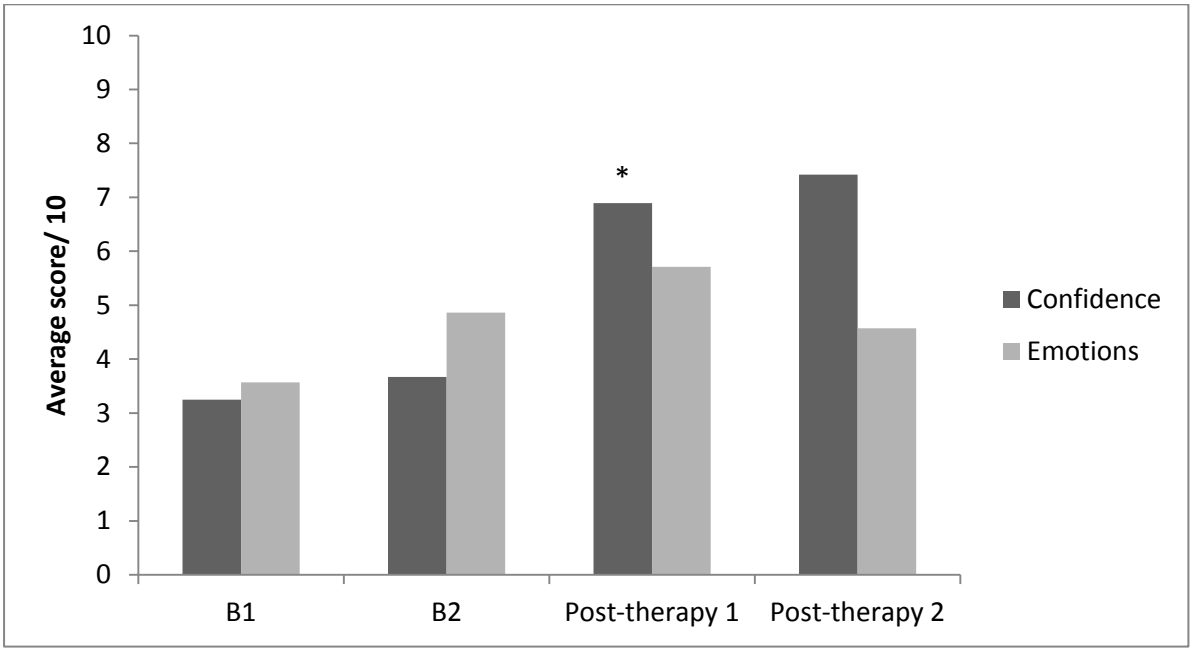


RCEQ

A Friedman test indicated a highly significant change in confidence ($\chi^2(3)= 22.69$, p=.000, two-tailed), but no change in emotions associated with reading during the project ($\chi^2(3)= 2.14$, p=.545, two-tailed). See Figure 9.

Analysis of confidence ratings using Wilcoxon tests indicated no change between B1 and B2 (Z= -1.10, p=.273, two-tailed), a significant improvement between B2 and PT1 (Z=-2.52, p<.05, two-tailed), with improvement maintained between B2 and PT2 (Z=-3.11, p<.005, two-tailed).

Figure 9: Kathleen's confidence and emotions scores on the RCEQ



Rosa

Exit interviews and usability evaluations

When reading on the Kindle, Rosa increased the font size and spacing of the text, but did not use the more advanced features. She reported difficulties in remembering how to operate the Kindle and navigate between aspects of it, and relied on the instruction manual. During the usability evaluation, she was only able to complete 6/11 tasks independently (see Appendix 3).

Despite difficulties in operating the Kindle and in reading, Rosa reported that it "*makes me want to read more*". Whereas she previously only read magazines, she started attempting to read books during the project:

> *"Since I had Kindle, I like to read. Even if later I don't know what is talking about. At that moment, I don't mind come and read. [The Kindle] make me want to do something. The words are bold, dark."*

She was able to reflect on her difficulties with great insight and clarity, aware both of the difficulties remembering the functions, but also in retaining text that was read:

> *"Yeah and now I'm seeing, I'm reading this .. book and I'm .. try, even if you tell me … ask me what the book is about [shakes head and smiles], yeah, it doesn't stay there …so, I mean have read one .. five more times*."

Despite needing more training to develop her emerging competence at using the Kindle, she enjoyed sampling and reading Buddhism texts, which led to conversations with others on the topic. She also reported feeling more sociable and inclined to want to go out with her young daughters, even though she was unable to articulate how this was attributed specifically to the Kindle.

GORT-4

Rosa's comprehension scores were very low on both paper and Kindle presentation, and showed little change across the four time-points (see Figure 10). Rosa did not employ her preferred strategies (increasing font size and spacing) on the Kindle during post-therapy assessments. Her reading rate was very slow on both paper and the Kindle and remained broadly stable across the project, although there was a slight increase in reading speed on the Kindle at PT2 (see Figure 11).

