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ShakePal: Developing and Testing a Communications App for People with Learning Disabilities

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Abstract— Nowadays, smartphones are increasingly used by the general population in their everyday lives. However, this upward trend is not the same for people with disabilities due to a variety of factors including usage difficulty. Unfortunately, there is a lack of research evidence regarding the design and use of technology for and by people with disabilities and that is mainly due to a variety of differences individuals' disabilities and the concept of smartphone devices. Building on previous work by one of the authors (Williams, 2019), we developed 'Shakepal', a simplified mobile application to overcome both elicited and potential difficulties faced by the cohort. The development of 'Shakepal' aims to allow users to easily communicate with their contacts through messaging and calling. The research was carried out at a centre for people with learning disabilities in Belo Horizonte in Brazil and the sample consisted of functionally literate individuals aged between 17-40 years old. The study provided insights regarding the aesthetics, the text and icon size of the smartphone application, and showed the value of adopting both User-Centered and Participatory Design approaches. Recommendations, based on our findings, are made regarding future application development.

Keywords— learning disabilities, mobile app, usability, User-Centred Design

I. INTRODUCTION AND CONTEXT

Smartphone usage is so universal in the developed world that it could be described as having reached saturation point. For example, in Brazil (where the fieldwork for the study reported in this paper was carried out) in 2018 144.33 million people aged 10 or older owned a mobile phone, and the devices were present in over 93 percent of Brazilian homes [1]. However, people with learning disabilities are considerably behind this trend. Figures from the UK suggest that only 62% of people with disabilities in the UK (as opposed to 95% in the general population) use smartphones for any reason, and 10% of the cohort may be limited or prevented from doing so due to their disability [2]. Work by one of the present writers has highlighted barriers both involving the usability of devices [3] and also contextual barriers imposed by carers, support workers, and others, generally over concerns around vulnerability [4]. Regarding the former, many problems may be identified, that make usage difficult for anyone. These may include small screen size, poor display resolutions, display

orientation changes, and various touchscreen input gestures (tap, swipe and pinch) and 'unlock' mechanisms - the latter including fingerprint recognition and shape forming [5].

There is certainly a lack of research evidence examining smartphone usability. An earlier paper in this journal [6] offered tentative reasons why there was no recognised body of evidence in the field. These included differences in participant cohort and definition; device type under scrutiny (e.g. iPads, Smartphones etc.); area of research focus (app evaluation, activities, global use) and methodology (usability tests, ethnographic approaches etc.) as mentioned in that paper, 'adding more complication is the fact that mobile … technology advances so rapidly that studies undertaken more than a few years ago no longer apply'. A 2007 study of 'mobile phones' [7] was given as an example, which discussed only calling and texting. Tentative findings from the limited amount of existing research reviewed suggest that touch screens present problems of size and sensitivity [8] as do remembering passwords and finding search boxes [9]. Almost no work has been undertaken on touch-screen interaction, but the latter work [9] discusses problems in dragging a virtual object round a screen, and the pressure needed in tapping, and work undertaken by one of the present authors and another colleague [3], adds that a 'pinch' movement is particularly difficult (as it may be for any user, in fact). In work examining more contextual elements to phone use, problems were elicited around camera functionality, charging devices and typing or spelling [4].

This paper reports on a study building on Williams' prior work ([3]as cited above) and motivated by the disparity in use and ownership between people with learning disabilities and the general population, the potential difficulties faced and the lack of research literature on the issue. The authors developed and tested an app, 'ShakePal', for use with smartphone devices, designed with a simplified interface to provide easier access to call and message functions for the learning-disabled cohort. In addition to describing the app itself, and a user evaluation of it, the paper begins with a detailed account of the app's development and the thought processes and rationale that went into it.

II. DEVELOPING THE APP

ShakePal is a mobile app that allows users to communicate with contacts by calling or messaging assisted by different technologies (text to speech, speech to text and magnifier), that usually take more than two steps to be activated in mobile operative systems. Besides accessing the app by pressing the icon on the screen, ShakePal could also be opened by shaking devices equipped by motion detection sensors.

A. App rationale and design

Our design process was theoretically framed by the Social Model of Disability, which considers human impairments a product of the different barriers that are present in the environment (e.g. communicational, social, physical), instead of in the individual themselves. Thus, in contrast to the medical vision of disabilities, the Social Model seeks to change the environment instead of rehabilitating an individual [10].

