Assistive Technology
The Official Journal of RESNA

ISSN: 1040-0435 (Print) 1949-3614 (Online) Journal homepage: https://www.tandfonline.com/loi/uaty20

Exploring the use of smartphones and tablets among people with visual impairments: Are mainstream devices replacing the use of traditional visual aids?

Natalina Martiniello, Werner Eisenbarth, Christine Lehane, Aaron Johnson & Walter Wittich

To cite this article: Natalina Martiniello, Werner Eisenbarth, Christine Lehane, Aaron Johnson & Walter Wittich (2019): Exploring the use of smartphones and tablets among people with visual impairments: Are mainstream devices replacing the use of traditional visual aids?, Assistive Technology, DOI: 10.1080/10400435.2019.1682084

To link to this article: https://doi.org/10.1080/10400435.2019.1682084

ASSISTIVE TECHNOLOGY
https://doi.org/10.1080/10400435.2019.1682084

Exploring the use of smartphones and tablets among people with visual impairments: Are mainstream devices replacing the use of traditional visual aids?

Natalina Martiniello, MSc, CVRT [a,b], Werner Eisenbarth, PhD[c], Christine Lehane, PhD [d], Aaron Johnson, PhD[e], and Walter Wittich, PhD, FAAO, CLVT [a,b]

[a]School of Optometry, University of Montreal, Montreal, Quebec, Canada; [b]Research Services, CRIR/Centre de réadaptation MAB-Mackay du CIUSSS du Centre-Ouest-de-l'Île-de-Montréal, Montreal, Quebec, Canada; [c]Center for Applied Vision Science, Munich University of Applied Sciences, Munich, Germany; [d]Department of Public Health, University of Copenhagen, Copenhagen, Denmark; [e]Department of Psychology, Concordia University, Montreal, Quebec, Canada

ABSTRACT

Smartphones and tablets incorporate built-in accessibility features, but little is known about their impact within the visually impaired population. This study explored the use of smartphones and tablets, the degree to which they replace traditional visual aids, and factors influencing these decisions. Data were collected through an anonymous online survey targeted toward visually impaired participants above the age of 18, whom had been using a smartphone or tablet for at least three months. Among participants (n = 466), 87.4% felt that mainstream devices are replacing traditional solutions. This is especially true for object identification, navigation, requesting sighted help, listening to audiobooks, reading eBooks and optical character recognition. In these cases, at least two-thirds of respondents indicated that mainstream devices were replacing traditional tools most or all of the time. Users across all ages with higher self-reported proficiency were more likely to select a mainstream device over a traditional solution. Our results suggest that mainstream devices are frequently used amongst visually impaired adults in place of or in combination with traditional assistive aids for specific tasks; however, traditional devices are still preferable for certain tasks, including those requiring extensive typing or editing. This provides important context to designers and rehabilitation personnel in understanding the factors influencing device usage.

ARTICLE HISTORY
Accepted 11 October 2019

KEYWORDS
computer access; information technology and telecommunications; universal design; usability; visual impairment

Introduction

People with visual impairments (that is, those who are blind or who have low vision, as defined by World Health Organization, 1992) use a myriad of assistive devices (such as hand-held magnifiers and screen-reading software) to mitigate the limitations posed by their visual impairments. Historically, traditional assistive devices refer to those specialized high and low tech tools designed for individuals with disabilities to increase their access to both the environment and written information, such as specialized screen-reading software, magnification programs and daisy book readers (Presley & D'Andrea, 2008). Despite their established utility, widespread adoption of such traditional assistive devices is often impeded by factors such as cost and deeply rooted negative perceptions associated with vision loss (Mulloy, Gevarter, Hopkins, Sutherland, & Ramdoss, 2014). Over the past decade, there has been a marked increase in the use of mainstream devices (such as smartphones and tablets), which are employed by the general population but also incorporate built-in accessibility features for users with diverse needs. These devices may lead to less abandonment as they are typically more affordable, are less likely to draw attention to the user, and are widely adopted by the general population (Irvine et al., 2014). While prior studies have investigated the use of such mainstream tools among people with visual impairments (Crossland, Silva, & Macedo, 2014; Griffith-Shirley et al., 2017; Kane, Jayant, Wobbrock, & Ladner, 2009; Rodrigues, Montague, Nicolau, & Guerreiro, 2015; Watanabe, Yamaguchi, & Minatani, 2015), we do not precisely know how such mainstream devices are being used, the degree to which they are replacing traditional visual aids for different tasks, or the factors which influence these decisions. This context would provide valuable information to designers, trainers and rehabilitation professionals in order to better meet the increasingly heterogeneous needs within the visually impaired population. Here we present the results from an international study which explores these questions in greater depth.

Review of the literature

Assistive devices are tools (such as magnifiers, telescopes and talking book readers) that maintain or improve the functional abilities of persons with disabilities and therefore support their inclusion within society (Raskind, 2013). For those with acquired vision loss, such devices facilitate the ability to resume daily activities such as reading, cooking, and traveling. As a consequence, they can enhance a users' subjective quality of life and self-esteem (Scherer & Glueckauf, 2005). Despite these established benefits, abandonment and disuse of

CONTACT Natalina Martiniello, MSc, CVRT natalina.martiniello@umontreal.ca School of Optometry, Université de Montréal, 3744, rue Jean-Brillant, room 260-7 Montréal, (Québec) H3T 1P1, Canada.

Minor changes have been made to this article that do not affect the academic content.
Supplemental data for this article can be accessed on the publisher's website.

traditional assistive devices are alarmingly high, with some reports indicating that the percentage of abandonment ranges from 30% to 50% for devices in aggregate, and up to 75% for particular devices (Furer, 2001). Though reasons for the abandonment of traditional assistive devices are diverse, explanations include cost, lack of technical support, and the stigma attached to their use (Phillips & Proulx, 2018; Sugawara, Ramos, Alfieri, & Battistella, 2018).

The expense of traditional assistive devices (such as screen reading and magnification software) limits the ability for many potential users to consider device acquisition (Gordon, Kerzner, Sheldon, & Hansen, 2007). While assistive device attribution and training are funded through some health-care programs, many jurisdictions do not have established governmental funding programs, and those in existence differ significantly with regards to eligibility criteria and funding levels (Gordon et al., 2007). This is especially pertinent given that the employment rate for individuals with visual impairments in most western countries is estimated to be less than 40%, thus relegating many potential users of assistive devices to lower-income brackets (Martiniello & Wittich, 2019). Access to funding issues are compounded for those with acquired vision loss who are neither studying nor working, and therefore often do not meet eligibility criteria. Moreover, the specialized nature of traditional assistive devices limits the ability for device users and persons within the user's social network (such as family members and mainstream technical support personnel) to assist when technical problems arise (Jarry, Chapdelaine, Kurniawan, & Wittich, 2017). Caregivers and family members typically have limited (if any) knowledge on the use of traditional assistive devices, may not understand how they work, and/or do not know how to facilitate the use of the device in daily living activities (Gitlin, 1995).

A body of previous work has also explored the stigma associated with traditional assistive devices for users who are still adjusting to acquired impairments. Such specialized devices attract attention from the general public and therefore uncover otherwise invisible disabilities (such as low vision that may otherwise not be apparent). Pape, Kim, and Weiner (2002) found that people with disabilities are more likely to abandon an assistive device if they had not yet accepted their impairment, if the device led them to feel excluded and different from others, and if the device was perceived by the user to be different from the norm. Likewise, Shinohara (2011) found that respondents expressed sensitivity toward the reaction of others around them when using their assistive devices, taking note when another person appeared uncomfortable, either by furtive looks or tone of voice. The presence of self-conscious feelings was associated with the existence of an invisible disability (such as low vision), which may otherwise not be apparent without explicit disclosure. This was particularly the case when using devices traditionally associated with impairment (such as a white cane), and when the design attracted attention due to differences from mainstream products used by the general public (Shinohara, 2011). Conversely, it has also been suggested that some users with invisible impairments value traditional assistive devices that 'stand out' because they alert members of the public to an otherwise undisclosed disability or illness when assistance may be needed (Faucett, Ringland, Cullen, & Hayes, 2017).