Figure 10: Rosa's GORT-4 comprehension scores on paper and Kindle

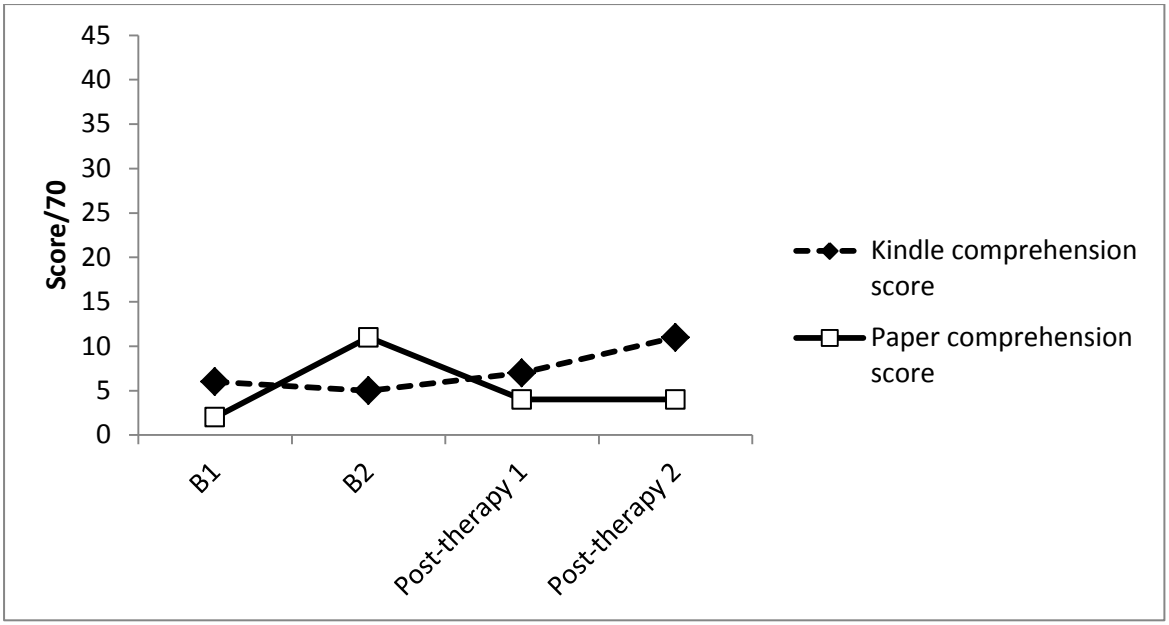
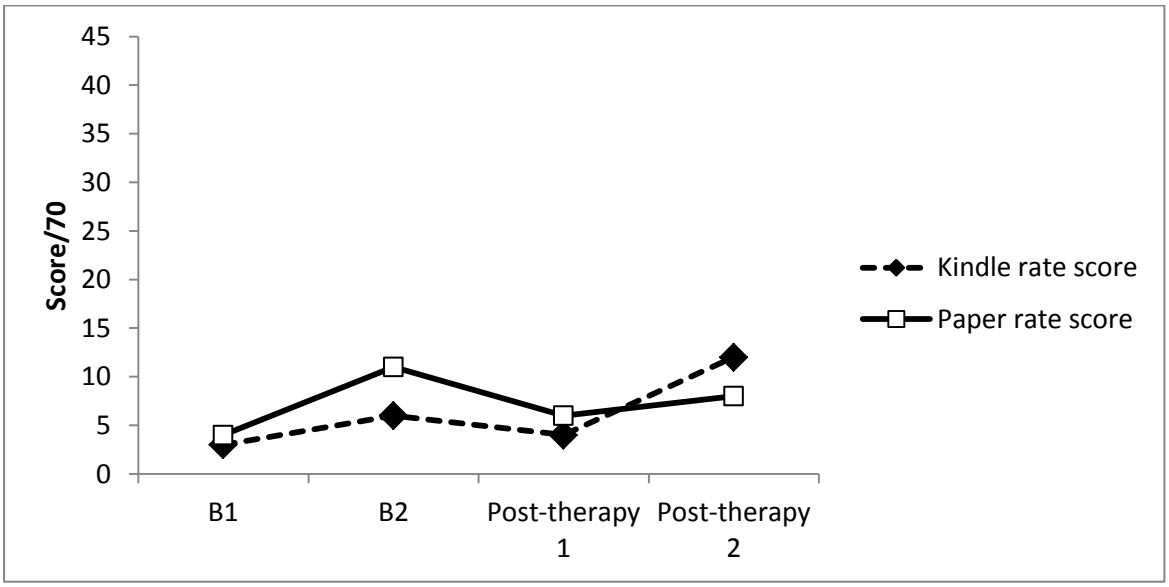


