Blind and Deaf Consumer Preferences for Android and iOS Smartphones

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1 Introduction

Access to and use of mobile wireless technology has become critical to social and economic participation for people with disabilities. As the technology increases in power and sophistication, these customers increasingly rely on mobile devices and software for functions previously available only through dedicated 'assistive technology'. Successfully serving this large and growing population has become a market imperative as well as a legislative mandate for the wireless industry in the US. Competition for this market is especially keen between the Android and Apple's iOS operating systems. This article presents survey research findings on the relative ease of use, importance and satisfaction experienced by blind and deaf customers using mobile devices on Android or iOS platforms. Focus group research conducted by the authors suggests that blind smartphone users overwhelmingly favour the iPhone, while deaf smartphone users show greater diversity in their device choices. Data collected through the Survey of User Needs (SUN) conducted by the Rehabilitation Engineering Research Center for Wireless Technologies (Wireless RERC) are presented to test this finding with quantitative data, and to test differences between blind and deaf users in terms of ease of use and satisfaction with iPhone and Android smartphones.

2 The Wireless Marketplace Meets Customers with Disabilities

In the US, accessibility and usability of wireless information and communication technologies (ICT) has been a legislative mandate for many years, most recently under the Twenty-First Century Communications and Video Accessibility Act

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(CVAA), which began to take effect in 2013 (U.S. Government Printing Office 2010). Reinforcing this mandate, intense competition within segments of the ICT industry has made people with disabilities—including a large proportion of older citizens—an attractive customer market.

This competition is especially obvious between products and services offered on the Android and Apple wireless platforms, the two dominant smartphone and tablet operating systems. With each release of updated operating systems, debate is renewed about which platform serves customers better, with and without disabilities. Other design qualities, including the form factor (pure touchscreen vs. physical keyboard, 'candy-bar' vs. clamshell design, etc.), overall organisation of features and functions in operating system menus and out-of-the-box accessibility can greatly impact usability. The virtual controls of touchscreen mobile devices, and their varying placement, style, and functionality among diverse apps and operating systems, can present challenges to users with disabilities. Customers who need or prefer a tactile keyboard over a touchscreen can choose only between Android and Blackberry devices.

Long considered the gold standard of smartphone operating systems, Apple's iOS is being effectively challenged by new capabilities available on the Android operating system. In September, 2012, a Business Insider online column rated Google Now competitive with Siri, Apple's popular voice-activated user interface. The column also cited Android's Talkback, which provides audio feedback when navigating the touchscreen interface with your finger, as competitive with VoiceOver on iOS. On the other hand, the accessibility features of Apple's iOS 6, including Guided Access for users with cognitive disabilities, continues to outshine those of Android Jelly Bean. (Smith 2012).

A 2013 comparison of Android 4.2 (Jelly Bean) and Apple iOS 6.1 operating systems (Ybanez 2013) noted the following:

The Android operating system offers this array of accessibility features:

1. TalkBack—provides voice feedback and navigating by swiping gesture with Explore by Touch feature;
2. magnification gestures—magnifies the screen with swiping gestures;
3. large text—enlarges font size;
4. power button ends call—uses the Power button to end calls;
5. auto-rotate screen—auto-rotates screen orientation;
6. speak passwords—speaks out your passwords;
7. accessibility shortcut—instantly accesses accessibility features with a button and touch combo;
8. text-to-speech—sets text-to-speech output;
9. touch and hold delay—adjusts touch and hold delay;
10. enhance web accessibility—installs scripts from Google to make the Web more accessible.

Apple's iOS 6 accessibility features are grouped according to disability: Vision:

1. VoiceOver—provides voice feedback and notification through gestures;
2. zoom—increases text size;
3. large Text—increases text size for Mail, Contacts, Calendars, Messages and Notes;
4. invert colours—inverts colours for less eye strain while reading text;
5. speak selection—text-to-speech output;
6. speak auto-text—speaks out auto-corrections and auto-capitalisations while typing.