The potential stigma of traditional assistive devices may be mitigated through mainstream devices which follow principles of universal design to address a range of user abilities and needs (Story, 1998). Many mainstream smartphones and tablets (such as those produced by Apple and Google) now incorporate built-in accessibility features that enable them to be used by individuals who are blind or who have low vision, without the need to use specialized traditional assistive solutions that set them apart from others (Watanabe et al., 2015). Among the built-in accessibility enhancements available on mainstream smartphones and tablets, users with low vision can adjust color, contrast and size, and customize the level of brightness to improve visibility and readability. Similarly, users who are functionally blind can activate speech output software (such as VoiceOver on Apple devices and Google Talk-Back on Android devices) that reads information aloud through the use of gestures and commands (Irvine et al., 2014). Such built-in speech-output software (which traditionally had to be purchased through expensive, third-party vendors) provides highly sophisticated assistance and enables users to read virtually any text on the screen (such as e-mails, internet pages, instant messages, and eBooks). Moreover, voice-controlled, digital assistants (such as SIRI and Alexa) can be used to both readout text and perform a variety of tasks (e.g., open apps, perform online searches, send messages and start a phone call). To facilitate the completion of writing tasks, such software incorporates a dictation feature which converts spoken words into text, a functionality that is particularly useful for those with motor impairments or who otherwise cannot access the on-screen keyboard.

Prior research has investigated blind and visually impaired users' utilization of smartphones and tablets, and the specific accessibility functionalities employed. Kane et al. (2009), relatively early in the smartphone adoption era, conducted a qualitative study to explore the use of smartphones as assistive devices among users who were visually impaired or who had motor impairments, and explored many of the practical challenges associated with the use of mobile devices as accessibility aids. Rodrigues, Montague, Crossland et al. (2014) found that Apple products remain the most commonly used operating system among users with visual impairments and that the use of smartphones remains relatively consistent (mean of 79% up to age 64) until the age of 65 where usage sharply declined in their sample (mean of 26%). The authors report that the use of tablet computers among seniors increases with age, suggesting a possible correlation between age and device usage. Rodrigues et al. (2015), through interviews and a usage diary analysis of five participants with visual impairments, identified several barriers to adoption of an Android-based smartphone including a steep learning curve and inconsistent navigation from app to app, but found that most users quickly adopted the phone to aid in their day-to-day tasks. Griffith-Shirley et al. (2017) conducted a survey of 259 smartphone and tablet users to explore their usage of free and paid apps (both generally used and those developed specifically for the blind and low-vision population) and found that 95.4% used smartphones, 40.5% used tablets, 37.1% used both, and the significant majority (79.9%) were Apple iOS users, while only 7% used Android. Little remains known, however, about the factors which contribute to a users' decision to select a specific device, or in what ways mainstream tools may be replacing traditional visual aids for different segments of the visually impaired population.

Objective and research questions

Given the above context, the purpose of this study was to explore the use of mainstream devices among participants with visual impairments, and specifically, to determine whether smartphones and tablets are used in place of traditional visual aids for certain tasks. Given the increased functionality of such mainstream tools, it was hypothesized that smartphones and tablets are replacing traditional assistive devices, depending on the tasks to be performed, the age of participants and their level of vision. Three research questions guided the analyses:

(1) What mainstream touch-screen devices (smartphone and tablets), accessibility features and installable apps are being used by individuals who are blind or who have low vision?
(2) Are users replacing the use of traditional assistive devices with smartphones and tablets for certain functional tasks?
(3) What factors (such as demographic variables or device characteristics) influence the decision to use either a traditional or mainstream device for specific tasks?

Results from this study will provide useful context to both designers and rehabilitation professionals who intervene directly with individuals who are blind or who have low vision. In particular, such results illuminate whether specific segments of the population – such as older adults – choose to use traditional or mainstream devices for different functional tasks, and whether specific factors, such as ease of use and physical features of the device, impact these decisions. As the population becomes increasingly diverse and heterogeneous, such factors can inform the design of assistive devices, and provide context for how rehabilitation professionals can best support and train the use of such tools to meet the needs of a diverse clientele.

Materials and methods

Data were collected through an anonymous online survey maintained by *Hosted in Canada Surveys* between September and December 2017. Ethics approval was obtained through the Center for Interdisciplinary Research in Rehabilitation of Greater-Montreal (CRIR #1238-0816) in order to recruit participants through the network of Quebec-based vision rehabilitation centers. Prior to beginning the survey, respondents read about the nature of the study and their participation on the initial page of the website. Informed consent was obtained by the decision to proceed with the online survey, in accordance with *The Declaration of Helsinki and Public Health* (Williams, 2008). Participants also had the option to provide their e-mail address if they wished to receive a summary of results and/or enter a draw to win a $100 iTunes or GooglePlay gift card (and 426 of the 466 participants did so). In such cases, the contact information was kept separate from survey responses in a confidential, encrypted, password protected file.

Eligibility and recruitment

Participation was open to those who were at least 18 years of age, who had been using a smartphone or tablet for at least three months, and who self-identified as having a mild, moderate, severe or profound visual impairment that is either congenital or acquired, in line with the visual acuity and fields defined by the World Health Organization (WHO, 1992, as described in Table 1). Due to the linguistic diversity of the research team, the survey was made available in English, French, and German in order to expand recruitment efforts internationally.

Once ethical approval was obtained, the invitation to participate was posted to over 150 pre-identified English, French and German social media groups geared toward members of the blind and low-vision community. In addition, the invitation was circulated to approved vision rehabilitation centers and consumer organizations serving blind, low vision and deafblind individuals throughout North America and the European Union. Finally, snowball sampling (whereby participants were invited to share the invitation with others they know) provided additional reach beyond these initial contacts (Goodman, 1961).

Materials and procedure

The survey consisted of approximately 55 questions, and required on average 42.7 (SD = 32.7) minutes to complete. The number of questions asked of any given respondent depended on participants' responses: for example, an individual who used both a smartphone and a tablet had to complete both sections of the survey, increasing the number of questions asked. The survey was pilot tested by two individuals beforehand to ensure accessibility for participants who use magnification or screen-reading software. Data were collected through a combination of close-ended and open-ended questions (the full survey instrument can be found in the Supplemental Materials). The first portion of the survey collected

Table 1. Definition of blindness and low vision (and its associated categories), per WHO (1992) classifications.

Category	Definition
Mild	Best-corrected distance acuity (in the better eye) of worse than 20/40 but better or equal to 20/60, or a reduced visual field of less than 60 degrees
Moderate	Best-corrected distance acuity (in the better eye) of worse than 20/60 but better or equal to 20/200, or a reduced visual field between 60 and 20 degrees
Severe	Best-corrected distance acuity (in the better eye) of worse than 20/200 but better or equal to 20/400, or a reduced visual field between 20 and 10 degrees
Profound	Best-corrected distance acuity (in the better eye) of worse than 20/400, or a reduced visual field of less than 10 degrees

demographic and historical information pertaining to the usage of traditional assistive devices. The remainder of the survey inquired about the use of smartphones and tablets, including the use of specific applications and accessibility features, and factors influencing the decision to select a particular mainstream device. These questions also explored the degree to which mainstream devices are replacing traditional assistive solutions for the completion of a variety of daily tasks.

Data analysis

The aim of this investigation, based on the *a priori* research questions, is two-fold: to describe the specific devices, accessibility features and apps that are used by participants with visual impairments, and to explore factors that potentially influence the decision to use mainstream rather than traditional devices for a variety of daily tasks. Kruskal–Wallis H tests (and when appropriate, Dunn post-hoc tests with the Benjamini-Hochberg multiple comparison adjustment applied) were used to identify statistically significant differences in the categorical independent variables (McKnight & Najab, 2010). User proficiency levels with various devices were collected based on a self-reported categorization of Beginner, Intermediate, and Advanced. For questions where participants were asked to rank device features based on importance, respondents' top 3 choices were assigned values of 3, 2, and 1, respectively, with all other options given a weight of 0 (such that higher weights in the analysis represent more preferred choices). As the distribution of these values was not consistent across different levels of the independent variables, the mean score (rather than median) for each feature was used as the data for analysis. In all instances, analyses were conducted with an alpha .05 significance level, and ε^2 is reported to describe the magnitude of effects. No multiple comparison adjustments were employed in the primary analyses because in this preliminary exploratory research, we did not wish to prematurely discard potentially useful observations that may generate hypotheses for follow-up studies (Streiner & Norman, 2011). All analyses were performed using R Statistical Software (Foundation for Statistical Computing, Vienna, Austria), version 3.4.4.