Figure 11: Rosa's GORT-4 rate scores on paper and Kindle



RCEQ

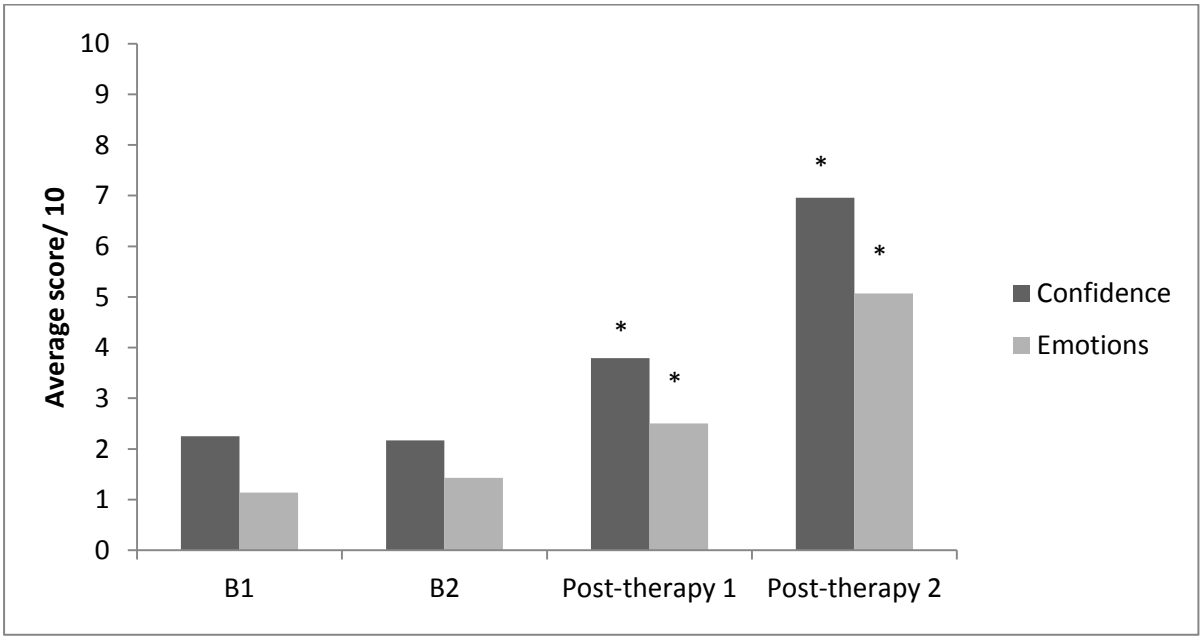
Rosa had very low scores for confidence and emotions associated with reading at the beginning of the project. A Friedman test indicated a highly significant change in both confidence and emotions

during the project (Confidence: $\chi^2(3)= 29.38$, p=.000, two-tailed), Emotions: $\chi^2(3)= 17.75$, p=.000, two-tailed). See Figure 12.

Analysis of confidence ratings using Wilcoxon signed ranks tests indicated no change between B1 and B2 (Z= -.302, p=.763, two-tailed), a significant improvement between B2 and PT1 (Z=-2.70, p<.01, two-tailed) and a further highly significant improvement between PT1 and PT2 (Z=-3.07, p<.005, two-tailed).

Analysis of emotions ratings indicated no change between B1 and B2 (Z=-1.41, p=.157, two-tailed), a significant improvement between B2 and PT1 (Z=-2.12, p<.05, two-tailed), and a further significant improvement between PT1 and PT2 (Z=-2.12, p<.05, two-tailed).

Figure 12: Rosa's confidence and emotions scores on the RCEQ



Summary of results

Can people with aphasia learn to use an e-reader following a brief period of training?

All participants made use of the Kindle's accessibility features; three changed the text size and spacing, two wrote notes and used highlighting and bookmarks and one participant found the text-to-speech feature very valuable. Participants generally became very proficient at operating the features of the Kindle that they used regularly. In particular, all four participants could independently switch the Kindle on, charge it, find a book and start to read, use the page forward and page back buttons on the side of the Kindle, use the Home button and the 5-way D-pad. Additional aspects of the Kindle that most participants found helpful were having a restricted page size and being able to have fewer, bold looking words on each page.

In contrast, participants disliked the small buttons and features that required a sequence of steps to be remembered, such as changing the size of the text and the line spaces. However, once a preference for these settings had been selected, participants typically kept these unchanged, meaning that they did not need to operate these features regularly. This may explain why several participants did not make full use of these features in post-therapy assessment. They may have become unaccustomed to changing them, as they had not needed to adjust them for several weeks.