Deaf and hard of hearing: Hearing Aids connects your device to supported hearing aids:

1. LED Flash for Alerts (on iPhone 5)—flashes the LED flash when receiving new alerts;
2. mono Audio—enables mono audio and adjustment of sound balance between the left and right channels.

Learning or physical and motor disabilities:

1. guided access—keeps the device in one app and control which features are available; triple tap Home button in the app you want to use;
2. assistive touch—assists you if you have difficulty touching the screen or if you need an adaptive accessory;
3. home-click speed—adjusts the speed for tapping the Home button to enable double and triple-click Home;
4. triple-click home—triple tap the Home button to access enabled accessibility features (VoiceOver, Invert Colours, Zoom, and AssistiveTouch).

Its large, crisp display (and also its larger virtual keyboard) helped Apple's iPad create the expanding tablet segment between smartphones and ultrabook computers. In 2012, iOS controlled an estimated 53.8 % of the tablet market, Android 42.7 % and Windows 2.9 % (mobiThinking 2013). This product segment also includes dedicated e-book readers including Kindle and Nook. Text-to-Speech (TTS) apps for tablets have made these devices even more attractive for those with vision and/or language disabilities (Royal National Institute of Blind People 2013). The iPad's compatibility with communication apps, such as Proloquo2Go, has made it a popular choice for alternative and augmentative communication (AAC) devices for children with speech communication disabilities (Disability Sanctuary 2013).

3 Wireless Access and Independent Living

The digital divide can be also a social divide—without access to mainstream consumer ICT, one is literally and figuratively not part of the conversation. For people with disabilities, who already face considerable obstacles to social and economic participation, access to wireless technologies is especially critical.

People with visual or hearing limitations have traditionally relied on a variety of assistive technologies, including hearing aids, magnifiers, currency identifiers, e-book readers, text telephones (TTY's), and Braille displays. Today's customisable electronic platforms with the ability to add downloadable applications ('apps') enable users to carry some of these assistive technologies right in their smartphones. Some smartphone features, such as GPS, offer services that have not previously been available through stand-alone assistive technologies.

4 Discovering Access Issues Through In-Person Research

The Wireless RERC conducts in-person user research through focus groups and product testing. From January through May 2013, the Wireless RERC conducted one take-home usability test (followed by a focus group with the test participants) plus two additional sets of focus groups in collaboration with partners in the wireless industry.

The take-home usability test included only people with visual impairment (blind and low vision), and focused on the accessibility of two specific smartphone models running the Android 4.2 operating system. The first set of focus groups included one group with visual impairment and one group with hearing loss (deaf and hard of hearing). The second set of focus groups included one group each for visual impairment, hearing loss and dexterity impairment. These last two sets of focus groups explored the out-of-the-box experience of smartphone users, regardless of the device owned by the participants.

The 44 participants with visual impairment and hearing loss in these several in-person studies varied in age (18–70; mean age of 44.4 years), race and ethnicity (22 White/Caucasians and 22 Black/African American) and gender (22 males and 22 females).

Following are five dominant themes identified from the Wireless RERC's 2013 focus groups and mobile handset testing among deaf, hard of hearing, blind and low-vision wireless customers. Overall, it was observed that most blind participants owned iPhones and held strong preferences for these devices. Deaf participants, on the other hand, displayed a greater tendency to own other types of smartphones, including Android-based and Blackberry devices.

4.1 The Out-of-the-Box Experience

Like many customers, people with visual or hearing limitations often find themselves on their own when choosing a new device and learning to use it. Some turn to online support or friends for help, but many appreciate the satisfaction of 'figuring it out on my own'. Video tutorials hold the potential for another source of support, but captioning and descriptive audio are generally less than useful for either blind or deaf customers. The Apple ecosystem is focused on a small family of similar devices and offers considerable help from the user community through online user groups. The broad diversity of Android devices offers more choice in device design, e.g. tactile keyboards. At the same time, this can make the Android ecosystem more difficult to navigate for customers with visual or hearing limitations.