Where applicable, open-ended questions have also been included to gather qualitative data in order to provide additional context about influential factors that could not be predicted in advance (O'Cathain & Thomas, 2004). As these responses were small in number, they are not included in the analysis of the current study.

Table 2. Sample demographics (N = 466; *See specific definitions for vision level in Q7 of the survey instrument. **Note that only 70% of respondents provided this information and that a single respondent could have reported multiple diagnoses to be counted in more than one category.).

Variable	N	% of respondents
Age		
18–39 years old	238	51.1%
40–59 year sold	171	36.7%
60+	56	12.0%
(not reported)	1	0.2%
Age at Diagnosis		
<1 year old	164	35.2%
1–5 years old	161	34.5%
6–17 years old	58	12.5%
18–34 years old	42	9.0%
35–59 years old	20	4.3%
60+ years old	2	0.4%
(not reported)	19	4.1%
Sex		
Male	216	46.4%
Female	247	53.0%
(not reported)	3	0.6%
Country of Residence (*N* > 5)		
United States	246	52.8%
Canada	91	19.5%
Germany	64	13.7%
United Kingdom	17	3.7%
Australia	11	2.4^
Czech Republic	6	1.3%
India	6	1.3%
Level of Education		
Some High School	23	4.9%
High School	82	17.6%
Vocational Training	34	7.3%
College Degree	70	15.0%
Undergraduate Degree	150	32.2%
Graduate/Postgraduate Degree	107	23.0%
Employment Status		
Unemployed	92	19.7%
Student	59	12.6%
Employed, Part-Time	51	10.9%
Employed, Full-Time	162	34.8%
Self-Employed	48	10.3%
Retired	54	11.6%
Degree of Vision Loss*		
Mild	9	1.9%
Moderate	30	6.4%
Severe	78	16.7%
Profound	349	74.9%
Diagnoses** (*N* > 5)		
Retinitis of prematurity	60	12.9%
Glaucoma	47	10.1%
Leber congenital amaurosis	33	7.1%
Cataract(s)	21	4.5%
Retinal detachment	19	4.1%
Optic nerve hypoplasia	19	4.1%
Nystagmus	12	2.6%
Retinal blastoma	10	2.2%
Albinism	10	2.2%
Diabetic retinopathy	10	2.2%
Optic nerve atrophy	8	1.7%
Macular degeneration	8	1.7%
Aniridia	6	1.1%
Septo-optic dysplasia	6	1.1%
Coloboma	6	1.1%

Results

Demographics

Table 2 shows a detailed demographic profile of the sample represented by the 466 completed responses received and included in the analysis (age M = 41, SD = 14, range 18–80). Responses received emanated primarily from individuals in the United States (52.8%), Canada (19.5%), Germany (13.7%), the United Kingdom (3.7%), and Australia (2.4%). The remaining 7.9% of responses were received from less represented countries. Slightly more than half of the respondents (51%) were between the ages of 18 and 39; 37% were between the ages of 40 and 59; and 12% were 60 years and older. 70.2% had at least a college degree and most (56%) were employed on at least a part-time basis. 75% of respondents self-reported profound vision loss, while 17% had severe losses, 6% had moderate losses, and 2% had mild losses. A majority (69.7%) of respondents had been diagnosed with

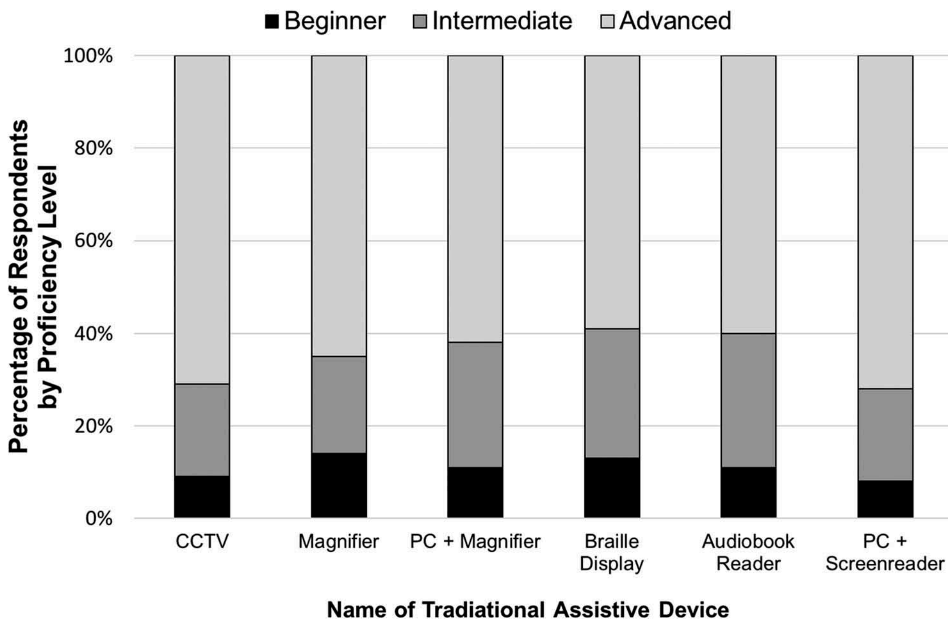

Figure 1. Self-reported proficiency in the use of traditional assistive devices among users of each device. Note. CCTV = closed-circuit television; PC = personal computer.

vision loss as infants or toddlers; 12.5% between the ages of 6 and 17; 9% between the ages of 18 and 34; 4.3% between the ages of 35 and 59; and 0.4% over the age of 60 (4.1% not reported).

Participants were asked to indicate which traditional assistive devices they use, and were permitted to select more than one device. All but one respondent had experience using one or more traditional assistive devices to complete a wide variety of daily tasks, including PCs with screen readers (85%), audio book readers (59%), braille displays (54%), PCs with magnification software (28%), handheld or digital magnifiers (22%), or CCTVs (19%). The self-reported degree of vision loss impacted the likelihood that a participant would use PCs with screen readers ($H(1) = 104.89$, $\varepsilon^2 = .17$, $p < .001$), braille displays ($H(1) = 61.43$, $\varepsilon^2 = 0.11$, $p < .001$), PCs with magnification software ($H(1) = 111.79$, $\varepsilon^2 = 0.18$, $p < .001$), magnifiers ($H(1) = 125.02$, $\varepsilon^2 = 0.22$, $p < .001$), and CCTVs ($H(1) = 52.83$, $\varepsilon^2 = 0.10$, $p < .001$). As shown in Figure 1, most participants considered themselves to have 'intermediate' or 'advanced' skills with these technologies. While their age did not impact on proficiency, those with more severe vision losses reported higher levels of proficiency for the use of braille displays ($H(3) = 64.04$, $\varepsilon^2 = 0.14$, $p < .001$) and PC with screen readers ($H(3) = 85.86$, $\varepsilon^2 = .18$, $< .001$). Age of diagnosis impacted on self-reported proficiency with respect to magnifiers ($H(5) = 30.10$, $\varepsilon^2 = .07$, $p < .001$), braille displays ($H(5) = 71.23$, $\varepsilon^2 = .16$, $p < .001$) and PCs with screen readers ($H(5) = 42.51$, $\varepsilon^2 = .10$, $p < .001$), with those diagnosed at older ages feeling less proficient than those diagnosed at younger ages.