One participant (Rosa) experienced difficulties operating the Kindle and would have benefited from a longer period of training, while another (Edward) mastered the basic functions, but not the more advanced ones. However, it is unlikely he would have benefited from more training given his strong preference for reading on paper or with ClaroRead™ software.

Does e-reader training improve reading comprehension?

The participants' reading comprehension at the start of the project was superior on paper than on a Kindle. Following training their comprehension on the Kindle caught up with, but did not exceed, that on paper. However, only two of the participants adjusted the Kindle to their usual settings at post-therapy assessment (Bethany and Kathleen) and only one participant used their normal settings

at maintenance assessment (Kathleen). It is therefore possible that comprehension scores on the GORT-4 for the Kindle would have been higher if all participants had used their preferred settings during all post-therapy assessments.

Do e-readers increase participation in and enjoyment of reading activities?

Three of the four participants (Bethany, Kathleen and Rosa) emphatically expressed their preference for the Kindle over reading on paper, volunteering that they 'loved [using] their Kindle'. These participants reported that they read more (frequently and for longer) with the Kindle than they had done on paper and were able to access new material, such as novels and non-fiction books. They also reported improved confidence in reading activities and two additionally reported more positive emotions associated with reading.

Furthermore, two participants (Rosa and Kathleen) reported wider benefits from taking part in the project, including being more willing to hold conversations, feeling more sociable and wanting to go out more. It is possible that this was linked to increased confidence resulting from their sense of achievement in learning to use the technology and being able to read more. Reading may also have helped them tap into a previous identity. For example, Rosa read a lot before her stroke and enjoyed discussing ideas. Despite her difficulties remembering the text, reading books about Buddhism appeared to give her confidence to engage others in conversation about Buddhist philosophy.

Discussion

Despite overwhelming enthusiasm for the Kindle from three of the four participants, this pilot presents a mixed picture of the benefits of e-readers. It raises important questions about

differences between reading on paper versus a digital device; how reading ability is measured; barriers to e-reader use; and the challenges of researching mainstream reading technologies.

Measuring reading ability

Reading comprehension and rate, as assessed by the GORT-4, did not indicate any advantage for reading on the Kindle compared to paper, either before or after training. Before training, comprehension and rate on the Kindle were markedly lower than on paper. It is possible that the Kindle distracted participants, taking attention away from processing the text. Reading on the Kindle may therefore have posed a greater cognitive challenge than reading on paper.

Alternatively, answering questions about a passage read on a digital device may simply be harder than a passage read on paper. Evidence for this comes from a study of Norwegian primary school children, who performed better on comprehension questions when the reading passage was presented on paper than on a PDF on a computer (Mangen et al, 2013). The authors argued that it is easier to form spatial-mental representations of a text when it is fixed on paper, than on a screen where the text moves as the reader scrolls through it. They propose that these representations support the reader in recalling information from the text. This effect may be magnified on an e-reader, as the screen is smaller and displays less text than a PDF, necessitating more frequent page-turning.

Across the group, reading comprehension and rate as assessed by the GORT-4 improved on the Kindle following training, but did not exceed the level on paper. One explanation for this was due to the method of administering the assessment. Passages were presented on the Kindle with text and spacing as similar as possible to the paper version. Participants were reminded that they could adjust the settings to modify the presentation of the text, but two participants (Edward and Rosa) did not do this at all under assessment conditions. A third participant (Bethany) used her usual

settings at the first post-therapy assessment, but did not do so at maintenance assessment (after an incident that appeared to distract her). Bethany's comprehension and rate both improved at post-therapy assessment, with her comprehension on the Kindle equalling her performance on paper, while her rate exceeded the level on paper. Her scores then fell back markedly at maintenance assessment. However, Kathleen was the only participant to consistently use her strategies post-training, but only showed a very slight improvement in her reading comprehension and rate on the Kindle.

Given these equivocal results, it is surprising that three of the participants were so positive about the benefits of using an e-reader. These participants all reported statistically significant gains in reading confidence, and marked improvements in participation in and enjoyment of reading activities. This suggests that the GORT-4 did not capture changes that occurred in everyday reading. Possible explanations for this are discussed below.

The GORT-4 requires participants to answer questions that assess detailed comprehension of the text. The e-reader may not have facilitated participants' comprehension of individual words and sentences, but enabled them to read faster and/or made the text less tiring to read, meaning that they could progress more rapidly through a book, follow the plot and were therefore able to enjoy the story.

Evidence for this comes from responses to questions in the exit interview. For example, Bethany reported, "*Its difficult reading it (on paper). Stuck in the word. I don't. Text speak is better for me".* Bethany appears to be indicating that the text-to-speech function not only supports her comprehension of the written text, but also stops her getting stuck on difficult words, maintaining her momentum through the story. Kathleen reports that paper books are *"Too small. Can't remember what I'm reading."* Her experience of using an e-reader was sharply contrasting: [The Kindle makes me feel good] "*because I can read and I remember what I'm reading."* These comments suggest that the Kindle supported Kathleen's memory of what she had read.

