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LONG PAPER

Augmentative and alternative communication devices for aphasia: the emerging role of "smart" mobile devices

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Abstract Recent advances in mobile technology offer new directions for augmentative and alternative communication (AAC); however, it remains unclear whether they meet the needs of individuals with aphasia. This paper reports on research seeking to understand this changing landscape. A Web-based survey of aphasia-oriented clinicians helped illuminate device adoption trends. Observations of group therapy sessions featuring high-tech AAC use and focus groups with the clinicians from those sessions provided further nuance and insight into usage and adoption. It was shown that "smart" mobile devices are garnering acceptance as a promising platform for high-tech AAC; however, contrary to the authors' expectations, these devices are not being paired with mobile versions of traditional picture dictionaries. Rather, clinicians reported appropriating generic applications to complement other (non-high-tech) communication strategies, suggesting new opportunities for design.

Keywords Augmentative and alternative communication (AAC) · Aphasia · Mobile technology · Communication support

1 Introduction

Language plays an important role in our lives, helping us express feelings, communicate ideas, and build relationships. Those with communication impairments such as aphasia, however, have trouble making their thoughts known. Though a wide range of computerized augmentative and alternative communication (AAC) devices, including the one shown in the centre of Fig. 1, is available to help individuals communicate more effectively, adoption to date has been limited [20]. For example, industry leader, Dynavox, is estimated to reach less than five per cent of individuals who could benefit from an AAC device [29]. While this gap is relatively well known, its causes are less well understood, challenging us to consider why, despite decades of development, these highly specialized devices are not meeting the needs of their intended audience.

Though traditional, custom-purpose AAC devices such as Dynavox remain the de facto standard for high-tech AAC, there has been a recent surge in the development of AAC-oriented mobile applications for consumer platforms such as iOS and Android. These applications typically provide picture-dictionary style functionality similar to that of traditional devices, but aim to capitalize on the familiarity and relative affordability of consumer devices. Though high-end smartphones and tablets are not cheap, they are relative to traditional devices which can run upwards of US$8000.

Despite this wide proliferation of mobile applications, little research has investigated their use by individuals with

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Fig. 1 One man's set of communication aids. In the centre, is an example of a traditional custom-purpose AAC device. This individual combines multiple AAC strategies, from low- to high-tech, in his daily communication

aphasia, emphasizing instead other target user groups, such as children on the autism spectrum [10, 14, 22]. Though there are some similarities between these groups in terms of language deficits, it seems clear that the overall needs and preferences of a teenager with a developmental condition could be quite different from an older adult with an acquired language impairment. This diversity in users can make it difficult to assess uptake through download statistics and other marketplace trends.

The goal of this work was, thus, to provide a snap shot of how high-tech AAC devices are currently being used by individuals with aphasia and to gain an early view of how this landscape might be shifting in response to the recent influx of new technologies. Through this lens, the goal was to identify opportunities for leveraging smart mobile devices to improve AAC device design for individuals with aphasia.

To achieve these goals, a Web-based survey was combined with observation sessions and focus groups. The survey was completed by aphasia-oriented clinicians in North America and helps shed light on which devices are being used, how they are being used, and by whom. To complement this broad view, local group therapy sessions featuring AAC use were observed and focus groups with clinicians from these groups were conducted.

The findings confirm a shift away from traditional AAC and towards smart devices. Interestingly, however, this shift was not focused on recreating traditional AAC functionality on modern technology. Though some use of AAC-oriented mobile applications such as Proloquo2Go[1] was observed, the more dominant—and interesting—trend was the appropriation of generic applications, including calendaring, drawing, recording, and reading applications. These generic tools were being used as a complement to other AAC strategies, such as gesturing and drawing, an approach markedly in contrast to typical high-tech AAC designs. From these findings, a number of opportunities for improving the design of high-tech AAC for individuals with aphasia were identified.

2 Background and related work

Aphasia is a communication disorder affecting roughly one million people in the USA [21]. It occurs as a result of damage to the language areas of the brain, most often resulting from a stroke, and is estimated to affect one-quarter to one-third of stroke survivors [18]. Aphasia affects people of all ages; however, the majority of individuals with aphasia are older due to the increased risk of stroke with age. Aphasia ranges widely in severity from mild complications in speech production to complete loss of language production and comprehension. Depending on the location and extent of brain damage, individuals can experience different combinations of deficits in naming, fluency, repetition, auditory comprehension, grammatical processing, reading, and writing [20].