Participants were asked to select the sources of training and technical support they accessed for their traditional assistive devices, and for both questions, respondents could select more than one option. Respondents reported learning to use their traditional assistive devices through self-learning (58%), web-based resources (52%), vision rehabilitation professionals (42%), other users with visual impairments (42%), and from sighted friends and family (18%). Technical support and troubleshooting assistance was sourced from web-based resources (76%), other users with visual impairment (57%), sighted friends and family (26%), and vision rehabilitation professionals (18%). Among respondents, 3% (including 10% of those who lost their vision between age 35 and 59 and a full half of those who lost their vision after age 60) indicated that they did not know where to attain technical support for their traditional assistive devices.

What mainstream devices, apps, and features are being used?

Most participants (97%) used a smartphone, 49.5% used both a smartphone and a tablet, and only 3% of respondents used a tablet alone. Those with moderate and severe vision losses were slightly less likely to use a smartphone (93% and 92%, respectively) than those with mild or profound losses (100%, 99%, $H(3) = 11.18$, $\varepsilon^2 = .02$, $p = .011$). Likewise, those with severe and profound vision losses were less likely to use a tablet (65% and 46%, respectively) than those with mild or moderate losses (78% and 83%, $H(3) = 24.55$, $\varepsilon^2 = .05$, $p < .001$).

Smartphones

A majority of smartphone users (89.8%) had more than 3 years of experience using their smartphone, with 7.5% having 1–2 years experience and 2.7% having less than one year of experience. The most commonly used operating system for smartphones was Apple iOS (82%), with 17% running Android, and less than 1% running Windows. When asked to select all the factors which influenced the decision to purchase a specific smartphone brand, the most common reasons for having selected the particular smartphone brand included its accessibility features (63%), it having been recommended by other blind or visually impaired acquaintances (11%), it being easy to use (7%), or it having been received as a gift (3%). When selecting a phone for purchase, participants indicated that the most important features (on a 3-point scale) were accessibility (M = 2.55, SD = 0.86), effectiveness (M = 1.26, SD = 1.04), durability (M = 0.54, SD = 0.83), dimensions (M = 0.53, SD = 0.91), weight (M = 0.44, SD = 0.77), security (M = 0.38, SD = 0.75), and comfort (M = 0.30, SD = 0.65). Those with mild (M = 1.57, SD = 1.27) to moderate (M = 1.65, SD = 1.31) vision losses were significantly less concerned about accessibility than those with severe (M = 2.46, SD = 0.97) and profound (M = 2.66, SD = 0.71) losses: H(3) = 27.58, $\varepsilon^2 = .08$, $p < .001$. Similarly, those with mild (M = 1.57, SD = 1.40) to moderate (M = 1.20, SD = 1.24) vision losses were significantly more concerned about the dimensions of the device than those with severe (M = 0.88, SD = 1.08) and profound losses (M = 0.38, SD = 0.76): H(3) = 29.61, $\varepsilon^2 = .08$, $p < .001$. The demographic factors considered (age, age of diagnosis, degree of vision loss, and proficiency) did not result in any statistically significant differences with respect to the other features (effectiveness, durability, weight, security, or comfort).

Most users relied on self-learning (69%), web-based resources (58%), or the assistance of other visually impaired users (43%) to learn how to use their smartphones, with only 18% receiving training and assistance from sighted friends and family and a mere 7.5% receiving assistance from vision rehabilitation professionals. For technical support purposes, the most common sources of assistance included web-based resources (76%), other visually impaired users (50%), sighted friends and family (30%), and vision rehabilitation professionals (8.2%). Only 2.4% of respondents indicated that they were not aware of where technical support could be attained.

Participants generally believed themselves to be skilled smartphone users, with 71% reporting advanced proficiency, 26% reporting intermediate proficiency, and 3% reporting beginner proficiency. Age (H(2) = 24.85, $\varepsilon^2 = .06$, $p < .001$) and age at diagnosis (H(5) = 13.62, $\varepsilon^2 = .03$, $p = .018$) impacted on smartphone proficiency, with older individuals generally feeling less proficient than younger individuals (Cramer's $V = .17$). Moreover, degree of vision loss (H(3) = 21.61, $\varepsilon^2 = .05$, $p < .001$) influenced proficiency, with those having more severe vision loss feeling more proficient than those with mild or moderate losses.

Tablets

With respect to tablets, most tablet users (70%) had more than 3 years of experience with their tablet device, with 19% having 1–2 years experience and 11% having less than one year of experience. In total, 79% of tablets were Apple iOS-based, while 18% ran on Android, and 3% ran on Windows. The most common reasons for having selected this particular tablet brand included its accessibility features (50%), it having been received as a gift (11%), it being easy to use (11%), it being affordable (5%), and recommendations from other blind and visually impaired users (4.9%). When selecting a tablet to purchase, participants indicated that the most important features (on a 3-point scale) were accessibility (M = 2.31, SD = 1.06), effectiveness (M = 1.22, SD = 1.11), weight (M = 0.65, SD = 0.90), dimensions (M = 0.65, SD = 1.01), durability (M = 0.57, SD = 0.79), comfort (M = 0.36, SD = 0.76), and security (M = 0.24, SD = 0.68). As with phones, those with mild (M = 1.83, SD = 1.17) to moderate (M = 1.35, SD = 1.27) vision losses were significantly less concerned about accessibility than those with severe (M = 2.27, SD = 1.10) and profound (M = 2.48, SD = 0.94) losses: H(3) = 17.02, $\varepsilon^2 = .09$, $p = .001$. Similarly, those with mild (M = 1.33, SD = 1.21), moderate (M = 1.35, SD = 1.22), and severe (M = 1.24, SD = 1.12) vision losses were significantly more concerned about the dimensions of the device than those with profound losses (M = 0.34, SD = 0.77): H(3) = 38.93, $\varepsilon^2 = .21$, $p < .001$. The demographic factors considered (age, age of diagnosis, degree of vision loss, and proficiency) did not result in any statistically significant differences in respect of the other features (effectiveness, durability, weight, security, or comfort).

Most users relied on self-learning (75%), web-based resources (46%), or the assistance of other visually impaired users (21%) to learn how to use their tablets, with only 15% receiving training and assistance from sighted friends and family and just 7% receiving assistance from vision rehabilitation professionals. For technical support purposes, the most common sources of assistance included web-based resources (73%), other visually impaired users (38%), sighted friends and family (24%), and vision rehabilitation professionals (9.8%). Only 1.6% of respondents indicated they were not aware of where technical support could be attained.

Age (H(2) = 22.79, $\varepsilon^2 = .09$, $p < .001$) but not age at diagnosis impacted proficiency, with those over 60 being significantly less likely to report 'advanced' proficiency than those in any other age group. The degree of vision loss also influenced proficiency (H(3) = 9.97, $\varepsilon^2 = .04$, $p = .019$), with those having mild or moderate losses being less likely to report advanced proficiency than those with severe or profound losses.

Smartphone and tablet features and applications used

Of the 466 respondents, 95% reported that they used their device to make phone calls; 93% to send and receive text messages; 92% to browse the web, 92% to read e-mail; 83% to listen to music; 81% for social media; 75% for calendar functions; 67% to take photos; 61% for reminders; and 53% to participate in video calls.

A detailed investigation was undertaken to explore the use that participants were making of their smartphones and tablets to perform a wide range of daily living tasks that might previously have been aided by traditional assistive devices. The number of respondents using their devices for these tasks, and the factors which were found to influence the likelihood of use, are summarized in Table 3.

Are mainstream devices replacing traditional assistive devices?

Participants were asked to which extent they agreed with the statement, "Overall, I feel that my smartphone or tablet computer has replaced the use of my other assistive devices" on the

Table 3. Proportion of respondents reporting the use of smartphone and tablets feature for accomplishing specific tasks and associated demographic factors (shaded values are significant, $p < .05$).

