Effectiveness of the Apple iPad as a Spot-reading Magnifier

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SIGNIFICANCE: There are no data available comparing the iPad as a portable magnification device with a portable video magnifier. Our study supports the use and integration of mainstream tablet computers into vision rehabilitation to overcome potential barriers to device uptake due to the stigma attached to traditional devices.

PURPOSE: Portable personal tablet computers have taken on an important role as assistive devices for individuals with visual impairment; however, their use is rarely supported by independent data. Our study aims to contribute to evidence-based practice by comparing a tablet computer with a portable video magnifier in their use as spot-reading devices.

METHODS: We compared the Optelec Compact 5 HD portable video magnifier (Optelec, Longueuil, Canada) and the Apple iPad Air tablet computer (Apple Inc, Cupertino, CA) using the SuperVision+ Magnifier app by asking 60 adults with low vision (age range, 19 to 97 years; mean visual acuity, 20/136) to spot read information on a bill, a medication box, and a food label. Their ability to complete each task was timed; they completed the Quebec User Evaluation of Satisfaction with assistive Technology questionnaire and indicated their preferred device.

RESULTS: Performance speed indicated that easier tasks were completed faster; however, there were no statistically significant differences in performance between the two device conditions. The highest satisfaction scores for both devices were identical: dimensions, ease of use, and effectiveness. Preference between the two devices was split at 25 for iPad, 33 for the portable closed-circuit television, and 2 for undecided.

CONCLUSIONS: The results indicate that performance speed on our spot-reading tasks was comparable across the two devices. In addition, subjective judgment of the device features and personal preferences lead us to conclude that both the iPad and the portable magnifier may have certain equivalence in their functionality, depending on the user and the task for which they are used.

Supplemental Digital Content: *Direct URL links are provided within the text.*

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Since the development of tablet computers in the early 2000s and the release of the first iPad in 2010,[1] portable personal tablet computers with tactile screen interfaces have become a popular mainstream presence. It comes as no surprise that the multifunctionality of these devices was soon discovered by visually impaired individuals to be useful. It has been proposed that low vision service providers will need to be better prepared to include tablet computers in their care provision[2] and that the coming generations of clients with low vision will already have incorporated these types of devices into their lives with ease to maximize their abilities across all aspects of daily life.[3] Miyake and colleagues[4] were among the first to report on the use of an iPad as a magnification device in 13 low vision patients and its beneficial effect on reading speed and print size, whereby the users indicated that the iPad was more comfortable than traditional devices. Similarly, Chun and colleagues[5] investigated the use of smartphones by members of the low vision community and reported that their 12 visually impaired participants found the voice-activated options extremely user-friendly. Crossland and colleagues[6] reported on the responses of 132 individuals with visual impairment to a survey on technology use, focusing on smartphones, tablets, and e-readers, and found that most respondents gained considerable benefit from these devices, independent of their level of vision, given their accessibility features. Both smartphones and tablet computers are equipped with a variety of accessibility features that have been described and evaluated in the context of low vision rehabilitation,[7–9] in addition to a myriad of apps that have been developed for the use in the context of visual impairment for magnification, contrast enhancement, object identification, and so on.[10–13] Objective and subjective measures of reading have been demonstrated to be similar across different types of electronic displays,[14] and some data indicated that reading speed may actually be increased with the use of devices such as the Apple iPad (Apple Inc, Cupertino, CA) compared with print media,[15] although these effects do not replicate under all circumstances.[16]

The need and relevance for developing the use, utility, and usability of tablet computers in the context of low vision have previously been highlighted by Grindrod and colleagues,[17] who developed an app specifically for use with the iPad designed to assist individuals with reading difficulties (e.g., due to low vision) when accessing medication labels. Others have pointed toward the utility of voice output on tablets and smartphones when managing diabetes and low vision due to diabetic retinopathy through assistive technology and medical devices. Thomas and colleagues[18] reported in their Cochrane review that there is currently no high-quality evidence demonstrating the usefulness of devices such as tablet computers, specifically when examining children and youth, a gap that is currently being addressed by Crossland et al.[19]

