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Full title: Smartphone, tablet computer and e-reader use by people with vision impairment

Running head: Electronic device use in vision impairment

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Abstract

Purpose: Consumer electronic devices such as smartphones, tablet computers, and e-book readers have become far more widely used in recent years. Many of these devices contain accessibility features such as large print and speech. Anecdotal experience suggests people with vision impairment frequently make use of these systems. Here we survey people with self-identified vision impairment to determine their use of this equipment.

Method: An internet-based survey was advertised to people with vision impairment by word of mouth, social media, and online. Respondents were asked demographic information, what devices they owned, what they used these devices for, and what accessibility features they used.

Results: 132 complete responses were received. 26% of the sample reported that they had no vision and the remainder reported they had low vision. 107 people (81%) reported using a smartphone. Those with no vision were as likely to use a smartphone or tablet as those with low vision. Speech was found useful by 59% of smartphone users. 51% of smartphone owners used the camera and screen as a magnifier. 48% of the sample used a tablet computer, and 17% used an e-book reader. The most frequently cited reason for not using these devices included cost and lack of interest. .

Conclusions: Smartphones, tablet computers, and e-book readers can be used by people with vision impairment. Speech is used by people with low vision as well as those with no vision. Many of our (self-selected) group used their smartphone camera and screen as a magnifier, and others used the camera flash as a spotlight.

Introduction

Smartphones, tablet computers and electronic books have become far more widely used in the last five years. More than half of British adults own a smartphone,¹ over 170 million Apple iPads have been sold,² and over 1.5 million books are available for download onto the Amazon Kindle electronic reader. Our clinical experience is that many people with vision impairment use these consumer devices to access books, the internet, and applications. Further, we have noticed some people using these devices as electronic low vision aids, by taking photographs and enlarging the image, or by using the camera flash LED as a torch to see in dim environments. Many third-party apps have been designed specifically for people with low vision, including TapTapSee,³ VizWiz,⁴ Optelec Magnifier,⁵ and a large number of magnification programmes and colour identifiers. However, limited data exist on how useful these systems are for people with vision impairment.

We have previously examined the screen parameters of electronic book readers and have calculated the visual requirements to use this system in terms of visual acuity and contrast sensitivity.⁶ However, given the greater accessibility options of newer devices, and the more widespread use of brighter LED screens, it is likely that these electronic systems can be used by a greater proportion of people with vision impairment. Reading speed has been shown to be faster with an iPad compared to paper, and faster on paper compared to an e-book, for people with stable wet age-related macular disease.⁷ These screen types appear to be similar in terms of fatigue and visual strain symptoms.⁸

Here we present results of a survey of people with vision impairments. We have collected data on the electronic devices used by these people, what they are used for, the accessibility features which are found particularly useful, and the details of other apps which are used.

Method

After discussion with people with vision impairment, we developed a questionnaire to be administered to people with vision impairment. The aim of the questionnaire was threefold: to identify what devices people with vision impairment were using; what accessibility features were found particularly helpful; and what apps were particularly useful. Each question was repeated, with small modifications, for smartphones, tablet computers, and electronic book readers.

The questionnaire was administered electronically using the Surveygizmo website (www.surveymzmo.com, Boulder, Colorado, USA). People with vision impairment were asked to complete the survey by publicising it on internet discussion forums, Twitter, and to colleagues. Two versions of the online questionnaire were created: one in English and one in Portuguese. One author (AFM) is fluent in both languages and ensured the translation was as precise as possible. Respondents first read a statement explaining that the survey was only for people with sight loss not corrected by conventional spectacles or contact lenses, and were asked to classify themselves as having no vision or having low vision. They were also asked what eye condition was the primary cause of their reduced vision, with a free text response. Basic demographic data were collected on age and sex. In addition, Surveygizmo recorded the geographical location of each user. The ethics committee of Anglia Ruskin University determined that due to the anonymous nature of this survey, ethics approval was not needed.

Results

There were 132 complete responses: 76 to the English language survey and 56 to the Portuguese language survey. The three countries with most respondents were the United Kingdom (52 responses) Portugal (40 responses) and the United States of America (15 responses).

Roughly a quarter (34 respondents, 26%) identified themselves as having no vision. All of the self-reported diagnoses were consistent with vision impairment. Diagnoses are shown in table 1.