Task	N	% of smartphone and tablet usage	Associated factors: Age	Age of diagnosis	Vision level	Proficiency
Audiobooks	333	71%	H(2) = 0.04, p = .98	H(5) = 5.12, p = .401	H(3) = 9.25, ε^2 = .02, p = .026	H(2) = 14.18, ε^2 = .03, p = .001
Braille Input	125	27%	H(2) = 13.81, ε^2 = .03, p = .001	H(5) = 15.76, ε^2 = .05, p = .008	H(3) = 23.60, ε^2 = .05, p < .001	H(2) = 22.06, ε^2 = .05, p < .001
Color Identification	149	32%	H(2) = 2.76, p = .252	H(5) = 5.75, p = .331	H(3) = 32.54, ε^2 = .07, p < .001	H(2) = 5.68, p = .058
Reading e-Books	306	66%	H(2) = 4.86, = .088	H(5) = 16.26, ε^2 = .04, p = .006	H(3) = 7.36, p = .061	H(2) = 36.43, ε^2 = .08, p < .001
Light Detection	142	30%	H(2) = 3.59, p = .166	H(5) = 6.58, p = .254	H(3) = 28.18, ε^2 = .06, p < .001	H(2) = 13.19, ε^2 = .03, p = .001
Magnification	84	18%	H(2) = 4.65, p = .098	H(5) = 4.96, p = .421	H(3) = 83.50, ε^2 = .18, p < .001	H(2) = 1.48, p = .477
Recording Memos	231	50%	H(2) = 10.32, ε^2 = .02, p = .006	H(5) = 1.75, p = .883	H(3) = 4.08, p = .253	H(2) = 14.24, ε^2 = .03, p = .001
Navigation	371	80%	H(2) = 3.56, p = .168	H(5) = 5.81, p = .325	H(3) = 13.31, ε^2 = .03, p = .004	H(2) = 34.50, ε^2 = .08, p < .001
Object Identification	286	61%	H(2) = 5.15, p = .076	H(5) = 17.27, ε^2 = .05, p = .004	H(3) = 64.78, ε^2 = .14, p < .001	H(2) = 22.70, ε^2 = .05, p < .001
OCR	324	70%	H(2) = 6.16, ε^2 = .01, p = .046	H(5) = 16.57, ε^2 = .04, p = .005	H(3) = 73.47, ε^2 = .16, p < .001	H(2) = 32.15, ε^2 = .07, p < .001
Sighted Help	182	39%	H(2) = 5.80, p = .055	H(5) = 11.64, ε^2 = .04, p = .04	H(3) = 35.34, ε^2 = .08, p < .001	H(2) = 17.62, ε^2 = .04, p < .001

Note. OCR = optical character recognition.

basis of a 5-point Likert scale (Totally disagree, Disagree, Somewhat agree, Agree, Totally agree). It was found that 62.5% agreed or totally agreed; 24.8% somewhat agreed; and 12.7% disagreed or totally disagreed. Younger participants (H(2) = 8.22, ε^2 = .02, p = .016) and those with greater proficiency (H (2) = 36.6, ε^2 = .08, p < .001) felt more strongly that this replacement was occurring.

To explore this question at a more granular level, the responses to four interrelated questions in the survey instrument (Q42 through Q45) were consolidated and analyzed: Among individuals who required the use of an assistive device to perform a specific task, and who had used or continued to use traditional assistive devices to accomplish those tasks, to what degree were they now using their smartphone or tablet devices in place of traditional devices for these tasks? The results of that analysis are presented in Figure 2 and corroborate the self-reported perception that smartphones and tablets are taking the place of traditional assistive devices at least some of the time for all of the identified tasks.

What factors influence device usage?

A variety of demographic factors including age, age at diagnosis, degree of vision loss, and proficiency with their device were found to influence the degree to which this replacement was occurring depending on the task at hand. Table 4 identifies the factors which were found to contribute to statistically significant differences in the degree to which mainstream devices were replacing traditional assistive devices for a variety of tasks.

At the most general level, participants were asked to which extent they agreed with the statement, "It is important to me that I use a smartphone or tablet computer like everyone else, rather than a specialized assistive device." Overall, 69.6% agreed or totally agreed with this statement; 17.8% somewhat agreed; and 12.6% disagreed or totally disagreed. User proficiency levels impacted these perceptions, with more proficient users agreeing more strongly with the statement (H(2) = 17.06, ε^2 = .04, p < .001).

When asked about the extent to which respondents agreed that having physical buttons on a device is important, more than half of respondents (56.9%) disagreed or totally disagreed with this statement, 25.9% somewhat agreed, and 17.2% agreed or totally agreed. User proficiency impacted these perceptions, with less proficient users agreeing more strongly with the statement (H(2) = 28.79, ε^2 = .06, p < .001). Open-ended comments here clarify that the incorporation of physical buttons depends upon the task, with participants highlighting the value of physical buttons for text input and more extensive writing tasks.

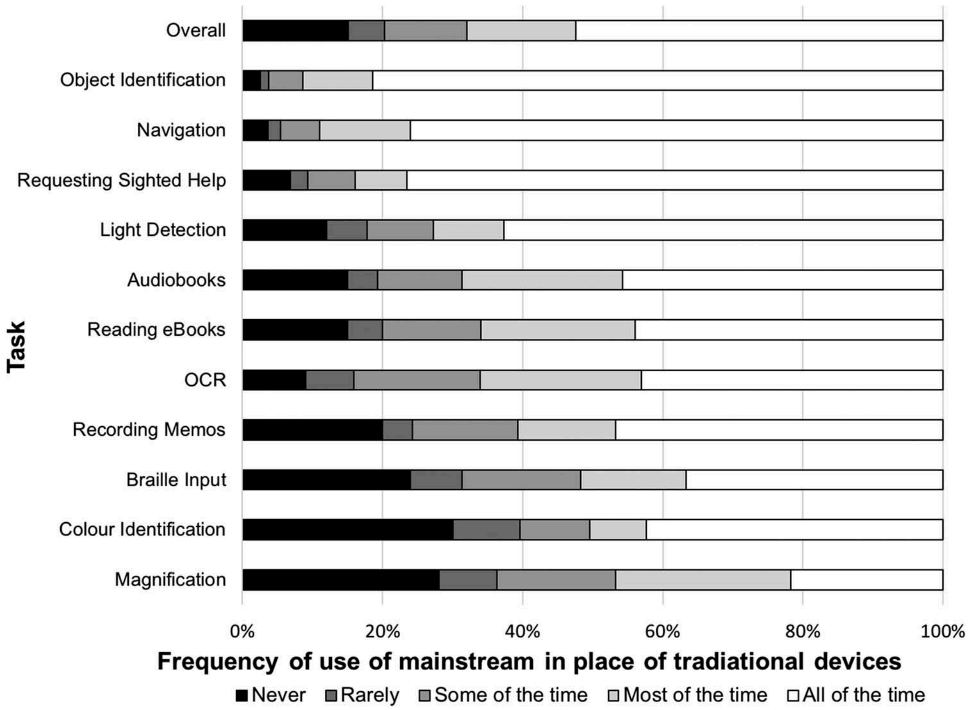

Figure 2. Frequency of mainstream device usage in place of traditional devices for specific tasks.
Note. OCR = optical character recognition.

Table 4. Factors that influence the degree of replacement of traditional devices by smartphones or tablets for specified tasks (shaded values are significant, $p < .05$).