Several recent studies have focused specifically on the utility of tablet computers, such as the iPad, in the context of low vision rehabilitation. Mednick and colleagues[20] have examined the effect of a two- to four-week iPad teaching module on clients with low vision and found in their qualitative investigation with six participants that they perceived an improved sense of independence and social connection after having learned about the accessibility and multifunctionality of the device, specifically through messaging and voice access features. Similarly, Kaldenberg and Smallfield[21] demonstrated the benefit of training four older adults with low vision on tablet computer use to improve functional ability as measured by the Canadian Occupational Performance Measure.[22] Walker and colleagues[23] focused on reading with the iPad in 26 low vision patients when using an app specifically designed to scroll text in a single line, thereby avoiding the effect of crowding in the visual periphery. They demonstrated that reading performance was equivalent to reading static text displays.

To date, the largest study on low vision reading using a tablet computer was presented by Morrice et al.,[16] wherein 100 participants ranging in age from 24 to 97 years were measured on reading rates, comparing the performance of an Apple iPad with that of a table-top closed-circuit television or other magnification devices. The authors concluded that reading speed did not differ significantly across the different device conditions. However, subgroup analysis indicated that previous experience in the use of the iPad had a beneficial effect on reading speed, an effect that was not found with the closed-circuit television. There was, however, a key methodological limitation in this study, whereby the paragraphs of the International Reading Speed Test[24] presented on the iPad were programmed into the iBook app, whereas the International Reading Speed Test paragraphs presented under the closed-circuit television condition were printed on paper that needed to be manipulated by the reader on the tray for the continuous reading task. The authors acknowledged that this limitation renders the two tasks only partially comparable. At present, there are no data available comparing the iPad as a portable magnification device with current standards of care, such as portable video magnifiers.

The present study aims to fill this void by examining objective (e.g., performance speed) and subjective (e.g., preference) variables of reading behavior, comparing the use of the Apple iPad with that of a portable closed-circuit television model, the Optelec Compact 5 HD (Optelec, Longueuil, Canada) (see Appendix Fig. A1, available at http://links.lww.com/OPX/A350). These devices were chosen based on a variety of reasons. They included (*a*) the popularity of the iPad among rehabilitation clients who frequently approach service providers with questions about the use of this tablet as a rehabilitation tool, (*b*) the emergence of clinical guidelines based on evaluations by rehabilitation centers for the use of tablets as rehabilitation devices,[25–27] (*c*) the popularity of the Optelec as the most frequently chosen electronic magnifier in rehabilitation services at the center where this study was conducted, and (*d*) the similarities of these device with regard to price, portability, and electronic magnification capacity, as well as their differences in screen size and other additional features.

METHODS

The study protocol was approved by the institutional review board of the Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain (no. 1077-0415) and adhered to the tenets of the Declaration of Helsinki for research with human participants.[28]

Participants

Descriptive variables for the 60 participants are presented in Table 1. They were recruited from the two vision rehabilitation agencies in the Montreal region, the Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain/Centre de réadaptation MAB-Mackay du CIUSSS du Centre-Ouest-de-l'Île-de-Montréal and the Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain/Institut Nazareth et Louis-Braille du CISSS de la Montérégie-Centre. Twenty-two participants (37%) failed the blind version of the Montreal Cognitive Assessment[29]; however, their data did not differ significantly from those

TABLE 1. Participant demographics

Variable group 2	n
Total survey respondents (male/female)	26/34
Impairment (in terms of best visual acuity)	
Distance (logMAR), mean (SD)	0.83 (0.27)
Near (logMAR), mean (SD)	0.60 (0.33)
Primary diagnosis	
Macular degeneration (including Stargardt disease)	30
Diabetic retinopathy	6
Glaucoma	5
Other (e.g., albinism, macular hole, Usher syndrome)	17
Unknown	2
Age (y)	
<50	6
50–59	3
60–69	7
70–79	10
80–89	28
≥90	6
Language	
French	26
English	26
Other (e.g., Spanish, Greek, and Arabic)	8
Highest level of education	
Primary	20
Secondary	14
Post-secondary	26
Self-reported reading ability	
Asked but not answered	19
Elementary	1
Moderate	3
Very good	4
Fluent	33

logMAR = logarithm of the minimum angle of resolution; SD = standard deviation.

who passed this test, an observation similar to a previous study,[30] and the data of both groups are combined here. A short language and reading questionnaire that has been used in a previous study[16] was subsequently administered verbally. It included questions on the participants' linguistic fluency, level of education, spot-reading practices (defined as a short reading task of a few words or numbers, less than a full sentence), and technological familiarity and open mindedness toward technology.