Nystagmus	15	Retinopathy of prematurity	3
Glaucoma	14	Uveitis	3
Retinitis pigmentosa	10	Stargardt disease	3
Age-related macular disease	9	Retinal detachment	3
Optic atrophy or optic neuropathy	7	Best disease	2
Macular disease (not otherwise specified)	6	Optic nerve hypoplasia	2
Genetic condition,	6	Trauma	2

not otherwise specified			
Retinopathy, not otherwise specified	5	Pathological myopia	2
Albinism	4	Leber congenital amaurosis	2
Unknown	4	Other	15

Table 1. Self-reported diagnoses. “Other” includes one each of: diabetes, achromatopsia, Coats disease, cortical blindness, toxoplasmosis, TB meningitis, optic nerve hypoplasia, cone dystrophy, retinal dystrophy, retinoblastoma, bilateral optic nerve severance, Alstrom syndrome, Eales disease, “medical error”, and ocular histoplasmosis. All “unknown” also reported being registered as legally blind, partially sighted, sight impaired or severely sight impaired. Fifteen people did not report the cause of their sight loss.

The modal age of the respondents was in the range of 45-54 years for the English language sample, and 24-34 years for the Portuguese language questionnaire. Six (5%) were under 18 years of age, and one (0.8%) was over 85.

Smartphone use

107 of the respondents (81%) used a smartphone. People with no vision were as likely to use a smartphone as those with low vision (no vision: 28/34, 82%; low vision: 79/98, 80%).

Cost, and the assumption that they would be unable to use one, were the most frequent reasons for not using a smartphone (seven people each). Six people were not interested in owning a smartphone, and four had never thought of owning one. More than half of those with a smartphone used an Apple device (59 people, 55%). About a quarter (23 people, 21%) used an Android phone, 15 (14%) used Nokia Symbian software, and one used each of Blackberry and Windows Mobile devices.

Of the 107 smartphone owners, 94% used their phone to make phone calls, 90% sent or received text messages (SMS), 80% used the internet on their smartphone, and 77% used apps. About three quarters used the camera on their smartphone, with more than half of the sample using the camera to see things more easily (by taking photos and zooming in). Audiobooks and e-books were less frequently used (table 2).

	Smartphones		Tablet computers	
	Number of responses	Percentage of smartphone users	Number of responses	Percentage of tablet users
Make calls	101	94%	-	-
Use text messages	96	90%	-	-
Use internet	86	80%	63	100%
Use apps	82	77%	34	54%
Use camera (to see more easily)	55	51%	26	41%
Use camera (other reasons)	75	70%	30	48%
Read e-books	39	36%	38	60%
Listen to audiobooks	36	34%	26	41%

Table 2. Activities performed by smartphone and tablet owners. Total number of smartphone users is 107; total number of tablet users is 63.

Speech was widely used on smartphones with 63 (59%) finding this useful. Large print was cited by 53 (50%) as being useful, and a large screen by 36 (34%). About a quarter (30, 28%) found the ability to change contrast useful, and 26 (24%) found font selection to be helpful. Table 3 shows these data for smartphones and tablet computers.

People with no vision were more likely to use text-to-speech, with all but one person with no vision finding this facility useful. Nearly half of those with low vision also used speech on their smartphone (table 3).

	Smartphone			Tablet		
	No vision	Low vision	All users	No vision	Low vision	Total
Speech	27 (96%)	36 (46%)	63 (59%)	12 (85%)	23 (47%)	35 (56%)
Large print	1 (4%)	52 (66%)	53 (50%)	0	44 (90%)	44 (70%)
Big screen	2 (7%)	34 (43%)	36 (34%)	0	34 (69%)	34 (54%)
Contrast	0	30 (38%)	30 (28%)	0	28 (57%)	28 (44%)
Font	0	26 (33%)	26 (24%)	0	31 (63%)	31 (49%)

Table 3. Accessibility options found helpful on (left) smartphones, (right) tablet computers. Values show number of respondents (who could select more than one, or less than one option). Note more respondents used a smartphone than a tablet computer.

Tablet computer use

Nearly half (63/132, 48%) of the respondents used a tablet computer. Cost was the most frequent reason for not owning one (25 people), followed by not being interested (10 people). Forty-five respondents (71%) used an Apple iPad. Those with no vision were slightly less likely to use a tablet computer: exactly half of those with low vision used one, whereas only 41% of people with no vision did. This difference was not statistically significant at the 0.05 level (difference of proportions test). The most frequent use of tablet computers was for internet access, with all of the respondents using their tablet computer for this purpose. More than half used apps and electronic books, with a significant proportion using the camera and audiobooks (see table 2). Similar to the smartphone responses, speech was used by over half of respondents (56%). Seventy per cent found large print to be useful, 54% thought the large screen was helpful, 44% liked the ability to change the font and 49% appreciated the ability to change contrast (table 3).