4.2 Accessibility Settings

As outlined in Sect. 2, both Android and Apple enable users to tailor their devices to their own unique abilities, limitations and preferences through a menu of accessibility choices generally located in the 'Settings' menu. Since these settings can be crucial to the usability of the device, they must be easily discoverable and operable by the first-time user.

4.3 Incoming Calls, Messages and Other Alerts

Blind users appreciate phone features such as assignable ring tones and audio caller ID. Deaf and hard of hearing customers, on the other hand, suggest a flashing alert for incoming mail or calls and the option to assign different cadences or rhythms to different types of communications, i.e. text messages, phone calls, emergency alerts. Both groups appreciate the vibration feature in their device to alert them of incoming calls, emails, text messages, etc. To be useful, however, the vibration must be noticeable even when the device is clipped to a belt or held in a purse. Availability of these features, and ease in setting them up, clearly affects satisfaction with a given device.

4.4 Screen Readers

Screen readers are applications that add spoken, tonal and tactile cues to the visual displays of touchscreen devices, making them much more usable for blind and low-vision customers. Android devices use an application called TalkBack, while

Apple's solution is called VoiceOver. Blind and low-vision testers at the Wireless RERC have noted that, to be truly useful, screen readers must be easy to activate and convenient to use. And in situations where the feature is not desired, e.g. a concert, it must be easy and quick to disable.

4.5 Voice Recognition

As the power of mobile wireless technology increases, visual or hearing limitations no longer prevent customers from becoming 'power users'. Voice recognition, or speech-to-text, facilitating hands-free and eyes-free control, contributes to these users' proficiency. Both Android and iOS devices incorporate this feature. Personal assistant apps now also provide customers with the tools to communicate, navigate, access information and conduct transactions online. At the time of this writing, Google Now and Siri have their own individual strengths, and a clear choice must be a personal one. One important consideration might be that Google Now is currently available on both iOS and Android, while Siri is an iOS-only feature. This is one of the frontiers of mobile wireless technology where Android and iOS devices will continue to compete for customers with and without disabilities.

5 Findings of the Wireless RERC's Survey of User Needs (SUN)

Wireless RERC focus group and user testing research to date suggests dominance of Apple's iOS among blind users, but not among deaf users. These results from our qualitative research can be tested quantitatively by analysing response data of these same two disability groups in the Wireless RERC's SUN. Additionally, analysis of survey responses from blind and deaf respondents can reveal how effectively various operating systems are meeting the needs of these customers with disabilities.

The SUN was originally launched in 2002, to ensure that RERC research, development and training activities are guided by users themselves. This unique, nationwide survey on wireless technology use by people with all types of disabilities has come to be an important reference for people with disabilities, disability advocates, regulators, the wireless industry and other researchers. SUN data are regularly utilised by the wireless industry and government to guide their initiatives.

We invite the public to complete the SUN and share how wireless technology affects daily life, and how it could be improved. Data presented here are based on a non-random sample. The survey is promoted as broadly as possible through

Table 1 Respondent demographics

	Blind	Deaf
Age mean	52	55
Age range	19–74	19–85
Female–male %	57–43	54–46

convenience sampling techniques, with special effort toward reaching under-represented groups. Sampling bias is partially corrected by weighting the response data by household income compiled in the 2011 American Community Survey (ACS) of the U.S. population of people with disabilities. ACS microdata are provided by the Integrated Public Use Microdata Series (IPUMS-USA) project at the University of Minnesota (Ruggles et al. 2010). Weighting the SUN response data by income helps to mitigate potential biases introduced by the convenience sampling approach. Household income was chosen for the sample weight because it is directly related to smartphone ownership and experience: as income rises smartphone ownership also rises (Morris et al. forthcoming). Household income also is strongly correlated with education level in the ACS sample.

The SUN has been updated over the years to keep up with the rapid pace of change in consumer technology. The results presented in this paper were compiled from the respondents to the Wireless RERC's fourth Survey of User Needs (SUN 4), launched in the fall of 2012. Of the 1,348 respondents, 85 are blind and 122 are deaf. One respondent who reported being both blind and deaf was excluded from this analysis in order to focus exclusively on the comparison between blind and deaf users.