The protocol was completed back-to-back with (*a*) the Optelec Compact 5 HD portable video magnifier and (*b*) the Apple iPad Air tablet computer (see Table 2 for device features) using the SuperVision+ Magnifier app from Massachusetts Eye and Ear Infirmary (http://www.schepens.harvard.edu/superVision). Each series of trials was preceded by a short (<5 minutes) hands-on training on how to use each device for the purpose of spot reading (e.g., how to hold it, where the camera is, how to zoom in and out, and how to alter the contrast). Each participant was given the chance to ask any question and to try using the device on the consent form.

For each device, three objects were chosen, and for each of these, two tasks were defined (one easy and one difficult). There were two object exemplars to ensure that participants were not more familiar with the object when manipulating it when using the second device. The objects were as follows: bills, cardboard boxes for eye drops, and food items. The bills were issued by a local cable company, where any sensitive or personal information was replaced by dummy information, and were printed out in black and white. The eye drops were the outer packages of Besivance (besifloxacin ophthalmic suspension 0.6% wt/vol, 2 mL; Bausch + Lomb; Rochester, NY) and Lotemax Gel (loteprednol etabonate ophthalmic gel 0.5% wt/wt, 0.5 g; Bausch + Lomb). The food items were the 175-g package of Kashi Chia Granola Dark Chocolate and Almonds and Sea Salt bars and a 20-bag package of Twinings of London English Breakfast black tea still in its transparent plastic wrapping.

The tasks were as follows: find the amount due and find the customer service telephone number (bill 1), find the due date of the invoice and find the technical support telephone number (bill 2; see Appendix Fig. A2, available at http://links.lww.com/OPX/A351), find the name of the medication (see Appendix Fig. A3, available at http://links.lww.com/OPX/A352), find the expiration date (eye drops 1 and 2; see Appendix Fig. A4, available at http://links.lww.com/OPX/A353), find the name and flavor of the product and find the number of bars (food 1), and find the name and type of product and find the number of tea bags (food 2; see Appendix Fig. A5, available at http://links.lww.com/OPX/A354). For each task, three variables were measured: whether or not the task could be completed within 3 minutes, the number of errors made in reading out the required information, and the time needed to complete each task. If the easy task for a particular object could not be completed, the hard task for that same object was omitted.

The order in which the devices were tested, the order in which the two object exemplars were chosen, and the order of which object to test first were all randomized (http://www.randomization.com); however, for each task, the easy condition was performed first. After each participant had been tested on one device for all three objects, we verbally administered a modified version of the Quebec User Evaluation of Satisfaction with assistive Technology (version 2.0),[31,32] in which the "services" section was omitted as well as the services-related satisfaction items when asked to select the three most important items. After both devices had been tested, the participants were asked which device they would favor or prefer and whether they wanted to add any qualitative observations about participation in this study.

RESULTS

Of our 60 participants, 57 considered themselves as comfortable with technology, whereby 14 owned a tablet and 34 owned a closed-circuit television. In terms of experience using each of the devices, 18 had previous experience with the iPad and 38 had experience with a closed-circuit television. Previous device use or ownership, however, did not influence any of the statistical analyses reported below.

Ability to Complete Tasks

Participants were classified in their ability to complete each of the tasks within a 180-second window (Table 3). A χ^2 test of independence was performed to examine the relation between device used (iPad, closed-circuit television) and task difficulty (easy, difficult). For all three types of reading tasks (bill, medicine label, food label), the relation between these variables was nonsignificant: bill: $\chi^2 = 0.004$, $P = .95$, Cramér $V = 0$; medicine: $\chi^2 = 1.875$, $P = .17$, Cramér $V = 0.116$; and food: $\chi^2 = 0.357$, $P = .55$, Cramér $V = 0.044$. Thus, there were no significant differences in the ability of the participant sample to complete the tasks between each device or because of the differences in level of difficulty, making the conditions relatively balanced. For the analyses hereinafter, please note that only participants who were able to complete any given task were included in the analyses of completion time. This approach to data analysis inherently may create a bias that is unable to reflect any relationship between the ability of completing a task and the time it takes to complete this task.