Aphasia is an acquired condition: those affected experience a sudden loss of a lifelong skill [21]. As such, individuals with aphasia have high expectations for communicative rehabilitation. Having communicated with friends, family, and colleagues throughout their lives, they are well aware of the usefulness and richness of communication. In this sense, their expectations are different from those with congenital communication disorders who have never been able to speak. Though rehabilitation may reduce the severity of impairment, complete remission is not guaranteed.

2.1 Classifications of aphasia

Numerous attempts have tried to classify aphasia and its various patterns of impairment; however, the wide variability in aphasia means that few individuals fit neatly into a single deficit-based category [5]. Although attempts at fine-grained classifications of aphasia have led to disagreement among researchers and clinicians, two broad categories—Wernicke's and Broca's—are well established.

Individuals with Wernicke's (or receptive) aphasia have fluent speech, formed of extended sentences with correct articulation and complex syntactical forms. However, these sentences are often meaningless due to the omission of important words, the addition of unrelated words, and the

[1] http://www.assistiveware.com/product/proloquo2go.

presence of neologisms (i.e. made-up words) and paraphasias (i.e. substitutions with semantically or phonologically similar words), and excessive circumlocutions [5, 35]. Importantly, people with Wernicke's aphasia generally have poor comprehension and are often unaware that their speech is meaningless, which can hinder successful adoption of compensation strategies.

In contrast, individuals with Broca's aphasia experience difficulties combining linguistic elements. They tend to communicate with short phrases in which function words such as conjugations, propositions, pronouns, and auxiliary verbs are omitted [5, 45]. Sentences are usually produced very slowly and with great effort [35], though auditory comprehension tends to remain relatively intact. In addition to language deficits, Broca's aphasia often presents with right-sided motor defect (hemiparesis) [35], which can make it difficult to adopt comprehension strategies that require manipulation of an external device.

Though most classifications attempt to categorize individuals based on their language deficits, Garrett and Lasker [19] classified people with aphasia based on their ability to use different AAC strategies for communication. In this classification, partner-dependent communicators rely on their conversational partners to structure and guide communication exchanges, often relying on the provision of fixed choices within highly familiar contexts, while those who can initiate communication and express ideas using different self-selected strategies are referred to as independent communicators. As will be shown in next sections, the vast majority of high-tech AAC devices for aphasia have been designed as personal devices, and thus predominately target independent communicators.

2.2 Augmentative and alternative communication

Most individuals with aphasia experience a lifelong disability, and as such, a substantial aim of treatment is to improve functional communication, often via the use of augmentative and alternative communication, or AAC, strategies. Broadly defined, AAC refers to any technique or device that supplements or replaces oral speech, either temporarily or permanently. The emphasis of AAC in aphasia rehabilitation is thus to increase functional communication as a compensatory, rather than restorative, approach [7]. AAC strategies are generally categorized as aided or unaided, with aided further divided into high- and low-tech. Though the focus of this research is mainly on high-tech aided strategies, each AAC user is likely to combine a variety of aided and unaided strategies; thus, to fully understand adoption, it is important to consider the broad complement of options available and the ways in which they are integrated in use.

Unaided, or no-tech, AAC techniques do not need any external equipment and involve different kinds of gesture, gaze, facial expression, body postures, and sign language [36]. These strategies can be used anywhere, are never forgotten at home, do not break, and are free. However, their use is limited as exemplified by the following quote by Michael Williams, an AAC user:

> "Gestures can get you a cup of coffee in the morning, but they do a poor job of telling your friend about that delicious piece of cake you had the other night. Gestures can only express things in the here and now. [They] are poor candidates for expressing things like truth and beauty" [46].

Aided AAC, on the other hand, involves equipment external to the user. *Low-tech AAC* supports are simple aided techniques that do not need any electronics or electricity and include writing, drawing, and communication books, boards, and cards [36]. *High-tech AAC* devices involve computers or electronics. Most high-tech AAC devices take the form of an electronic symbol-based dictionary, leveraging the retained ability of individuals to recognize image-based representations of objects. Some further offer the ability to construct iconic sentences (e.g. [40]).

Traditional commercial offerings include Dynavox (shown in Fig. 1), Tellus Smart, Vantage, Gus Communicator, and Lingraphica[2]. More recently, mobile applications have been introduced, such as TalkRocketGo (as shown in Fig. 2), Proloquo2Go, VocaBeans, and SmallTalk[3].