Electronic book reader use

Only 22 respondents (17%) used an electronic book reader; 32 people were not interested in owning one, 19 had never thought of getting one, 14 thought they would not be able to use one, and 13 thought it would be too expensive. Those with no vision were much less likely to use an electronic reader (20% of those with low vision; 6% of those with no vision). More than half of the electronic readers (13, 60%) were electronic paper screens with no backlight, and two people had an illuminated electronic paper display. Four used devices with LCD screens and the remainder did not know which screen type their reader used. Eighteen people used their reader for reading for pleasure, eight used it for reading for studying, 10 people accessed the internet on their device, and eight people listened to audiobooks on their electronic readers. The most popular accessibility option was print enlargement, used by 13 people. Speech was used by eight people (including both of those with no vision who used e-readers), and font selection was found helpful by 10.

Apps

The most frequently used apps were not specifically designed for vision impairment, such as navigation systems, Skype, Facebook, and newspaper and broadcaster services. However 13 people used TapTapSee, four used Fleksy, three used VizWiz, and six used apps to use the camera flash as a spotlight for seeing in low light conditions.

Multiple device use

Of those who use a smartphone, 54 (53%) also use a tablet computer, and 18 (18%) also use an e-reader. Twelve (12%) use all three types of device. Fourteen (11%) did not use any of these devices.

How did people find out about using these devices?

All but 11 of the sample knew that electronic devices could be used by people with vision impairment. Of those who did, about one third (31%) found out online, a similar proportion found out from a friend (30.7%), seven people found out from an organisation for vision impaired people, and seven people found out from a rehabilitation worker. Only two participants learnt that these devices could be used from their optometrist, and only one found out from an ophthalmologist.

Effect of age on device use

Figure 1 shows device use by age for each type of device. It can be seen that smartphone use remains relatively constant until the age of 65, after which it declines. The use of tablet computers increased with age in adulthood. E-readers were less common in the younger age categories and most popular in the 55-64 age group.

Figure 1. Device use as a proportion of all responses per age group.

Discussion

Consumer electronic devices can be used by people with vision impairment, regardless of the level of vision impairment: almost a quarter of our sample self-identified as having no vision. The most frequently used device in this group of people was the smartphone. Tablet computers were used by nearly half of the respondents to our survey and e-reader devices were less popular. Apple devices were the most commonly used, accounting for over half of smartphones used and two thirds of tablet computers used. The iPhone and iPad were amongst the first smartphones and tablet computers to be widely commercially successful. It is not clear whether the greater use of Apple products amongst our respondents reflects the general population, or whether Apple's accessibility options are preferred by people with vision impairment. Electronic book readers were the least used device amongst our sample. This could be due to the lower contrast screen of many electronic readers, or simply the demographics of our sample. Half of our population used tablet computers, and many read electronic books on their tablet computer or smartphone. In a population with fewer tablet computer users, uptake of electronic readers may be higher.

People who described themselves as having no vision were just as likely to use smartphones and tablet computers as people with low vision. Although fewer people with no vision used e-readers, this number was too small to perform the difference in proportions test.

A similar, smaller study of 12 people with optic atrophy has been performed in the USA.⁹ Although our study is far larger, it is still not representative of the wider population of people with vision impairment. A prevalence study of how widespread the use of these devices is would be of great value. It may well be that far more than 8% of the wider population of people with vision impairment are not aware that these devices can be used by people with vision impairment. A larger study by Woods and Satgunam examined the use of handheld video devices (such as iPods, mobile phones and the PlayStation Portable) in people with good sight and those with vision impairment.¹⁰ They found no significant difference in the likelihood of having watched video on a portable device between those with sight loss (24%) and those without (32%, $p=0.20$). They did find a difference in this activity between older (over 60 years) and younger people with and without vision impairment. We did not find as marked an age effect in our data, although fewer of those over 65 used a smartphone. However, we were asking about more general device use rather than specifically watching video on an electronic screen.

Given that three quarters of our sample had some residual vision, it is perhaps surprising that a relatively large number of our respondents used text-to-speech on their devices. Other accessibility options which were found useful included the ability to enlarge text, and the large screen on many of these devices.