We followed a combination of Design Thinking and User-Centred Design (UCD) approaches for the ideation of a technological solution to support people with intellectual disabilities in their communication. Design Thinking encourages designers to first empathise with users and stakeholders in order to explore, understand and define a problem, to then ideate different potential solutions [11]). These steps of generating empathy, discovering the problem, to then test a design idea in different fidelity levels are the essence of Design Thinking [12]. Thus, innovation comes from addressing the users' needs in the context of a problem through research, instead of starting the design process from a defined solution [13]. This allows researchers to have a better understanding of the context and users' perspectives and insights throughout the design process [14].

At the same time, following UCD principles, we focused on the usability and usefulness of our design idea, through the incorporation of the users' views on key stages of the processes [15], particularly on the problem understanding and testing stages.

For the Empathise and Definition stages of the Design Thinking process, we based our research on data elicited from ongoing research by one of the authors (Williams) on a project examining the role and impact of mobile devices on the lives of people with learning disabilities (see, e.g. [3], [4], [6] and[16]) Data examined included that from one-to-one and group interviews with the cohort, and the results from a usability study.

By conducting thematic analysis on the interview transcripts, we were able to elicit the main issues the target users faced when using technologies to communicate were difficulties in sending text messages, requiring help to use their mobile devices and to enable the accessibility options (such as text magnifier or voice-over), and difficulties when typing on keyboard.

In the next stage of Design Thinking, Ideation, researchers attempt to generate diverse solutions through different techniques, without judging or evaluating them [14] (Henriksen et al., 2017). Here we used two main methods: Brainstorming and Inspiration Cards. In the brainstorming session, the team diverged regarding the technological options to be used as a solution. Many devices were considered, such as micro:bits

microcomputers and laptops, together with combining existing technologies to make a new device for our target users, such as a bracelet with the ability to send text messages.

The Inspiration Card is a method in which designers and experts in the context being studied collaborate generating novel ideas by combining concepts from both the domain knowledge pool and available technologies [17] (Halskov & Dalsgård, 2006). For the Inspiration Card session, the team met two experts: a drama teacher and a special education teacher, both experienced in communicating with people with intellectual disabilities. One of the authors (Williams) had also undertaken a considerable body of work with the cohort. Based on the information we had about our users and the descriptions of the method by Mose Biskjaer et al. [18] we subdivided our technology cards in type of device (i.e. mobile, laptop or microcomputers), and the potential application of the technologies (i.e website, app). The Domain cards were categorised as who is involved in the context of use (i.e. friends, support staff, family, users and network of strangers) and the aspect of meaningful use to be taken into consideration (memory, keyboards use, awareness, skills/learning, independence and interface accessibility).

Following this method, the team narrowed down the ideas elicited to ten and then to three, based on all the information available (research data from interviews and prior usability work, and observations by the experts consulted), resulting in what we considered to be the most useful and creative in accordance with the Social Model of Disability. For example, we rejected the idea for an application that would help our users communicate with strangers by explaining to them their disability. This idea was found problematic as it would place our users in a minority position that could potentially reduce their self-worth in terms of how they see themselves in relation to other people. There might also be issues around security and vulnerability by adopting this practice.

The most reoccurring issue from the data appeared to be difficulties in texting. This was combined with features from the other solutions ideated, such as the feature to open the app by shaking the mobile device and the creation of a contact facility.

Thus, by converging through a logical process of combining solutions and based on the ideas elicited, we decided that the final design idea was an ultra-simplified communication app, to give users access to their contacts and enable them to communicate through different options. Considering the Social Disability Model, we also wanted to tackle usability issues that traditional phones had, by adding access to our app by enabling its activation by shaking (thus the name ShakePal) and having some accessibility options always available.

The next stage, prototyping, began with the creation of a potential feature list offering an overview of all the sections and pages that the app would have.

At this point, the team discussed the organisation and hierarchies of the app. Traditionally, mobile phones have a contact-based flow, that is, in order to call or message someone, the user has to first find the contact they want to communicate with in a list and then select the action to perform (calling or messaging). Thus, ShakePal has an action-based flow, in which users first select what they want to do and then they select the contact. This would allow a particular range of actions to be offered, most of which would be accessible in a maximum of two steps. For example, instead of grouping in one menu option all the actions related to contacts (such as adding a new contact or editing their information details), these were disaggregated in the main menu for an easier and more direct access. In terms of interaction, this meant that instead of needing to tap that first a menu and then the sub-option, the user would just tap once for each action.