Table 1 shows select demographics for blind and deaf participants in the survey. The relatively high values for mean age result to a substantial degree from the exclusion of minors under age 18 from the sampling.

5.1 Wireless Use and Operating Systems of Blind and Deaf Consumers

Table 2 illustrates the percentage of blind and deaf respondents who reported using mobile phones and tablets, and also who reported having wireline service in their homes. Notably, deaf users are more likely to use smartphones and tablets than blind users. The data in Table 2 also show that a majority of blind users own a smartphone.

Selecting just the respondents who said they had either 'no wireless device', 'basic phone' or 'smartphone' produces a gamma coefficient of 0.515 at the $p < 0.001$ significance level, indicating a very strong and significant relationship between disability type (blindness and deafness) and level of sophistication of mobile device used. Accordingly, deaf respondents are significantly more likely to

Table 2 'If you own or use a cell phone or tablet, what kind do you use?' (check all that apply)

	No wireless device %	Basic cell phone %	Smart phone %	Tablet %	Wireline %
Blind	8	30	54	17	83
Deaf	6	12	69	50	53

'Is there at least one telephone inside your home that is currently working and NOT a cellphone?'

Table 3 'If you own or use a SMARTPHONE, what kind do you have?' (check all that apply)

	Android %	Apple iOS %	Blackberry %	Windows %	WebOS %
Blind	18	86	6	8	4
Deaf	34	53	15	2	0

own more sophisticated wireless devices than blind respondents. Deaf respondents are also far less likely than blind respondents to have a functioning wireline phone in their homes.

These results likely reflect the need of deaf users for access to efficient text messaging. Most wireline phones do not provide captioning/text writing capabilities (although TTY is still available in the United States, and telephone service providers like Sprint offer caption-enabled wireline devices and service). Most simple (non-smart) mobile wireless phones have text messaging capabilities that are supported by wireless service providers, but they are more cumbersome to use for composing and reading text messages. Deaf consumers embraced the original T-Mobile Sidekick and its successors, which offered a slide-out QWERTY keyboard, after it was introduced in the United States in October 2002, and anecdotal evidence (and survey data presented in Table 3) suggests they also embraced the classic Blackberry phone with the physical QWERTY keyboard.

Greater smartphone ownership rates by deaf respondents compared to blind respondents might also result from greater ease of use of the numerous vision-based features on smartphones as experienced by deaf users relative to blind users. Recent accessibility innovations for blind users such as Siri and VoiceOver on iOS, and Google Now and Explore by Touch on Android do not fully overcome the visual access challenges that blind users experience, which non-blind deaf users do not experience. Simple mobile phones with numeric keypads and raised physical keys and a nub on the number '5' key for orientation, on the other hand, can be accessed effectively by blind users.

Table 3 shows the use of Android, Apple iOS, Blackberry, Windows and WebOS operating systems among blind and deaf smartphone users. Together, Android and iOS serve the majority of these customers, while 17–18 % of each group uses Blackberry, Windows or WebOS. Notable in these results is the overwhelming use of iPhones by blind respondents, and the much higher rate of use of Android and Blackberry by deaf respondents.

Comparing just the use of iPhones and Android smartphones among blind and deaf respondents produces a gamma coefficient of 0.589 at the $p < 0.01$

Table 4 How satisfied are you with your primary wireless device?

	Blind		Deaf	
	Android ($n = 5$)[a] %	iOS ($n = 29$) %	Android ($n = 22$) %	iOS ($n = 40$) %
Very satisfied	42	77	35	62
Somewhat satisfied	0	23	48	38
Neither satisfied or dissatisfied	39	0	9	0
Somewhat dissatisfied	0	0	7	0
Very dissatisfied	19	0	0	0

Primary device

[a] Percentages reflect impact of weighting the sample by income, and therefore vary somewhat from expected values calculated by dividing the number of cases fitting selected criteria by the total number of cases

significance level, indicating that blind respondents are significantly more likely to own iPhones than Android smartphones.