Barriers to devices being used included cost, a lack of awareness of how useful these devices could be for people with vision impairment, and not having considered using these systems. Given the latter two barriers, it is of concern that most people in this study did not hear that they could use electronic devices from an eye care professional: only seven found out from a rehabilitation worker, two from an optometrist, and one from an ophthalmologist. As professionals start to see more patients and service users with these devices, it is hoped that they will start to recommend these devices more. We urge all clinicians and others working in vision impairment to emphasise that these systems can be useful to people with little or no vision.

Our study has several limitations. First, the nature of this survey is that only those who are familiar with technology could access it, as it was administered only on the internet. We chose this platform deliberately as we wanted a large number of respondents, we wanted to survey people who were 'expert' users of technology, and we wanted to ensure that it would be accessible to people with no vision (through the use of screen reading software). However we emphasise this is a very self-selected group of people and no conclusions can be drawn about the prevalence of device use by people with vision impairment. It is particularly noticeable that our population is relatively young and only 7% (9/132) had age-related macular disease. Although our population was self-selected, not all of the respondents used these devices: four respondents to the English language survey, and 10 of those responding to the Portuguese survey, did not use a smartphone, tablet computer, or e-reader. We did not ask about the use of a desktop or laptop computer. A further limitation is that we have relied on self-reported information on, for example, diagnosis and level of vision. Although we have no reason to suspect people may have been dishonest in their responses, we have no way to validate the accuracy of the information given by the respondents. One potential error can be identified: one respondent to the Portuguese version of the survey responded that they found large print useful, despite self-identifying as having no vision. Anecdotally, some ophthalmologists in Portugal will describe someone as having no vision if their visual acuity is less than 3/60. Both of the respondents with "no vision" who found the large screen useful

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7 were also from Portugal. Large screens can be useful for people with no vision as it is easier
8 to locate onscreen buttons by using speech feedback on a larger screen. An alternative error
9 could have been if someone with no vision in one eye and low vision in the other had selected
10 the “no vision” option. Unfortunately we can not verify this. In retrospect, it would have
11 been interesting to ask people to report the presence of any other sensory or motor
12 impairments. Six respondents did not use their smartphone for making calls. It would have
13 been very informative to determine whether these people have hearing impairment, or
14 whether they find the phone interface on their smartphone difficult to use. Further, it would
15 be interesting to know whether joint or mobility difficulties are a barrier to uptake of these
16 devices.
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22 We were pleasantly surprised that our survey attracted responses from around the world. We
23 did not design our study to detect differences in device use in different countries (for example
24 high income compared to low income countries). Future research could identify differences
25 in device use in different populations. A further potential difference between countries is in
26 the availability of electronic books and other information in different languages.
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31 Many agencies offer training in the use of electronic devices to people with vision
32 impairment. Some of the respondents to this survey may have received such training. The
33 potential benefit of this training can not be determined from the responses to our
34 questionnaire, but this remains an interesting area of research. In the free text region at the
35 end of the survey, some respondents indicated that if they were able to try a device before
36 buying it they may be more likely to use it. As technology improves, and the generation of
37 people most comfortable with technology ages, it is clear that consumer devices such as these
38 will be used more widely. We were surprised by the number of people who used the camera
39 and zoom function on their devices as an electronic magnifier. As the cameras on
40 smartphones improve, it may be that portable electronic magnifiers (such as the Compact+,
41 Optelec, Barendrecht, Netherlands) fall out of use. This is an exciting and fast-moving field,
42 and developments such as a 41 megapixel camera on a mobile phone (Nokia 1020, Nokia,
43 Espoo, Finland) and heads up displays (Google glass, Google, Mountain View, California,
44 USA) are likely to be adopted by people with vision impairment. Future accessibility options
45 include the use of scrolled text on an iPad,¹¹ development of haptic icons on touchscreens,¹²
46 mobile phone based navigation systems for blind users,^{13,14} and development of automated
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face-recognition systems on mobile phones.¹⁵ The increased availability of these devices must be a positive step for people with low vision.

Based on our findings, we have several recommendations. We recommend that device and content manufacturers consider the needs of people with vision impairment when designing and upgrading their systems. We hope that more information such as electronic books becomes available in languages such as Portuguese. We recommend that all of those who work with people with vision impairment advise people about the potential of these devices. Further, when prescribing low vision aids it is important that they are usable with electronic devices.

Disclosure

The authors report no conflicts of interest and have no proprietary interest in any of the materials mentioned in this article.

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Figure 1. Device use as a proportion of all responses per age group.
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