		Influencing factors			
Task	N	Age	Age of diagnosis	Vision level	Proficiency
Audiobooks	372	H(2) = 7.72, ε^2 = .02, *p* = .021	H(5) = 5.20, *p* = .392	H(3) = 0.27, *p* = .966	H(2) = 14.92, ε^2 = .04, *p* = .001
Braille Input	150	H(2) = 10.16, ε^2 = .07, *p* = .006	H(5) = 4.51, *p* = .341	H(3) = .81, *p* = .666	H(2) = 17.94, ε^2 = .12, *p* < .001
Color Identification	188	H(2) = 1.05, *p* = .592	H(5) = 3.08, *p* = .545	H(3) = 4.95, *p* = .084	H(2) = 1.06, *p* = . 588
Reading e-Books	337	H(2) = .64, *p* = .726	H(5) = 7.35, *p* = .118	H(3) = 2.98, *p* = .395	H(2) = 13.08, ε^2 = .04, *p* = .001
Light Detection	137	H(2) = .45, *p* = .797	H(5) = .63, *p* = .96	H(3) = 4.16, *p* = .125	H(2) = 3.55, *p* = .169
Magnification	109	H(2) = 3.62, *p* = .164	H(5) = 1.48, *p* = .915	H(3) = 3.73, *p* = . 292	H(2) = 1.56, *p* = . 459
Recording Memos	279	H(2) = 9.92, ε^2 = .04, *p* = .007	H(5) = 7.67, *p* = .175	H(3) = .55, *p* = .907	H(2) = 11.50, ε^2 = .04, *p* = .003
Navigation	338	H(2) = 17.50, ε^2 = .05, *p* < .001	H(5) = 14.16, ε^2 = .04, *p* = .015	H(3) = 12.29, ε^2 = .04, *p* = .006	H(2) = 6.68, ε^2 = .02, *p* = .035
Object Identification	243	H(2) = 21.86, ε^2 = .09, *p* < .001	H(5) = 11.18, ε^2 = .05, *p* = .025	H(3) = 4.59, *p* = .204	H(2) = 9.85, ε^2 = .04, *p* = .007
OCR	332	H(2) = 3.28, *p* = .194	H(5) = 2.31, *p* = .68	H(3) = 1.44, *p* = . 696	H(2) = 12.00, ε^2 = .04, *p* = .002
Sighted Help	162	H(2) = 1.20, *p* = .55	H(5) = 5.61, *p* = .23	H(3) = 1.09, *p* = .578	H(2) = 5.68, *p* = .058

Note. OCR = optical character recognition.

Discussion

It is evident that mainstream smartphone and tablet devices fulfill an important role in the lives of individuals who are blind or who have low vision. While the above findings demonstrate the impact of such devices, they also provide imperative context about the different ways in which such mainstream tools are used by diverse segments of the visually impaired population and accentuate that users with visual impairments constitute a heterogenous population. Demographic variables including age, age at diagnosis, degree of vision loss, and proficiency impact the degree to which individuals choose to use their smartphones or tablets to complete tasks, and the extent to which they have replaced traditional assistive devices. Ultimately, such distinctions are vital to consider both within design and training interventions and highlight the diverse needs that exist among users with visual impairments.

Mainstream devices and features being used

A vast majority of participants (97%) choose to use a smartphone rather than a tablet, excluding those with mild or moderate visual impairments who are slightly more likely to select a tablet for specific tasks. This coincides with the fact that participants with milder visual impairments placed greater emphasis onscreen dimension as an important feature taken into consideration when selecting a device. Setting aside the degree of vision, however, it is important to highlight that the preference for smartphones above tablets spans across all age groups in this study. Strikingly, participants on average describe using as many as 11 separate traditional devices to complete tasks ($M = 5.32$, $SD = 2.58$), whereas it can be seen that these same tasks in a majority of cases are now completed through the use of a mainstream device alone.

Here, portability is accentuated by one participant as an important advantage of the smartphone, as it minimizes the need to carry multiple devices simultaneously: "I replaced a lot of small devices with one small device. I love that. Mobility is the real advantage". This is further evidenced by the fact that a full 80% of participants use a smartphone for navigation purposes (outdoor GPS) rather than as tools that are exclusively employed within the home. Similarly, the escalating accessibility of mainstream applications such as Audible, iBooks and Kindle – as well as applications which provide optical character recognition – increase access to electronic information, where it was often not available beforehand. In this way, mainstream devices that incorporate universal design can be understood as not merely providing a means to perform tasks, but also as tools which invigorate the universal availability of accessible texts through guidelines that encourage application designers to meet accessibility standards.

Overall, the top five tasks listed in Figure 2 highlight that mainstream devices, in many cases, are functioning as multipurpose tools that facilitate independence in increasingly diverse contexts. These findings emphasize the need for future trainers and rehabilitation personnel to view the training in the use of mainstream devices not as a specialized, insular activity, but one that should be increasingly understood through an interdisciplinary lens (Bronstein, 2003). Rehabilitation training and care has traditionally been fragmented, with technology training offered separately from other disciplines such as activities of daily living and orientation and mobility instruction (Hinds et al., 2003). However, it is clear that such mainstream solutions are markedly different from many traditional devices that are designed to perform a more restricted scope of tasks, and, as expressed by one participant, clients should, therefore, be provided with opportunities to understand the full potential of such mainstream tools within the context of their overall rehabilitation goals:

> The real challenge is to make certain blind people who get these devices are made aware of the possibilities and how to work the accessibility features. I've run into a number of people with these devices who had no idea about the access technology [these devices] contained or how to use it (…) These are life-changing devices if people are able to connect the dots.

Despite these identified advantages, participants also accentuate that mainstream smartphones and tablets are limiting in some instances and cannot replace the use of traditional tools for the completion of certain tasks, particularly as these pertain to extensive typing and editing needs. As characterized by one participant, "an iPhone can replace most standalone assistive technologies, but it cannot replace a desktop computer". Slightly more than half of participants (56%) disagreed to at least some extent with the statement that physical buttons were an essential feature of a device, with participants describing the effective use of dictation and on-screen braille input for briefer text entry functions. Though participants described feeling reluctant to use a device that did not incorporate physical buttons prior to learning the use of their smartphone or tablet, a common theme was that this intimidation decreased quickly once they gained proficiency. Indeed, those with greater proficiency were significantly less likely to prefer devices with traditional physical buttons. However, even among more proficient mainstream device users, comments also highlight that it is imperative to understand the limits of such tools which cannot replace more sophisticated traditional devices used for document management purposes. This preference for physical buttons for extensive typing needs is also echoed in findings by Watanabe et al. (2015), and Caprani, O'Connor, and Gurrin (2012) further explore the potential benefit of traditional physical buttons for older adults with cognitive and motor impairments when completing certain tasks. Our findings, therefore, raise the value of viewing traditional and mainstream devices not as opposing options, but as existing on a continuum of solutions which may be employed depending on the task to be performed. Consideration of specific user needs and the tasks to be performed are vital to contemplate both at the design stage and within assessment and training contexts. In this way, the best device must not merely depend upon the user, but on the specific task in question for that user.

Replacement of traditional devices

Our findings provide overwhelming evidence that in this sample, mainstream devices are now replacing traditional assistive solutions. This is especially true for object identification, navigation, requesting sighted help, listening to audiobooks, reading eBooks and optical character recognition, where in each case, at least two-thirds of respondents indicated that mainstream devices were replacing traditional tools most or all of the time (see Figure 2). These results are consistent with the fact that a full 87.4% of participants agreed at least to some extent with the statement that, overall, mainstream devices are replacing the use of traditional assistive solutions. Similarly, a vast majority of respondents (87.4%) agreed at least to some extent that it is important for them to use a mainstream device that is adopted by the general public, alluding to the avoidance of tools which may work to separate users from the norm. Interestingly, prior research has found that an iPad and a portable CCTV are essentially equivalent from a functional perspective (Morrice, Johnson, Marinier, & Wittich, 2017; Wittich, Jarry, Morrice, & Johnson, 2018), suggesting that the decision to replace a traditional assistive device with a mainstream solution may be driven by reasons above and beyond functional factors.

The influence of stigma and social acceptance, especially among those with invisible or newly acquired impairments, is well established in previous research (Mulloy et al., 2014), and findings from this study suggest that this is true among users with visual impairments as well. Fraser, Kenyon, Lagacé, Wittich, and Southall (2015) conducted a critical discourse analysis of text published between January 2009 and 2013 in a major Canadian newspaper, examining stereotypical depictions of age-related conditions and assistive device usage. It was found that depictions of aging and assistive device usage often exacerbate existing stereotypes, and may consequently lead to a reduction in help-seeking and lower overall assistive device adoption (Fraser et al., 2015). The overwhelming agreement among participants in this study who affirm their preference to use widely accepted devices is especially relevant as the prevalence of acquired age-related vision loss continues to increase, with this number expected to double by 2050 (Varma et al., 2016).