Table 4 demonstrates differences in satisfaction between blind and deaf users of Android smartphones and iPhones. All blind and deaf iPhone users reported being either 'Somewhat satisfied' or 'Very satisfied' with their wireless devices. Among Android customers, 83 % of deaf users, but only 42 % of blind users were 'Somewhat satisfied' or 'Very satisfied' with their devices. It should be noted that there were very few blind users of Android smartphones, making this analysis less reliable.

Table 5 shows similar differences between Android smartphone and iPhone users: 96 % of deaf users and 85 % of blind iPhone users described their devices as 'Easy' or 'Very easy' to use. Among Android smartphone owners, 80 % of deaf users and 42 % of blind users described their primary devices as 'Easy' or 'Very easy' to use. Again, the number of blind android smartphone users is low, making analysis less reliable.

6 Discussion

Data presented from the Wireless RERC's SUN suggest that Apple's iPhone is currently better than Android-based smartphones at meeting the needs of blind consumers. Differences in adoption rates, ease of use and satisfaction between the two operating systems are less pronounced among deaf users.

These results likely reflect in part the experiences of customers with devices that have been on the market for more than the past year, during which time the accessibility features and capabilities of the Android operating system have expanded considerably.

The survey results also reflect in part how people with disabilities (and perhaps those without disabilities) choose their mobile phones. Socially reinforced patterns of preferences and economic choices can develop among close-knit communities

Table 5 How easy or hard is your wireless device to use?

	Blind		Deaf	
	Android ($n = 5$)[a] %	iOS ($n = 29$) %	Android ($n = 22$) %	iOS ($n = 40$) %
Very easy	42	56	22	68
Easy	0	29	58	28
Somewhat hard	39	13	20	4
Hard	19	2	0	0
Cannot use it without help	0	0	0	0

Primary device

[a] Percentages reflect impact of weighting the sample by income, and therefore vary somewhat from expected values calculated by dividing the number of cases fitting selected criteria by the total number of cases

bound together by shared experiences and challenges that are distinct from those of the general population. Such patterns seem to have developed among blind and deaf consumers, and others with disabilities. The Wireless RERC's survey research shows that when making their mobile technology purchase decisions, people with disabilities rely most commonly on recommendations from friends, family and others in their personal network (Wireless RERC 2013). Blind and deaf consumers are among the most likely to seek out recommendations from their personal networks. Other sources of product information such as online consumer information sources, websites of service providers and device manufacturers, and sales personnel are all much less frequently consulted when making a purchase decision.

These patterns have been highlighted by participants in the Wireless RERC's focus group and user testing research. Disappointed by limited understanding of disability by customer service personnel working for handset manufacturers and wireless carriers, blind and deaf consumers have reported that they rely primarily on peers for help in choosing and using their new device.

The Wireless RERC's focus group and user testing research also revealed the substantial challenges that blind and deaf consumers experience when switching between Android, iOS or other platforms. A successful out-of-the-box experience requires personal commitment and access to assistance. Particularly for blind consumers, switching to a new device and operating system represents a considerable learning curve affecting satisfaction and ease of use, at least in the short term.

For these customers, Apple's comparatively well-defined ecosystem makes locating peer support (and 'figuring out' a new device) an easier task. In contrast, the rich landscape of device choices available to Android customers is a mixed blessing for those with disabilities. Hardware and software variations across platforms and carriers result in unique accessibility characteristics for each device. Usefulness and usability of accessibility features and assistive applications also vary across devices and carriers. Discovering and understanding all the available choices can be challenging. Nevertheless, for both Android- and iOS-driven

devices, effective technical assistance informed by genuine disability awareness is an emerging priority for the wireless industry.

The accelerating pace of wireless technology development, and the importance of the large and growing market of customers with disabilities, guarantees that healthy competition in this arena will continue. This is a promising sign for those with disabilities, as well as the rest of the population, who are likely to live long enough to experience age-related loss of function.

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