GORT-4 scores may also not have reflected changes in everyday reading due to the extra demands of responding to the assessment. Everyday reading requires multiple cognitive processes, including language skills, inferencing (local and global), working memory and meta-cognitive skills. These include the ability to monitor comprehension, identify errors or gaps in understanding and resolve problems when something has not been understood (Meteyard, Bruce, Edmundson & Oakhill, 2015). One advantage of everyday reading is that when gaps in understanding are identified, the reader can return to and re-read relevant sections. Answering comprehension questions, however, also requires offline processing and hence poses additional demands. The reader must understand the question, remember, access and extract relevant information and draw inferences from the text. The cognitive and linguistic demands of responding to the questions may therefore exceed the demands of simply reading a book for enjoyment.

Webster et al. (2013) also reported a complex relationship between changes on formal assessment and everyday reading. They used the Discourse Comprehension Test (DCT, Brookshire and Nicholas, 1993) as their primary outcome measure, a text-level reading assessment based on comprehension questions about written paragraphs. They found that some participants improved on the DCT but did not report changes in reading participation, while others reported increased enjoyment and confidence in reading but made no gains on the DCT.

Barriers to the use of e-readers for people with aphasia

The Kindle e-reader presented linguistic, cognitive and physical barriers to people with aphasia. In terms of linguistic demands, a key barrier was the poor quality of the text-to-speech feature, which was only used by one participant. People with aphasia may find it particularly difficult to understand poor-quality text-to-speech if they have auditory processing impairments. This feature has improved on newer models, but, at the time of writing, it is only available on Kindle Fire tablets, not on the simpler e-readers that were designed only for reading (e.g. Kindle Paperwhite). None of the

Kindle's major competitors (e.g. Kobo™, Nook™, Sony™) currently include a text-to-speech feature. In addition, several features required participants to read and select options from menus (e.g. adding a bookmark). The accessibility of such features could be improved by the use of pictorial icons.

The cognitive demands of using the Kindle are considerable, particularly operating functions that require multiple steps. For example, in order to change the line spacing, participants needed to press a button on the keyboard, scroll down to line spacing, move across to the correct spacing and then select this option. Rosa, the participant who found it most difficult to learn to use the device, was the most impaired on the CLQT (moderately impaired). She was also the only participant who would have benefited from more than four training sessions learning to use the Kindle. This suggests that cognitive ability may predict the amount of time it takes for a person with aphasia to become a proficient user of the Kindle. However, Rosa reported finding the Kindle useful and enjoyable, suggesting that cognitive abilities do not predict how positive or negative a person is about their experience of using the technology.

Finally, the Kindle posed physical challenges to the participants, requiring fine motor skills in order to operate the small keys on the keyboards. Although the participants were able to use the keyboard effectively, three commented in the usability evaluation that they disliked this aspect of the Kindle.

Two participants who had impaired peripheral vision reported benefits from using the Kindle, suggesting that this was not a barrier to use of an e-reader. Bethany had tunnel vision in her right eye, while Rosa had blurred peripheral vision in both eyes. The small size of the e-reader's screen, relative to the size of a page of a book, may have facilitated reading for these participants.

Challenges of researching the benefits of e-readers for people with aphasia

A key challenge in carrying out research using e-readers was the rapid pace of change in the market, with new models introduced and discontinued at a giddying rate. The original model selected was discontinued before purchasing, while the Kindle Keyboard 3G is no longer available at the time of writing. There were also compromises to be made in selecting the most suitable model for people with aphasia; as they are not designed with people with aphasia in mind, features that make text more accessible are often spread across the different models. For example, the available model that featured a touchscreen did not have text-to-speech and vice versa. Currently the improved text-to-speech feature is only available on the tablet models of the Kindle (e.g. Fire HD), which people with aphasia might find more difficult to use due to the complexity and number of different applications available on the devices. The findings of this study suggest that when selecting an e-reader for use by people with aphasia, the key factors to consider are the presence and quality of the text-to-speech feature, the amount of reading required to operate the e-reader (e.g. in selecting options from a menu), the number of steps needed to operate key functions and the physical accessibility of the buttons or touchscreen.

A challenge in carrying out intervention targeting text-level reading is the selection of suitable outcome measures. The GORT-4 was chosen as it contained a large number (28) of texts at varying levels of complexity and arranged into two matched sets (Form A and B). This enabled comparison of reading on paper and the e-reader at each assessment point. However, the assessment had a number of disadvantages. It was developed for school-aged readers in America, meaning that some passages are clearly aimed at young children, while others contain vocabulary and topics that may be less familiar to a European audience (e.g. park ranger, railroad, movies). Questions cover a range of comprehension types, including inference, and some are ambiguous (e.g. there are often two plausible responses to questions based on inferring a character's motive). However, there are no other standardised reading assessments that feature such a large and wide range of reading passages, suggesting a need for a text-level assessment of reading designed for adults in the UK. An

assessment featuring several matched texts at different levels of complexity would enable comparison of reading on paper and using different reading technologies.