Time to Complete Tasks

Note that reading time (in seconds) was calculated only on those participants who successfully completed the task within

TABLE 2. Comparison of device features for the Optelec Compact 5 HD and the Apple iPad Air

Features	Optelec Compact 5 HD	Apple iPad Air (2013)
Price (Can$; April 2018)	950	429
Display size	12.7 cm/5 in	24.6 cm/9.7 in
Screen resolution (pixels)	800 × 480	2048 × 1536
Screen contrast ratio	500:1	1000:1
Screen brightness (cd/m^2)	350	415
Dimensions (cm)	13.7 × 8.8 × 2.3	24.0 × 16.9 × .75
Weight	294 g/10.4 oz	469 g/16.5 oz
Camera (megapixel)	8	5
Magnification	×1.5–×18	×1.1–×15
Camera field of view (degrees visual angle)	64.0–7.2	39.6–2.6
Distance viewing	Up to 1 m/3 ft	Up to 10 m/32 ft
Battery life (h; constant use)	3 (measured)	9.5 (measured)
Illuminator	1	−1
Contrast change	1	1

TABLE 3. Number of participants who completed each of the reading task and corresponding errors and mean time (and SD) to complete each task

Task	Device	Difficulty	Completed (/60)	Errors	Time (s)	SD (s)
Bill	Apple iPad	Easy	38	22	60.92	44.88
		Hard	27	15	56.78	50.66
	CCTV	Easy	51	26	48.05	36.60
		Hard	37	22	67.11	50.32
Medicine	Apple iPad	Easy	55	18	37.66	27.69
		Hard	21	7	49.57	39.98
	CCTV	Easy	51	17	32.79	29.97
		Hard	11	9	71.36	54.16
Food	Apple iPad	Easy	48	23	55.58	36.20
		Hard	46	12	41.32	39.46
	CCTV	Easy	51	18	59.50	40.10
		Hard	41	10	44.08	44.10

CCTV = closed-circuit television.

180 seconds (Fig. 1, Table 2). Our analysis was interested to what extent the time to a complete task is associated with device (iPad, closed-circuit television) and task difficulty (easy, difficult). This can be examined statistically using a 2×2 ANOVA. As the concept of P value–based rejection of the null hypothesis has become increasingly questioned, in addition to F ratios and P values from the ANOVA, here we also include the Bayes factor value calculated from a Bayesian ANOVA conducted in JASP.[33] There are many advantages of Bayesian inference over traditional P values.[34] For the purposes of the current study, the most important is the ability of the Bayes factor to quantify the evidence for a null hypothesis (i.e., there is no difference in use between an iPad and a closed-circuit television in the reading tasks). The Bayes factor is essentially an odds ratio for the strength of evidence for H_1 vs. H_0, and is expressed as BF_{10} (or its inverse, H_0 vs. H_1, $BF_{01} = 1 / BF_{10}$). For the interpretation of the Bayes factor, we used those recommended by Wetzels and colleagues,[35] whereby as the value of the Bayes factor increases more than 1, the data are more likely to occur. For example, a Bayes factor equal to 5 indicates that the data are five times more likely to be explained by the research hypothesis (in the case of a BF_{10}) or the null hypothesis (in the case of a BF_{01}). We use the verbal interpretation of the Bayes factors as recommended by Wetzels et al.,[35] whereby a Bayes factor of 1 finds no evidence for either hypothesis, that between 1 and 3 finds anecdotal evidence for the hypothesis, that between 3 and 10 finds substantial evidence for the hypothesis, that between 10 and 30 finds strong evidence for the hypothesis, that of 30 to 100 is very strong, and finally that more than 100 is decisive evidence for the hypothesis. However, in addition to the verbal description, we also report the Bayes factor values and effect sizes (η^2) for meta-analytic purposes.