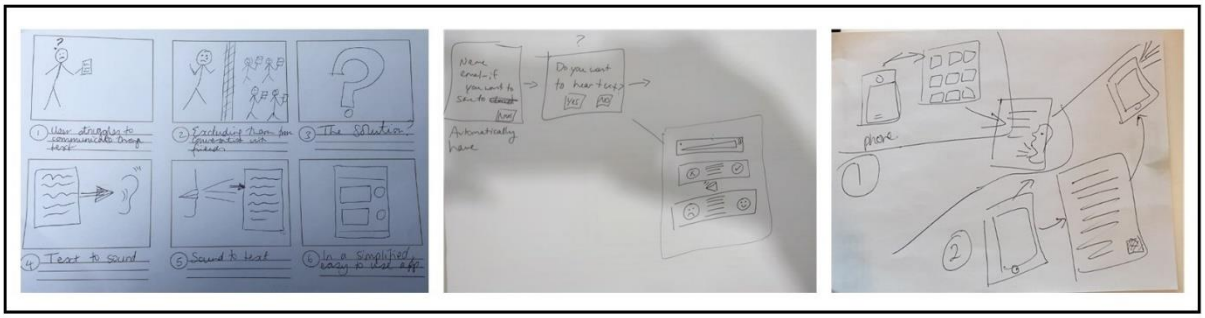

Figure 1: Pencil sketch examples

The next step was to create a set of low-fidelity digital wireframes based on design ideas sketched out on paper. A wireframe ‘is a static, low-fidelity … visual representation of an interface using only simple shapes’ [19]. The specific tool chosen by the team was the online version of Balsamiq software. This app has a drag and drop interface and made it easy to reproduce the initial drawings, which contained mobile app elements such as buttons and text.

While creating the wireframes the team made many decisions. For example, one of our group members suggested to base the app on icons without text labels. In this case, the literature recommended that one of the most common practices for accessibility for people with cognitive disabilities was using icons and symbols along with text [20]. Furthermore, the disability theory as explained by Sitbon et al. [21] required the team to focus on our users' capabilities and we knew that they had trouble using interfaces with many icons.

Additionally, we had to decide if the app should include a keyboard or not. Apps traditionally use keyboards to input text, but our data showed that using a keyboard represented a barrier for some members of the cohort. Thus, it was decided to complement the app to include a dictation option.

Another topic discussed in this stage was whether to include voice-over. This feature reads aloud the text and information contained on a screen. This was important as we considered our goal was to design a technology that would enable our users to easily access the assistive functionalities that were difficult to activate in other apps or operative systems.

The low-fidelity wireframe prototypes depicted the main features and navigation of our app: users would select the type of communication on the main page and if they wanted to send a message they would have the option to dictate it instead of only being able to use the keyboard.