Further limitations of this study include the small number of participants. The single-case design meant that it was not possible to analyse the GORT-4 results statistically.

Conclusion

Following a very brief period of intervention, three participants learnt to use an e-reader proficiently. Of these, two reported remarkable gains in reading participation and enjoyment. Three reported increased confidence in reading, with two of these reporting wider benefits from taking part, perhaps due to a sense of achievement in having learnt to use a new technology, or due to reading enabling them to reconnect with part of their former identity that they thought they had lost. However, reading comprehension and rate were found to be superior on paper even following e-reader training, at least when assistive functions were not utilised.

These results suggest that e-readers may facilitate reading through mechanisms other than enhancing reading comprehension. These may include the use of text-to-speech to supplement reading comprehension with auditory comprehension thus increasing reading speed, and the reduction in visual and cognitive processing demands through reducing visible text on each page.

Future research should build on this pilot by trialling e-readers with a larger group of people with aphasia. Linguistic and cognitive factors that may affect ability to use an e-reader should be explored further, and use of tablets incorporating an e-reader should be explored to evaluate their accessibility to people with aphasia.

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Appendix 1: Exit interview questions

1. Can you tell me a little about your **experience** of taking part in this project? OR Can you tell me about **what you've been doing**/ have done in this project?
   Probes:

   - What has it involved?
   - What have you been doing?
   - What you have learned?
   - What have you gained?

2. I wanted to find out a little more about how you have been using the kindle, what do you **use** it for?

3. Has it **changed** how you read?
   a. *Probe whether participant has noticed any changes in reading habits, speed, topics/ interests, comprehension, recall*
   b. *Probe whether anyone else has commented on it – family member or friend or other passed comment on participant's reading or kindle or participation in project*

4. How do you **find** using it?
   Probes
   a. What's easy?
   b. What's hard?
   c. Do you feel you can use it independently now?
   d. Are you worried about using it in the future, by yourself?
   e. Would you recommend it to others?
   f. What do other people think of it (i.e. family/ friends)?

5. Has it **changed anything else** in your life?
   a. *Probe whether participant sees any change in exploring books more, noticing things on tube/ in magazines etc (in public forums), whether visiting libraries or bookstores more, whether paying more attention to books and authors more/ papers/ magazines*

6. How do you see yourself using it in the future? OR
   What are you hoping that you will be doing with your reading in the future?

7. How **satisfied** are you with what you've done in these sessions/ in this project/ what you've got from this project?

8. What has really worked for you?

9. Do you think the people you've worked with could have done anything differently? (And what impact would that have made for you?)

Appendix 2: Kindle Framework Analysis Topsheet

1. What Doing on the Project

1.1 What reading on the project and what Kindle functions used
1.2 Success or failure
1.3 Motivation for choosing or using/ not choosing or not using
1.4 The how and where of reading

2. Previous reading/ Own problems with reading

2.1 Speed (qualitative aspect of reading)

2.2 Difficulty with words (memory/ understanding/ retrieval)

2.3 Opinion on reading ability or skills relating to reading

3. Benefits of Kindle

3.1 Benefit to reading

3.2 Access / Feature benefits

3.3 By-product/ side-effect benefits (includes realisations about self)

3.4 Impact of Kindle on other reading/ broader life aspects

3.5 Perceived value of Kindle (recommend to others)

4. Emotional reactions to Kindle (and project experience)

4.1 Positive emotional reactions

4.2 Reasons for response

5. Accessibility of Kindle

5.1 Positive views

5.2 Reasons for positive

5.3 Negative views and reasons (might be explicit comment OR overt evidence in the session of not understanding how to use the kindle/ how to access its functions)

5.4 Views on how to improve Kindle

6. Future use

6.1 Future use for reading

6.2 Intended/ purchased kindle

Appendix 3: Usability evaluation- Detailed Individual Task Results

Key:

Can operate function? : 0= No, 1= Can do with assistance of HCI researcher, 2= Can do with reference to handbook, 3= Yes.