Modern mobile devices offer a number of benefits. Improved display technology has made it possible to have highly portable lightweight tablets with relatively large displays, facilitating interaction for those with reduced motor-control. Moreover, current devices are generally equipped with location-sensing capabilities, enabling the design of AAC devices that organize vocabulary based on the user's locational context [15, 16]. Although high-end phones and tablets are not cheap, relative to the cost of a traditional custom-purpose device, they can be an affordable—and flexible—alternative. Nonetheless, drawbacks exist. Off-the-shelf devices are delicate relative to the rugged hardware used in traditional devices, and their speaker output can be insufficient for communication in noisy environments.

While these trade-offs are known, less clear is how they are shaping adoption decisions. One of the research goals was thus to better understand which devices are in fact

[2] www.dynavoxtech.com, www.techcess.co.uk, store.prentrom.com, www.gusinc.com, www.aphasia.com.

[3] www.assistiveware.com/product/proloquo2go, vocabeans.com, myvoiceaac.com, www.aphasia.com/slp/SmallTalk_Apps.

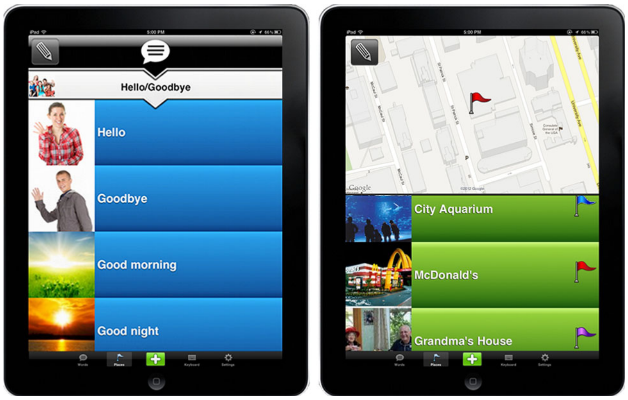

Fig. 2 TalkRocketGo, a mobile AAC device for iOS and Android, has standard categories such as greetings (*left*), as well as location-specific vocabularies (*right*) that use the device's location-sensing capabilities. (Image reprinted with permission from MyVoice Inc.)

being used by people with aphasia and recommended by their clinicians.

2.3 Technology for aphasia

While many individuals with aphasia willingly adopt low-tech AAC strategies to complement their residual language skills, the same has not been true for high-tech AAC devices. Instead, these have generally only been tried as a last resort, once other strategies and treatments have failed [23, 36]. This is perhaps because most high-tech AAC for aphasia takes the form of speech-generating devices (SGDs), in which pre-fabricated messages are selected or composed by the user and then read out by the device. These systems tend to replace rather than augment the user's natural speech. As such, they run the risk of under-representing the user's linguistic and cognitive competences, by creating uncertainty over authorship and whether or not messages produced accurately reflect the user's intent [26]. Moreover, learning to use an SGD typically requires a substantial investment of time and energy and most individuals prioritize efforts to regain natural speech [6].

For these reasons, it is perhaps not surprising that rehabilitation has been a key theme in research on technology and aphasia. Numerous studies have explored the potential therapeutic benefits of using computerized treatment exercises (for an overview, see [36]). Although they differ in their exact forms, these endeavours broadly use the computer to mimic the same sorts of exercises provided during therapy. Their main advantage is in terms of access: a computerized tool is always available to the patient, right from his or her home. Recently, research has also begun to explore the use of novel technologies such as digital paper in therapy [34].

C-VIC, later commercialized as Lingraphica[4], was the first computerized communication support tool developed specifically for aphasia [40]. Earlier SGD systems (which were not specifically targeted to aphasia) used custom hardware to associate a fixed physical layout with a limited number of words and phrases. C-VIC instead took advantage of mass-market hardware (personal computers) and therefore offered a much larger and more flexible vocabulary. It was also the first to introduce sentence construction in a computerized tool. With this, users could build up more sophisticated communications by combining smaller words and concepts into larger expressions.

One drawback to having a more powerful vocabulary is that an increased size and complexity makes navigation slower and more cumbersome, prompting researchers to develop more efficient navigation mechanisms. One approach is to organize the vocabulary based on semantic associations to reduce navigation time [33]. Other approaches include using the user's context to prioritize likely relevant words and phrases. MyVoice (currently marketed as TalkRocketGo) [15] and TalkAbout [25] both use the GPS features available in modern smartphones to provide quick access to relevant words based on the user's location; TalkAbout additionally uses face recognition to link vocabulary to particular individuals.