For the task that required reading the bill, we found that there was moderate evidence for no effect of device ($BF_{01} = 5.588$, $F_{1,149} = 0.127$, $P = .72$, $\eta^2 = 0.001$), moderate evidence for no effect of task difficulty ($BF_{01} = 4.689$, $F_{1,149} = 0.227$, $P = .63$, $\eta^2 = 0.002$), and strong evidence for no interaction between the two ($BF_{01} = 26.625$, $F_{1,149} = 1.069$, $P = .303$, $\eta^2 = 0.007$). With evidence for the null for both device and task difficulty, the JASP interface allowed us to

label these as nuisance variables, which means that they are included in the null model. With this inclusion, the null BF_{01} was 6.036, meaning that these data are six times more likely to be explained by the null hypothesis than the alternative. We therefore conclude that there is no difference in reading speed with the bill for both device type and task difficulty.

For the task that required reading the medicine labels, there was moderate evidence for no effect of device ($BF_{01} = 5.3$, $F_{1,134} = 2.129$, $P = .15$, $\eta^2 = 0.001$), strong evidence for an effect of task difficulty ($BF_{10} = 11.429$, $F_{1,134} = 11.606$, $P \leq .001$, $\eta^2 = 0.008$), and anecdotal evidence for an interaction between
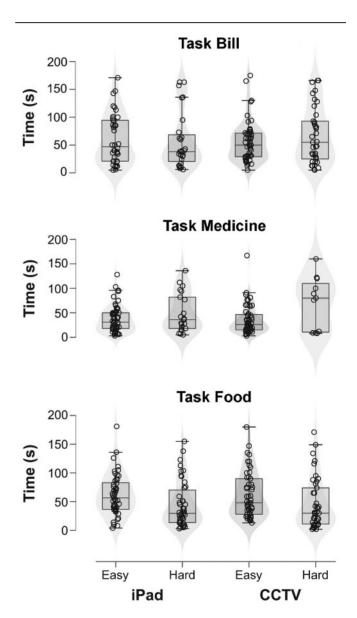

FIGURE 1. Parameters of time to complete reading task (in seconds) for the different treatments presented as box plots, indicating the median and quartiles, with whiskers reaching up to 1.5 times the interquartile range. The violin plot outlines illustrate kernel probability density; that is, the width of the shaded area represents the proportion of the data (circles) located there, to provide the reader information on the variability of these data.

the two ($BF_{10} = 2.401$, $F_{1,134} = 2.782$, $P = .10$, $\eta^2 = 0.018$). Note that unlike with the bill, for the medicine label, we observe strong evidence for an effect of task difficulty, with the alternative hypothesis being 11.4 times more likely to explain these data in comparison to the null. However, the observed Bayes factor for device type indicates that the null (i.e., no effect of device) explains these data 5.3 times better than the alternative hypothesis. The resulting conclusion is that there is a difference in reading speed based on task difficulty, whereby the easy task was completed faster, independently of which device was used.

Finally, for the task that required reading the food labels, we observe that there was moderate evidence for no effect of device ($BF_{01} = 6.11$, $F_{1,182} = 0.02$, $P = .89$, $\eta^2 = 0$), moderate evidence for an effect of task difficulty ($BF_{10} = 4.98$, $F_{1,182} = 7.339$, $P \le .007$, $\eta^2 = 0.039$), and anecdotal evidence for a null interaction between the two ($BF_{10} = 1.2$, $F_{1,182} = 0.032$, $P = .86$, $\eta^2 = 0$). Thus, for the food labels, our data are best explained for having an effect of task difficulty (data are approximately five times more likely to be explained by the alternative hypothesis than by the null) but no effect of device (data are approximately six times more likely to be explained by the null). Again, the finding indicates that reading speeds were faster on the easy task, independently on the device used. In summary, across all three reading tests (bill, medicine label, food label), the Bayesian ANOVA and traditional ANOVA reveal that the data provide moderate support for a null effect of device, meaning that there is no difference in reading speeds across the tested devices for those who were able to complete the task.