Stigma, however, is not the only factor contributing to the preference to use a mainstream rather than a traditional device. Open-ended comments highlighted the fact that such mainstream devices are more affordable, more intuitive to use, and require less bureaucratic paperwork to obtain:

> It's not so much important to me that I can use the same device like everyone else for blindness pride reasons. However, from a financial and affordability standpoint, I am thankful I can use the same kind of device as everyone else, instead of having to either spend money I don't have for specialized devices or software, or having to justify to get rehab to pay for it.

Influential factors: Relationship between proficiency and usage

For many tasks, age and proficiency impact the degree of replacement (with younger and more proficient users being more likely to replace their traditional assistive devices). While correlations were observed between proficiency and age and age at diagnosis, proficiency (rather than age) was more commonly identified as a significant factor. In other words, also among those older adults who self-report higher proficiency, mainstream devices are replacing the use of traditional assistive solutions for a majority of tasks most or all of the time. These results suggest that proficiency, rather than age, is the driving influential factor which determines device usage and degree of replacement. As participants across all ages become more proficient and comfortable with the use of their mainstream devices, they are more likely to prefer a smartphone or tablet for the completion of a majority of tasks.

These findings raise the need to invest training and program resources to facilitate the learning of such mainstream devices, particularly when considering the expressed preference of most participants to use a device that is widely accepted by others. While 42% of participants still rely on vision rehabilitation professionals for the training of traditional devices, only 7% turn to such specialists for the training and technical support of their smartphones and tablets. Instead, a majority depend upon online resources and other visually impaired acquaintances, likely influenced by the greater availability of online training and technical support for mainstream products that are sold to the general public. As expressed by one participant,

> If the phone needs to be repaired, I can go to the store within a couple of days. If a specialized device needs to be repaired, there's more jumping through hoops involved and it takes forever for the device to get back to me.

This being said, participants in this study who acquired their vision loss after age 60 were still more likely to rely upon rehabilitation professionals for such support, and are more likely to be unaware of where to seek technical support when problems arise. Though not specifically focused on age-related vision loss, the difficulty of securing technical assistance was highlighted in prior work by Jarry et al. (2017). Given that proficiency appears to be related to usage, future design and training programs must consider ways to harness online and external resources for more proficient users who can rely on such supplements, while bolstering traditional training and supports for older and less proficient users who appear to be experiencing gaps, as this may influence their ability to employ mainstream devices for more complex tasks.

Shifting priorities and definitions

Given the widespread replacement of traditional assistive devices for many tasks, these findings also provide strong support for programs and initiatives which increase the availability of such mainstream tools for users with visual impairments who may otherwise face financial restrictions. The CNIB *Phone It Forward* program (CNIB, 2018), for instance, collects and refurbishes old and unused smartphones from the general public and redistributes them to blind and low-vision users who otherwise would not have access to these tools. Though mainstream smartphones and tablets are undoubtedly less costly than many traditional assistive devices, most existing funding programs, such as the government health insurance in Quebec, Canada, do not include these mainstream devices among those aids which are eligible for funding (Régie de l'assurance maladie du Québec [RAMQ], 2018). This may still pose a barrier to those who experience financial difficulties, which is especially relevant given the prevalence of both people with disabilities and older adults who live close to or below the poverty line in most western countries (Martiniello & Wittich, 2019). As participants in this study are typically using a single mainstream device in place of several traditional solutions, funding such mainstream devices would alleviate the financial burden placed on existing governmental programs. This will become increasingly pertinent to consider as the prevalence of age-related vision loss continues to place additional burdens on existing governmental programs

(Varma et al., 2016). Though a caveat should also be made that the continued funding of traditional devices must be maintained for those users and tasks where it is deemed more appropriate, existing paradigms should also accommodate these shifting trends and harness the full potential that mainstream solutions afford.

A final central theme warrants reflection. Participants in this study not only described how and when smartphones and tablets replaced traditional assistive devices, but also provided a nuanced understanding of what constitutes an ‘assistive device’ in the first place. Interestingly, mainstream features not inherently designed to solve accessibility challenges can and are being used by participants:

> An advantage of having a smartphone is that if you are lost you can send your location to a sighted friend or family member so that they can either come and get you or direct you from the map.

Though functionalities such as video-calling were not designed to address difficulties (such as requesting sighted assistance when lost), these mainstream features are seemingly taking on the role of ‘assistive device’ in such cases. In this way, smartphones and tablets are ultimately enabling participants to not only perform a wider range of tasks, but are also shifting the definition of ‘assistive device’ to include mainstream products that are being harnessed in increasingly creative and flexible ways.

Limitations and future research

The majority of participants in this convenience sample were younger, more advanced technology users, likely due to the social media recruitment efforts and the fact that data collection occurred through an online survey. While a subset of participants (n = 56) in this study were over the age of 60, the majority were working-age adults with profound congenital visual impairments. Our results provide a starting point for understanding the experiences of older adults or those with acquired visual impairment who may not have extensive prior experience with assistive devices. Future research should, therefore, strive to gain a more in-depth understanding of this growing population and their unique needs.

Moreover, while the survey instrument did endeavor to gather information from those with additional impairments such as those with dual sensory loss, this was not the primary aim of the investigation and thus these data are limited in scope. Future research should likewise focus more explicitly on the implications of comorbidity on device usage, particularly as many users may acquire multiple impairments as a consequence of normal aging, and the very nature of a disability may also depend on the environment and context (Wittich, Southall, & Johnson, 2016). Such users may have different or compounding needs compared to those with visual impairment alone. Given the suite of accessibility features increasingly available on mainstream smartphones and tablets, future research should explore how effectively such tools meet different and sometimes opposing needs for the same user.

While our study focused on those who already have access to a smartphone or tablet (regardless of how frequently they choose to use these mainstream options), future investigations should also explore those who choose *not* to acquire a smartphone or tablet at all in favor of using traditional devices, particularly among older adults who may be long-term users of traditional assistive devices. Likewise, the current study did not directly inquire about the impact of costs associated with a device after procurement which may be an important question to explore in future research.

Finally, the current study, in common with many online surveys, is based on broadly defined self-reported degrees of visual impairment, making it difficult to extrapolate the actual functional experience of participants. Future investigations which incorporate both objective and self-reported measures would provide useful context and a more wholistic image of sensory functioning.

Conclusion

As the ubiquity of mainstream devices continues to increase, it is essential to explore not only the impact of such devices within the visually impaired population as a whole, but also the ways in which this may differ among diverse segments of user populations. Within our sample, mainstream devices are replacing the use of traditional devices most or all of the time, but specific tasks still require the use of traditional methods. Moreover, as users become more proficient, they are more likely to choose mainstream devices that are widely adopted by the general population. Ultimately, future designers, trainers, and governmental programs must adapt to accommodate these shifting trends, in order to ensure that such mainstream tools are harnessed to their fullest potential where appropriate.

Acknowledgments

We would like to acknowledge the *Fonds de recherche santé du Québec* (FRQS Grant No. 32305), the CNIB Ross C. Purse Doctoral Fellowship, and the Bavarian Quebec Research Alliance for funding this research. We would also like to thank Magdalena Bittner for her contributions in the development of the survey instrument.

Funding

This work was supported by the Fondes de Recherche Quebec Santé (FRQS) [# 32305]; CNIB Ross C. Purse Doctoral Fellowship [not applicable]; Bavarian-Québec Research Alliance.

Declaration of Interest

None of the authors report any potential conflict of interest in respect of this research.