Self-rating score: 1 (Hard) – 5 (Easy)

	Bethany		**Edward**		**Kathleen**		**Rosa**	
	Can operate function?	Self-rating score	Can operate function?	Self-rating score	Can operate function?	Self-rating score	Can operate function?	Self-rating score
Switching on	3	5	3	5	3	5	3	5
Finding a book and starting to read	3	5	3	5	3	5	3	4
Page forward and page back	3	5	3	5	3	5	3	5
Change size of text	3	5	3	5	3	5	2	2
Change font	3	5	3	5	1 (didn't recognise the word 'font' as 'typeface')	5	N/A	N/A

Change line spacing	3	5	3	4	3	5	2	2
Change no. of words per line	3	5	3	4	3	5	1	1
Highlighting a word	3	5	N/A	N/A	2	4	N/A	N/A
Using the Kindle dictionary	3	4-5	3 (Finds definitions difficult to understand).	4	3	5	2	1
Adding and deleting a note	3	5	N/A	N/A	1 & 2 (She uses the handbook to help her at home.)	2	N/A	N/A
Adding/deleting bookmarks	3	5	N/A	N/A	3	5	N/A	N/A
Using text to speech	3 Likes and uses it often, following the story/ reading at the same time as listening. '*Easy but automatic. Bit computer*...' [robotic]	3 or 4	N/A He doesn't like the '*mechanical*' voice.	N/A	N/A	N/A	N/A	N/A
Back button	3	5	3	5	3	5	0	1

Home button	3	5	3	5	3	5	3	5
Shopping in the Kindle Store	3 Finding the book is easy. Uses search facility, but loading takes time.	4	0 SLT researcher and his wife have bought his books	1	3 '*I do it lots'*.	5	N/A	N/A
Switching off	3	5	3	5	3	5	3	5
Charging it up	3	5	3	5	3	5	3	5
Do you like the way it looks?	'*Not really. I don't like the narrow, short lines. Too short. Much more... I wish, more* ...' (Would like more text on a page).	3	Doesn't like it. Finds the buttons fiddly. Would prefer a touchscreen model.	1	Likes	5	Likes Rosa doesn't read paper books. '*I was reading magazines [before my stroke]. Since I had Kindle, I like to read. Even if later I don't know what is talking about. At that moment, I don't mind come and read. [The Kindle] make me want to do something*." '*The words are bold,*	5

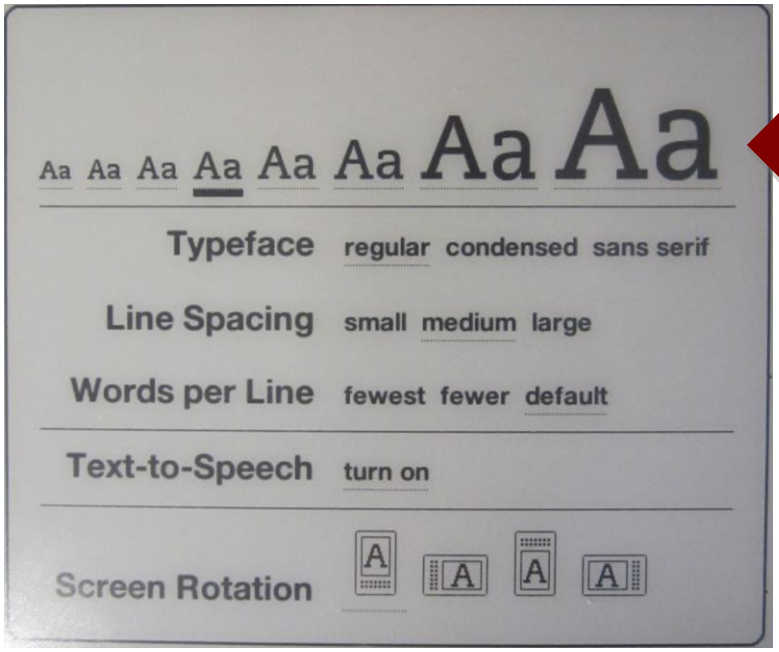
							dark.'	
Do you like the way it feels?	Uses '*bedroom, bath, everywhere. The train. Listening and...*'	4	'*No, it's a blasted nuisance'.* He knocks the page forward and back buttons and touches the keyboard buttons by mistake.	2	Likes Kathleen can't read paper books as the words are too small. "*The buttons are a little fiddly but once you've used it for a while, you get used to it."*	5	Rosa holds it in her lap. She found the D button fiddly and used her nails to operate this: '*My fingers are too big*.'	3
How does using a Kindle make you feel?	Good		Sometimes good, sometimes frustrated (e.g. with dictionary)		Good		"*Good. Even though I know I'm not good [at it*]"	
Do you prefer Kindle or paper book?	Kindle *'(Kindle): Listening. Out loud. I follow the story and the lines. (Paper): It's difficult reading it. Stuck in the word. I don't. Text speak is better for me.'*		Paper He likes the memories/familiarity of a known paper book.		Kindle		Kindle	

Other comments	*'It's good. Really, really good. Talking as well as reading it. It's so much better. Vocabulary. Out loud. At bedtime. Reading it. Or listening to it is so much better.'* Bethany uses her Kindle every day. She uses dictionary occasionally.		He prefers reading paper books. *"I also like books I've looked at for years and years. I've got Rupert books. It's the feel and the paper".*		[It makes me feel good] "*because I can read and I remember what I'm reading. My husband's bought me one*." (Kindle Fire). Paper books: "*too small. Can't remember what I'm reading."* *'I love my Kindle. It's the best thing I've had. I didn't think I could read, but I can read. I used to read all the time before my stroke and I missed it.'*		'*Makes me want to read more. Even though I forget what the story is*.'	
Total score	51	89	36	61	43.5	86	25	44

Appendix 4: Example from manual showing how to change font size.