Building on the observation that individuals with aphasia can often produce correct sounds and words, but have difficulty bringing these together to form larger utterances, SentenceShaper takes a different approach. Instead of focusing on linguistic support (e.g. by matching visual representations of concepts to words), SentenceShaper provides processing support through an environment in which the user can iteratively record small segments of words and phrases, then combine them to build up larger messages [27, 28, 42]. This enables the user to break the production of an utterance down into a number of smaller steps that can be tackled individually. A key advantage to the SentenceShaper approach is that the resulting speech is in the user's own voice.

Adults with aphasia generally desire the ability to fully express themselves by engaging in communicative exchanges that are reflective of their retained cognitive capabilities. One criticism of SGDs is that they tend to be best suited to the communication of basic wants and needs and the expression of basic social etiquette (e.g. "please" and "thank you"). In contrast, they do a poor job of supporting higher communication goals such as the transfer of knowledge or the development of social closeness.

In response, a number of tools have been designed to support social engagement via storytelling. TalksBac guides users through a continually updated selection of

[4] www.aphasia.com.

short sentences and phrases that can be read aloud via a speech synthesizer during conversation [43]. PROSE, designed to be used in conjunction with TalksBac, enables the user to introduce pre-recorded stories into conversations [44]. Both systems rely heavily on the availability and willingness of a caregiver to manage and update entries in the system on an ongoing basis.

Recent efforts have targeted more independent use. XTag supports the retelling of past experiences via a tagging and sharing application that couples picture taking with extra information such as mood and location [1]. Camelandar provides a structure for organizing and sharing these daily life stories [47]. Finally, Daeman et al. [12] developed a storytelling application for individuals with expressive aphasia that supported social exchanges through a multi-modal tablet-based interface that supported taking photographs, making drawings and annotations, and recording sounds.

Davies et al. [13] also considered technology as a means of integrating AAC strategies through an in-depth investigation of how one individual incorporated an off-the-shelf PDA into his communication. Though this individual was highly motivated and very technologically savvy, he did demonstrate how a device could be used as a complement to other strategies to create fluid and engaging communication. In particular, this participant made effective use of the camera functionality by selectively taking photographs of salient objects and activities to use as a reference in later conversation. The PhotoTalk project built off this finding by creating an application to support the gathering and use of such images [4].

Finally, research has explored how to make technology itself more accessible to people with aphasia. The Aphasia Project investigated how technology can be designed to support individuals with aphasia in their daily life [30]. They developed a number of applications including an image and sound-enhanced daily planner [31] and a visually enhanced recipe book [41]. Other work in this space includes the work by Al Mahmud and Martens [2] to develop an accessible email tool, and the work by Devlin and Unthank [17] to develop a text simplification system for the Web.

Reflecting back on the earlier description of the types of aphasia, it is notable that almost all of the above technologies are intended to support independent expression, with no work aimed at support for comprehension. Thus, these devices will be most helpful to those with relatively intact auditory comprehension and substantial expressive deficits, as is the case with Broca's aphasia. However, the form factor of these devices can be a challenge for individuals with the kinds of associated motor impairments typical of Brocca's aphasia. While those with Wernicke's aphasia are less likely to encounter physical difficulty with the above technologies, their designs are less helpful to those with more severe comprehension deficits, as tends to be the case with Wernicke's aphasia. Finally, the above devices are generally targeted to the person with aphasia as a personal tool, rather than as shared devices to be used in collaboration with the communication partner. Thus, with respect to Garrett and Lasker's classification, these devices may be best suited to independent communicators. Computerized support for partner-dependent communicators remains an under-explored space.

3 Methodological approach

The present research aimed to gather a comprehensive picture of different perspectives on high-tech AAC device use. To capture a broad view, a Web-based survey of clinicians—that is, of professionals who work directly with individuals with aphasia, including speech-language pathologists (SLPs), occupational therapists (OTs), and communicative disorder assistants (CDAs)—was conducted. To understand AAC device use in practice, a number of group therapy sessions were observed, in which a variety of AAC techniques, including high-tech devices, were employed. Observing group sessions enabled the examination of AAC device use by a spectrum of individuals over a relatively short time period. Finally, to better understand the observations, focus groups were held with clinicians from these group therapy centres.

The authors do acknowledge that their methodology relies heavily on input from clinicians, with relatively less input from users themselves. Eliciting detailed and nuanced input directly from individuals with aphasia can be challenging, and moreover, the wide variability in manifestations of aphasia hampers the ability to generalize needs from a small sample. Clinicians, in contrast, are extensively trained, familiar with AAC devices, and over the course of their careers will work with a broad and varied sample of individuals. Thus, they were best positioned to reflect on broad and long-term needs and to envision future designs.