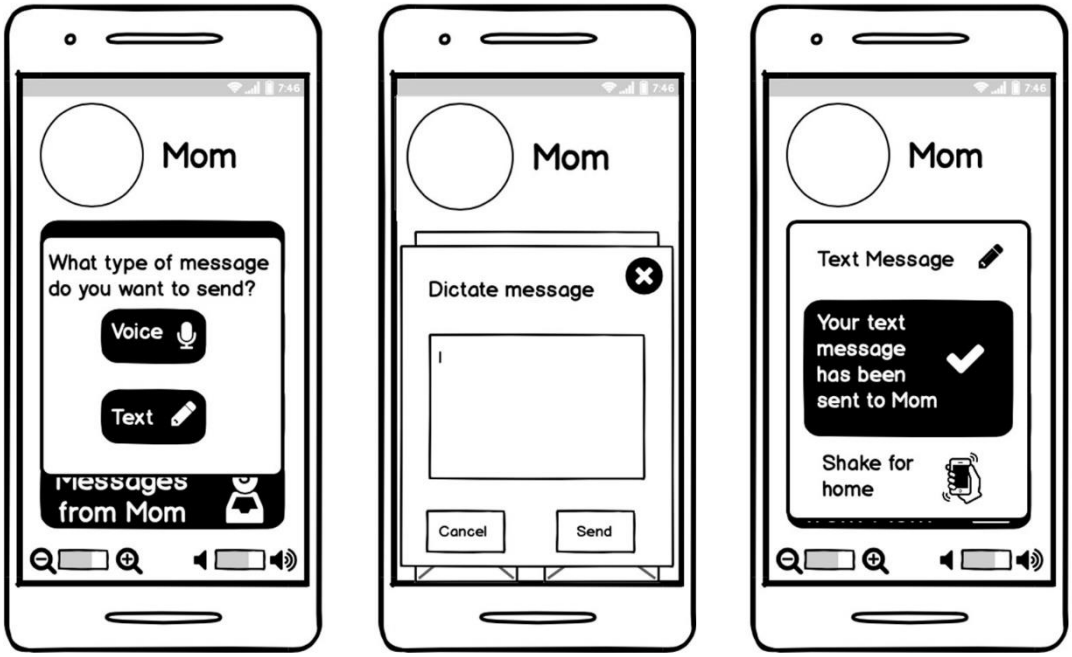

Figure 2:Wireframe examples showing early prototypes of sending of text

We next created high-fidelity prototypes of ShakePal, since they are seen as better for using testing because they look the same as the final product, allowing a more realistic experience [22]. The prototypes were designed with Adobe Illustrator and made interactive with Marvel App. The graphic design was based on different accessibility guidelines and recommendations for design for people with intellectual disabilities, such as contrasting colors (the tool 'Colour Contrast Analyser' or CCA was used to verify adequate contrast), sans-serif fonts (in this case, 'Tiresias' font), avoiding text decoration, and the use of icons along with text for a better understanding [21]. In this stage, the final version of labels, instructions and other texts were edited aiming for clarity and unambiguity. For example, there are headers that group elements under a question (e.g. 'What would you like to do?', 'Who would you like to call?') and buttons include the actions they involve (e.g. 'Go to my messages', 'Take a new picture').

Finally, all the texts in the app were translated to Portuguese by a native speaker from Brazil.

B. Description and functionality

Simplicity was of paramount importance when designing the app. The iteration reported here enabled a particular range of actions to be offered, nearly all of which could be undertaken within a maximum of two steps, and also facilitated message recording and text to speech within a basic interface. There are two sections of the app that are always visible across the navigation of the app. The top bar includes the name of the app and a

'Home' button for direct access to the main section. At the bottom of the app there are two assistive technologies options: 'Zoom', which focuses and magnifies the app view, and 'Voice-over' that reads aloud the contents of the app. Most buttons include both text labels and icons. The input fields all have the name of the field on top of the editable area and not inside of it, so users don't have to memorise the function of the field. Whenever a field requires the user to insert information, there is a dictation icon (represented by a microphone), which would convert the user's speech to text. Once the app is opened, users are presented with a 'Home' screen (see Figure 3).

Figure 3: ShakePal home screen

This presents a series of communication and contact options, all action-oriented: 'Call someone', 'Send a message', 'Go to my messages', 'Add a contact' or 'Change contact'.

When accessing the option 'Call someone' on the main menu, cards with the photos and names of the contacts available are displayed, sorted in order of frequency of contact (' (Figure).

Figure).

Once a contact is chosen, a 'Calling…' screen is presented with the photo and name of the contact, and a button to 'Make the call' (Figure).

Figure 4: 'Call someone' screen

Figure 5: 'Calling' screen

When accessing the option 'Send a message' on the main menu shown above (Figure), users are presented with the same cards showing photos and names of the contacts available (' (Figure).

Figure). After choosing one person, a screen appears (Figure) giving several options regarding the format of a message to compose.

Figure 6: 'Message composing' screen

First, there is an editable field, which prompts a keyboard. Alternatively, users can press the dictation icon which converts speech to text and presents the rendered content in real time in the editable field. Users can either read or edit the dictated text, or, 'Pause', 'Stop', 'Play' or 'Delete' the audio message. There are choices to 'Send as audio' or 'Send as text'. Once sent, a confirmatory text comes back: 'Message was sent successfully'.