ORCID

Natalina Martiniello http://orcid.org/0000-0002-2739-8608
Christine Lehane http://orcid.org/0000-0001-7872-0890
Walter Wittich http://orcid.org/0000-0003-2184-6139

References

Bronstein, L. R. (2003). A model for interdisciplinary collaboration. *Social Work*, *48*(3), 297–306. doi:10.1093/sw/48.3.297

Caprani, N., O'Connor, N., & Gurrin, C. (2012). Touch screens for the older user. In F. A. Cheein (Ed.), *Assistive Technologies*. London, UK: IntechOpen. doi:10.5772/1089

CNIB. (2018, September 19). *CNIB foundation launches phone it forward*. Press Release. Globe Newswire. Retrieved from https://globenewswire.com/news-release/2018/09/19/1572936/0/en/CNIB-Foundation-launches-Phone-It-Forward.html

Crossland, M. D., Silva, R. S., & Macedo, A. F. (2014). Smartphone, tablet computer and e-reader use by people with vision impairment. *Ophthalmic & Physiological Optics*, *34*, 552–557. doi:10.1111/opo.12136

Faucett, H. A., Ringland, K. E., Cullen, A. L. L., & Hayes, G. R. (2017). (In)Visibility in disability and assistive technology. *ACM Transactions on Accessible Computing*, *10*(4), 14. doi:10.1145/3131767

Fraser, S. A., Kenyon, V., Lagacé, M., Wittich, W., & Southall, K. E. (2015). Stereotypes associated with age-related conditions and assistive device use in Canadian media. *The Gerontologist*, *2015*, 1–11.

Furer, M. J. (2001). Assistive technology outcomes research: Challenges met and yet unmet. *American Journal of Physical Medicine & Rehabilitation*, *80*(7), 528–535.

Gitlin, L. (1995). Why older people accept or reject assistive technology. *Journal of the American Society on Aging*, *19*(4), 41–46.

Goodman, L. A. (1961). Snowball sampling. *Annals of Mathematical Statistics*, *22*(1), 148–170. doi:10.1214/aoms/1177705148

Gordon, P., Kerzner, L., Sheldon, T., & Hansen, E. (2007). *Assistive devices in Canada: Ensuring inclusion and independence*. Ontario, Canada: ARCH Disability Law Centre.

Griffith-Shirley, N., Banda, D. R., Ajuwon, P. M., Cheon, J., Lee, J., Park, H. R., & Lyngdoh, S. N. (2017). A survey on the use of mobile applications for people who are visually impaired. *Journal of Visual Impairment & Blindness*, *111*(4), 307–323. doi:10.1177/0145482X1711100402

Hinds, A., Sinclair, A., Park, J., Suttie, A., Paterson, H., & Macdonald, M. (2003). Impact of an interdisciplinary low vision service on the quality of life of low vision patients. *British Journal of Ophthalmology*, *87*(11), 1391–1396. doi:10.1136/bjo.87.11.1391

Irvine, D., Zemke, A., Pusteri, G., Gerlach, L., Chun, R., & Jay, W. M. (2014). Tablet and smartphone accessibility features in the low vision rehabilitation. *Neuro-Ophthalmology*, *38*(2), 53–59. doi:10.3109/01658107.2013.874448

Jarry, A., Chapdelaine, C., Kurniawan, S., & Wittich, W. (2017). Blind adults' perspectives on technical problems and solutions when using technology. *Journal of Blindness Innovation and Research*, *7*(1). doi:10.5241/7

Kane, S. K., Jayant, C., Wobbrock, J. O., & Ladner, R. E. (2009). *Freedom to roam: A study of mobile device adoption and accessibility for people with visual and motor disabilities*. Proceedings of the 11th International ACM SIGACCESS Conference in Computers and Accessibility, (pp. 115–122), Pittsburgh, PA.

Martiniello, N., & Wittich, W. (2019). Employment and visual impairment. In J. Ravenscroft (Ed.), *The Routledge handbook of visual impairment: Social and cultural research* (pp. 415–437). London, UK: Routledge.

McKnight, P. E., & Najab, J. (2010). Kruskal-Wallis test. In W. E. Craighead & I. B. Weiner (Eds.), *The Corsini encyclopedia of psychology and behavioral science* (p. 626). New York, NY: Wiley.

Morrice, E., Johnson, A. P., Marinier, J.-A., & Wittich, W. (2017). Assessment of the Apple iPad as a low-vision reading aid. *Eye*, *31*, 865–871. doi:10.1038/eye.2016.309

Mulloy, A. M., Gevarter, C., Hopkins, M., Sutherland, K. S., & Ramdoss, S. T. (2014). *Assistive technologies for people with diverse abilities (Chapter 5)*. New York, NY: Springer Science + Business Media.

O'Cathain, A., & Thomas, K. J. (2004). 'Any other comments?' Open questions on questionnaires – A bane or a bonus to research? *BMC Medical Research Methodology*, *4*, 25. doi:10.1186/1471-2288-4-25

Pape, T., Kim, J., & Weiner, B. (2002). The shaping of individual meanings assigned to assistive technology: A review of personal factors. *Disability and Rehabilitation*, *24*(1–3), 5–20. doi:10.1080/09638280110066235

Phillips, M., & Proulx, M. J. (2018). Social interaction without vision: An assessment of assistive technology for the visually impaired. *Technology and Innovation*, *20*, 85–93. doi:10.21300/20.1-2.2018.85

Presley, I., & D'Andrea, M. F. (2008). *Assistive technology for students who are blind or visually impaired: A guide to assessment*. New York, NY: AFB Press.

Raskind, M. (2013). *Assistive technology*. council for learning disabilities. Retrieved from http://www.council-for-learning-disabilities.org/wp-content/uploads/2013/11/AssistiveTechnology.pdf

Régie de l'assurance maladie du Québec [RAMQ]. (2018, December 31). Tariff for insured visual aids and related services, CQLR c A-29, r 8.1. *Health Insurance Act*. Retrieved from http://canlii.ca/t/53hjp

Rodrigues, A., Montague, K., Nicolau, H., & Guerreiro, T. (2015). *Getting smartphones to talkback: Understanding the smartphone adoption process of blind users*. Proceedings of the 17th International ACM SIGACCESS Conference on Computers and Accessibility, (pp. 23–32), Lisbon, Portugal. doi:10.3389/fphar.2015.00023

Scherer, M. J., & Glueckauf, R. (2005). Assessing the benefits of assistive technologies for activities and participation. *Rehabilitation Psychology*, *50*(2), 132–141. doi:10.1037/0090-5550.50.2.132

Shinohara, K. &. (2011). *In the shadow of misperception: Assistive technology use and social interactions*. CHI 2011 (pp. 705–714), Vancouver. doi:10.1177/1753193411416425

Story, M. F. (1998). Maximizing usability: The principles of universal design. *Assistive Technology: The Official Journal of RESNA*, 4–12. doi:10.1080/10400435.1998.10131955

Streiner, D. L., & Norman, G. R. (2011). Corrections for multiple testing. *CHEST*, *140*(1), 16–18. doi:10.1378/chest.11-0523

Sugawara, A. T., Ramos, V. D., Alfieri, F. M., & Battistella, L. (2018). Abandonment of assistive products: Assessing abandonment level and factors that impact on it. *Disability and Rehabilitation: Assistive Technology*, *13*(7), 716–723. doi:10.1080/17483107.2018.1425748

Varma, R., Vajaranant, T. S., Burkemper, B., Wu, S., Torres, M., Hsu, C., … McKean-Cowdin, R. (2016). Visual impairment and blindness in adults in the United States: Demographic and geographic variations from 2015 to 2050. *Journal of the American Medical Association: Ophthalmology*, *134*(7), 802–809.

Watanabe, T., Yamaguchi, T., & Minatani, K. (2015). Advantages and drawbacks of smartphones and tablets for visually impaired people – Analysis of ICT user survey results. *Institute of Electronics, Information and Communications Engineers*, *98*(4), 922–929.

Williams, J. R. (2008). The declaration of helsinki and public health. *Bulletin of the World Health Organization*, *86*(8), 650–651.

Wittich, W., Jarry, J., Morrice, E., & Johnson, A. (2018). Effectiveness of the Apple iPad as a spot-reading magnifier. *Optometry and Vision Science*, *95*(9), 704–710. doi:10.1097/OPX.0000000000001269

Wittich, W., Southall, K., & Johnson, A. (2016). Usability of assistive listening devices by older adults with low vision. *Disability and Rehabilitation: Assistive Technology*, *11*(7), 564–571. doi:10.3109/17483107.2015.1042076

World Health Organization. (1992). *The ICD-10 classification of mental and behavioral disorders: Clinical descriptions and diagnostic guidelines*. Geneva, Switzerland: Author.