Performance Errors, Quebec User Evaluation of Satisfaction with Assistive Technology Data, Device Preferences, and Qualitative Comments

Across all three reading tasks, there were relatively few errors made (<3% error across all reading tasks), and there was no statistically significant difference in the number of errors as a function of reading task ($F < 1$, $P > .05$, $\eta^2 < 0.06$) or across each device ($F < 1$, $P > .05$, $\eta^2 < 0.06$). However, there was a significant main effect in the number of errors due to task difficulty ($F = 8.586$, $P = .005$, $\eta^2 < 0.127$), with participants making more errors in the difficult task compared with the easy task. When examining the Quebec User Evaluation of Satisfaction with assistive Technology data obtained for the iPad, the three most highly ranked satisfaction features of the device (in order of importance) were dimensions, ease of use, and effectiveness. Interestingly, for the portable closed-circuit television, the same three features were ranked at the top in the same order. When the participants were asked which device they favored, 25 preferred the iPad and 33 preferred the closed-circuit television, with an additional 2 participants preferring neither device because the screen was too small for their magnification needs and viewing preferences. The qualitative comments were not sufficiently frequent to warrant thematic analysis; however, the general distribution of positive comments (e.g., "I love the portable closed-circuit television, so few things can go wrong with it" and "My first time using an iPad, I love it") and negative remarks (e.g., "I have trouble keeping the iPad steady, and the camera is off to the side" and "The closed-circuit television screen is too small") reflected device preferences.

DISCUSSION

The purpose of the present study was to compare the utility of the Apple iPad as a spot-reading magnifier with that of a handheld electronic magnifier. The results indicate that performance speed on our series of reading tasks (reading a bill, a medicine label, and a food label) was comparable across the two devices. Intuitively, participants completed most of the easier tasks faster; however, this effect was generally independent of which device was used. In addition, the overall low error rate could be viewed as evidence supporting the use of either device successfully as a spot-reading magnifier. Furthermore, the device properties with which participants were most satisfied in each device (dimensions, ease of use, effectiveness) were identical, giving further support to the idea of comparable utility. Finally, device preference was approximately split between the iPad and the portable closed-circuit television, and this preference did not have an influence on performance speed in our tasks.

The data presented here add to the ongoing discussion on how tablet computers can and should be integrated into the rehabilitation of individuals with low vision. Specifically, it has been our clinical observation that contemporary technologies that have the potential to be used as assistive devices are often already incorporated into the lives of our clients, many of whom own a smartphone or similar technology. The uptake and use of tablets are facilitated by their mainstream characteristic as a common device, as well as their wide availability, relatively low cost, and the absence of stigmatizing traits that have been associated with magnifiers or other identifiable devices for "impaired" persons.[36] For example, previous research into the (non)use of the white cane has indicated that the stigma associated with this device acts as a key barrier to its uptake, given its role as an identifier for visual impairment.[37] This perception of stigma in the context of assistive technology has been shown across different impairments and is often perpetuated by the media as well,[38] demonstrating a cycle that is difficult to break and that requires ongoing public outreach and education.

Research data in low vision rehabilitation often lag behind in the effort to support clinical practice and evidence-based recommendations. Therefore, the present study provides further research evidence for the use of devices such as the iPad in rehabilitation and supports the suggestion that tablet computers can be used as an alternative to already existing traditional assistive technologies. This information is specifically of interest in the context of device training, as rehabilitation clients may already be familiar with some of the features of a device they own (e.g., their phone or tablet), and the focus of the rehabilitation professional may be to refine and further enhance the use of these known and additional features. In the case of tactile screen devices, this would allow professionals to focus on monitoring current developments in app availability and changes in the abilities supported by each feature, a task that at times seems daunting given the speed at which technology continues to develop, improve, and increase in its functionality. The multifunctionality of tablet computers further plays into the choice of incorporating already existing devices into the rehabilitation process, thereby allowing both the client and the professional to take advantage of a possible reduction in the number of different devices that used to be required, but may now be replaced by and integrated into one device.