In order to see previously received or sent messages, a 'Go to my messages' menu item is located in the main menu (home screen, Figure). This button is updated in real time to show the number of unread messages as a digit in parenthesis. After this button is activated, a list of 'My messages' appears, with the photos and names of the contacts that are in the contact list which also shows if there are unread messages available (again, as in ' (Figure).

Figure). By tapping one of the cards, the users can see a history of the messages sent and received from that specific contact. Messages received are presented with the picture of the contact, if available. The messages can

be text only, or text and audio. Those containing audio have a 'Play' icon. A 'Send a new message' button is at the bottom of the screen for further communication with the specific contact.

The next entry on the main menu is an 'Add a contact' button. Activating this leads to the screen shown in Figure :

The information that can be added is: 'Name', 'Photo' (either by taking a new picture or by choosing from the device's gallery) and the phone number. In order to edit the information of a saved contact, a 'Change contact' button can be activated, from the main menu, which accesses a screen similar to the 'Add a Contact' one shown in Figure .

Figure 7: Add a contact screen

III. SHAKEPAL EVALUATION

A. Methodology

The evaluation of the app was undertaken as part of wider research examining the impact of mobile devices on the lives of adults with learning disabilities. The study reported here was carried out at the Association of Parents and Friends of Exceptional People of Belo Horizonte (APAE-BH), in the capital of the state of Minas Gerais, Brazil. This is a non-profit social organization which promotes overall development and improvement of the quality of life of people with intellectual and multiple disabilities among other goals.

1) Population and sample

Participants were sought who had 'mild' intellectual disabilities and who, as such, were 'functionally literate'. That is, they were able to read street signs and simple sentences, follow simple instructions, and use a simple list. They also had to have used and be familiar with mobile phones. They were recruited by staff at APAE and had been shown an accessible information sheet and had signed a short consent form prior to the research session. Twenty-three people met the criteria and elected to participate, with ages ranging from 17 to 40, as follows:

Age range	Number
17-19	5
20-29	12
30-39	5
40-49	1
Total	23

Table 1: Age ranges of participants - Brazil

2) Method

Before examining the app, participants were briefed in simple language about the project. They were asked about their own use of mobiles, what the benefits of mobile technology were for them, and the barriers they faced. These answers provided research data for the full project, and has been reported elsewhere [3], [4]. They were then introduced to the app (on the researcher's mobile phone) and its functionality and told that they would be asked to carry out some simple tasks on it such as to find a contact. The fact that it was the app, and not their ability or skill, that was being evaluated was strongly emphasised, both by the researcher (Williams) and the participating member of staff.

Having thus concluded the briefing, the usability sessions were undertaken in groups of three. The app was again demonstrated, and any questions answered. The set tasks were then carried out individually. At the end, general opinions and observations were sought. The tasks were:

- Home screen: Participants were asked what each of the menu entries signified. Questions were asked randomly, so for example, the first question to one participant might be 'Where would you tap to add a contact'? Another might be asked first what entry to tap to see how to send a message, etc. Following this, participants tapped a link of their choice.
- Contacts screen: A list of contacts appeared when the user chooses to make a call or send a text, where the participants had to choose a person they wished to telephone or text (according to their prior selection) by tapping on the appropriate photo.
- Voice call screen: Having chosen the contact, if the choice was to call, it only remains to 'finalise the call' by pressing the labelled button.
- Compose/send message screen: As the app did not include any links beyond this point, participants were only required to understand the various elements of the screen, individually (to understand that, for instance, that the text next to the photo of 'mum' was what she had written, and that the arrow was the participant's reply).
- Add contact screen: Again, as the app did not include any links beyond this point, the task was to understand the screen. Questions asked included how a name, number and a profile photo could be added (this would include by voice, as signalled by the microphone symbol next to the text input boxes.)

B. Findings

1) Home page

In the group sessions, a general consensus amongst all of the groups was that that there was too much writing on this 'Home' screen. The layout came about through trying to avoid having content only visible by the swipe action.

The icons were very small. The supporter pointed out the tiny '+' sign next to the smiley face on the 'Add a contact' ['Adicionar contato' on the screenshot] was hard to see. It may have been better to have used two circles of approximately the same size, one with the 'smiley face' emoji and the other with a large plus sign in it.