2.1 Change **size**

Press **Text button (AA)**



Use the direction buttons to choose the size you prefer

Table 1. Participant details

	Bethany	**Edward**	**Kathleen**	**Rosa**
Gender	Female	Male	Female	Female
Age	22	73	62	43
Years of education	15	17	11	16
Occupation	Student	Lecturer	Office worker (retired)	Student
First language	English	English	English	Portuguese
Handedness	Right	Right	Right	Right
Vision/Hearing	Tunnel vision in right eye; no reported hearing difficulties	No reported difficulties (corrected vision)	No reported difficulties	Blurred peripheral vision in both eyes
Time post onset	3 years	8 years	4 years	2 years
Type/location of CVA	Multiple ischaemic CVAs	Left-sided ischaemic CVA	Left-sided haemorrhagic CVA	Left-sided haemorrhagic CVA
Hemiparesis	Right-sided hemiplegia	Right-sided hemiparesis	No hemiparesis	Right-sided hemiparesis

Table 2. Participants' scores on background and screening assessments

N.B. Scores shaded in grey lie outside the normal range.

CAT	***Bethany***	***Edward***	***Kathleen***	***Rosa***	**Max.**	**Normal mean**	**Normal range**
Naming objects	44	44	46	40	48	46.4	42-48
Naming Actions	6	6	7	2	10	9.88	8-10
Spoken Picture Description	25	43	46	37	N/A	52.2	33-87
Comprehension of spoken words	29	29	27	26	30	29.2	25-30
Comprehension of spoken sentences	17	30	23	23	32	30.2	26-32
Comprehension of spoken paragraphs	4	3	2	2	4	3.87	3-4
Writing: Copying	27	27	27	27	27	26.8	24-27
Writing Picture Names	19	5	21	14	21	20.2	14-21
Writing to Dictation	27	10	28	20	28	27	22-28
CLQT	***Bethany (age 22)***	***Edward (age 73)***	***Kathleen (age 62)***	***Rosa (age 43)***	**Max.**	**Normal mean (S.D.): ages 18-69**	**Normal mean (S.D.): ages 70-89**
Attention	198	191	187	122	215	199.6 (10.65)	173.3 (35.8)
Memory	137	140	125	80	185	168.2 (11.9)	157.8 (13.4)
Executive Function	30	26	26	13	40	31.4 (4.43)	25.4 (4.31)
Language	25	28	27	20	37	32.6 (2.57)	30.6 (2.34)
Visuospatial Skills	100	89	86	53	105	95.4 (6.47)	81.7 (12.8)
Composite Severity Rating Range	3.4	3.8	3.4	1.6	4.0	3.5-4.0	3.5-4.0
RCBA-2	***Bethany***	***Edward***	***Kathleen***	***Rosa***	**Max.**		

Word-Visual	10	9	10	8	10	Normal data not available
Word-Auditory	10	10	10	9	10	
Word-Semantic	9	10	10	9	10	
Functional Reading	8		8	6	10	
Sentence-Picture	9	10	10	10	10	
Paragraph-Picture	9	9	8	5	10	
Paragraph-Factual	9	10	9	7	10	
Paragraph-Inferential	10	10	8	9	10	

Figure captions

Figure 1. Bethany's GORT-4 comprehension scores on paper and Kindle

Figure 2: Bethany's GORT-4 rate scores on paper and Kindle

Figure 3: Bethany's confidence and emotions scores on the RCEQ

Figure 4: Edward's GORT-4 comprehension scores on paper and Kindle

Figure 5: Edward's GORT-4 rate scores on paper and Kindle

Figure 6: Edward's confidence and emotions scores on the RCEQ

Figure 7. Kathleen's GORT-4 comprehension scores on paper and Kindle

Figure 8: Kathleen's GORT-4 rate scores on paper and Kindle

Figure 9: Kathleen's confidence and emotions scores on the RCEQ

Figure 10: Rosa's GORT-4 comprehension scores on paper and Kindle

Figure 11: Rosa's GORT-4 rate scores on paper and Kindle

Figure 12: Rosa's confidence and emotions scores on the RCEQ