The features of tablet devices require further study, in part, because their accessibility has the advantage that the same device could potentially be used over a range of visual impairments, all the way to the absence of light perception, given the voice-over, braille display, and text-to-speech possibilities. In addition, the large-range multifunctional possibilities could potentially lead to a situation where one such device might take on the role of several traditional devices, a topic that is specifically relevant in the

context of third-party payer health insurance systems where assistive devices are partially or fully covered.[39] To our knowledge, tablet computers are currently not included in many of the lists of eligible devices, but this choice may need to be revisited should more supporting evidence like the one presented here emerge.

Most of the research on e-reading has been conducted with a focus on tablet computers that use electronic ink screens (e.g., Amazon Kindle Paper; Amazon, Seattle, WA). The Apple iPad uses an liquid crystal display screen similar in size and resolution to other devices on the market (e.g., Amazon Fire Tablet) with similar camera resolution. Previous research has indicated that reading performance on both these display types is comparable on subjective and objective measures.[14] Consequently, although we did not test this, our results could be similar across other liquid crystal display-based tablet computers and may even generalize to electronic ink displays, a hypothesis that will still require further exploration. In either case, the present study focused on spot reading, which does not allow us to make any generalizations to the reading of continuous text, which is the purpose of devices such as the Kindle that are designed specifically for continuous reading. Future studies should specifically be designed to answer the question as to whether tablet computers, such as the iPad, are comparable in their ability to facilitate extended reading of hard-copy text when compared with traditional continuous reading devices, such as tabletop closed-circuit televisions.

Our findings, however, need to be viewed within certain constraints and limitations. The tasks that were chosen for the experimental setup are relatively narrow in scope and may not represent all situations in which spot reading may be conducted. For example, our participants were seated at a table, providing physical stability for both the materials and the participant. The findings may not generalize to situations where a handheld device is used while standing and using one hand to operate the device while the other hand holds the item of interest. Although our laboratory setup included regular lighting, we did not measure lighting conditions. Improved performance may be a possibility in cases where participants may have wanted the option of improving their light settings to their preference. Please note that the iPad does not have a light source for illuminating text, whereas the Optelec does. For logistics reasons, we neglected to measure dexterity as part of the protocol; however, we acknowledge that future studies, especially with older adults, should include a systematic measure of dexterity, such as the Purdue Pegboard, as standardized comparison values for older adults with low vision already exist.[40] Our sample ranged widely in age, and we did not detect any specific age effect on performance on our measures. However, most of our participants were older than 65 years. It is therefore possible that our findings may not replicate in a younger participant pool, a question that is currently partially under investigation by a team in the United Kingdom.[19] An additional factor that could have influenced our data is the difference in screen size between the two devices. The iPad screen diameter is 9.7 in. whereas the Optelec Compact 5 HD measures only 5 in diagonally. We speculated that this difference may affect the objective or subjective data in a more apparent way, but screen size emerged as a factor only in the question of device preferences, where two participants noted that either screen was smaller than what they would hope for. Finally, the physical act of using the Optelec device versus the iPad differed in that the Optelec is designed in such a way that it can slide across a flat surface while magnifying, whereas the iPad needs to be held steady above a paper placed on a flat surface. We had expected that such a difference might show in the data for the electricity bill; however, this was not the case, leading us to speculate that our participants managed these physical task differences equally well. Future studies may want to harmonize these testing aspects further across comparison conditions. Given the large variety of electronic magnifier and tablet devices available on the market, it is difficult to speculate as to which degree our findings generalize to other similar technologies. Technologies with similar screen, camera, lighting, and ergonomic features would likely result in similar data; however, this will need to be further verified under controlled experimental conditions.

Our results add to the already existing body of evidence that tablet computers, such as the Apple iPad, can successfully be used as assistive devices for tasks that were historically reserved for traditional assistive technologies. Such mainstream devices hold great potential to overcome stigma and allow individuals with visual impairment to integrate the same technology that is used by their peers into their daily functioning. Given the speed of technology development and the increasing access to devices, apps, and interactive features, such an approach to vision rehabilitation has become a viable alternative that needs to become standard of care and regularly incorporated into the education of vision rehabilitation professionals to optimally serve our clients, improve their functional independence, and increase their quality of life.

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