The 'Zoom' and 'Voice Control' ['Controle de voz'] were partially hidden by the phone's horizontal navigation bar (Figure), showing back, home and all apps:

Figure 8: Device's own (horizontal) menu bar

It might be for this reason that nobody noticed the 'Zoom' or 'Voice control' until prompted.

2) Contacts screen

There were no problems here in terms of usability, although it is worth noting that the contacts were all identified as names except for one: 'Mãe' (Mum). This may have been a mistake, as two participants pointed out that the photo did not show their mothers (although they seemed to accept that the other contacts were simply people they did not know)

3) Voice call screen

There were no problems with this screen except for a minority of participants who complained (as with the 'Contacts' screen) that the photo did not depict their own mother.

4) Compose/send message screen

There was some confusion about this screen, especially around the creation of voice messages. This might be because the 'Send as an audio' ('Enviar como audio') button is below another set of buttons related to the recording, and below that there is the option to send as text. The fully developed app will allow the message to be narrated as audio, but sent as text, as there will be a speech to text facility.

The record icon was not recognised by 3 (of 10) participants. However, it is a universal symbol and therefore difficult to make any recommendations beyond that of educating the users, and possibly adding the word 'mic' or 'record' under the icon.

Most people tapped the text box to enter a message, but the existing message (posted to show what a text entry would look like) appeared to confuse some people. In the fully functional app, of course, the box will be blank, ready to be filled by text or audio (speech to text).

5) The 'Add contact' screen.

Two problems manifested themselves. A minority of the participants did not realise that 'Take a photo' was specifically for the new contact's profile. The option to 'Choose from the gallery' ('Escolher na galleria' on the screenshot) was similarly ambiguous for these participants

6) General comments

In a post-testing feedback session, participants were asked to make general comments about their experiences in using the app and if they felt it could be improved in any way. It is difficult, of course, for people with learning disabilities to articulate their thoughts (and indeed, some may be unused to actually expressing a view and making choices - although the ethos at APAE was clearly to encourage and facilitate this). However, with coaxing and gentle probing, a number of comments were forthcoming. Overall, there was agreement that the colour scheme was very good. However, although the interface was not criticised in aesthetic or navigational terms, there were two areas in which it was felt that the app could be improved. These related to text and icon size - both of which were considered too small.

IV. RECOMMENDATIONS

Results from the home screen suggested that there was too much text. Similarly, one result of the general feedback was that participants felt the text size (Tiresias font, 12 points, but rendered differently depending on the device) was too small. Work by one of the writers [23], [24] on larger, static screens found that even on the larger screen there were the same problems. A possible solution to both would be to reduce the content, in order to create the space necessary to enlarge the remaining text - but without the label or instruction losing its meaning or creating ambiguity.

The following suggestions, of course, would require testing for this (and for ease of reading only the translation of each label is included, although the word reduction is not necessarily the same in the Portuguese version:

- 'Ring someone' to 'Ring'
- 'Send message' to 'message' (although this would only be possible in English)
- 'Go to my messages' to 'My messages'

Add contact' and 'Change contact's details' could be amalgamated into a main 'Contacts' link, with the two options on other pages as described below

Also, with regard to text reduction, there is no real need for the question at the top of the page. Either it could be eliminated, or simply 'I want …' ['Quero …']. Eliminating it would create more screen space of course. This, in turn, would create room at the bottom of the page to prevent the phone's own navigation bar obscuring the app's content. The fully developed app will adapt to the Operating System, avoiding superimposed external menus.

The issue of icon size (and representation) is more difficult. The solution may lie in education and familiarity with iconography, in addition to attempting to increase the size, if at all possible.

V. CONCLUSION

This paper has described the conceptualising, development and testing of a simple app to enable independent texting and phoning from a mobile device by people with learning disabilities. It discusses how the process was informed by the Social Model of Disability and followed Design Thinking and User-Centred Design (UCD) approaches. Results suggested that, although there was general satisfaction with the app, certain misconceptions were evident, and many modifications could be made to improve it in future iterations. The exercise clearly showed that User-Centred Design, whilst laudable and effective to a certain degree, needs to be undertaken in tandem with an element of Participatory Design (and evaluation). Changes in the interface and functionality planned for the next phase of the process will all be made based on the experience and recommendations of the people with learning disabilities themselves. Hopefully, in the longer term, more research such as this will provoke greatly needed design changes to make the technology easier to use - for everyone.

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