Other related efforts have employed domain experts as informants as well. Allen et al. [3] provided a detailed account of involving domain experts in the design of assistive technology, identifying five types of experts and three different roles they can play. Moffatt et al. [31] involved a high-functioning individual with aphasia in brainstorming sessions on the design of a multi-modal daily planner. While this participant was not himself a target user for the planner, he would have been prior to rehabilitation. Boyd-Gaber et al. [8] relied even more heavily on domain experts, using clinicians as proxy users throughout a participatory design process, while Allen et al. [4] included input from SLPs and family members in the design of a photograph-based communication aid. The use of close family members as proxies has been adopted in designing for other cognitive impairments as well [11].

3.1 Web-based survey of AAC device use

This investigation began with a Web-based survey to solicit input from a wide spectrum of individuals in a variety of contexts. The survey, built using LimeSurvey[5], consisted of four sections: respondent demographics, high-tech AAC devices adoption, factors affecting device use, and strengths and limitations of current devices. To ensure clarity, the survey was both pre-tested by colleagues and pilot tested with two SLPs fitting the recruitment criteria.

Respondents were recruited via snowball sampling, with initial advertisements published in e-newsletters and sent as a mass email to the members of a number of aphasia organizations, as well as to SLP and OT colleges and associations. The survey was open for two months (February–March 2011) and received a total of 67 viable responses. Of these, 49 respondents worked in Canada and 18 in the USA. Respondents were highly experienced. The majority were SLPs (61) and had a graduate degree (master's 48, Ph.D. 14) with ten or more of years experience working with people with aphasia (50).

3.1.1 Characteristics of adopted devices

To get a picture of current trends in use, respondents were first asked to list, in their opinion, the top three devices used by individuals with aphasia and the top three recommended by clinicians. In both cases, the most common responses were DynaVox, iPad, and iPod Touch, as shown in Table 1. The fact that the top-rated device in terms of use (Dynavox) differed from that in terms of recommendations (iPad) reflects the changing landscape of AAC device use: in the freeform section participants noted that although they were increasingly recommending devices such as the iPad, many users had already invested too much time, effort, and money into DynaVox to switch.

Despite the prevalence of iPad and iPod Touch recommendations, only 34 out of 67 respondents were recommending them to clients; 11 respondents were unfamiliar with their use as AAC, and an additional 15, though aware, had not worked with them.

When asked about the advantages and disadvantages of using a consumer device for AAC (see Table 2), the chief motivation for recommending one was that they carry less stigma relative to traditional devices. Given the emphasis prior work has placed on stigma as a deterrent to adoption

Table 1 Top devices identified as being most used and most recommended by the number of respondents listing it in their top 3

Most used	#	Most recommended	#
Dynavox	34	iPad	30
iPad	21	iPod Touch	26
iPod Touch	16	DynaVox	18
Tellus Smart	7	iPhone	9
Vantage Lite	7	Vantage Lite	7
ChatPC	4	Tellus Smart	5
LightWriter	3	Chat PC	4
Zygo Macaw	2	LightWriter	3
		Zygo Macaw	2

$N = 67$

Table 2 Advantages and disadvantages of consumer mobile devices relative to traditional AAC devices, by number of respondents listing it

Advantages	#	Disadvantages	#
Less stigma	12	Limited software options	8
More portable	8	Lower volume	4
Lighter	5	Less durable	3
Cheaper	4	Screen hard to read[a]	16
		Screen hard to use[a]	5

$N = 67$

[a] Specific to the iPod Touch

[37, 38], this finding underlines the potential for consumer devices to encourage adoption. Other advantages included that they are lighter, cheaper, and more portable.

The main drawback (across all consumer devices) was that there are limited software options available that are appropriate for people with aphasia, with secondary disadvantages including that they have lower volume and less durability. For the iPod touch (and presumably similarly sized devices), the small screen size was also noted as a disadvantage.

It was difficult to untangle AAC device adoption from external influences. Many respondents intertwined limitations imposed by government funding restrictions with the devices themselves, as such restrictions influenced which devices were recommended and which were ultimately adopted. This suggests that the results would be biased to the geographical context of the respondents (N.B.: over 70 % were Canadian) and that use and recommendations will fluctuate over time. For example, some respondents noted that within the Ontario Assistive Devices Program (ADP) the only approved mobile application was Proloquo2Go, and the only funded consumer device was the iPod Touch; however, by the last stage of this research, the ADP had started to approve iPads for funding. Funding

[5] http://www.limesurvey.org/.

restrictions can clearly have a powerful impact on adoption; however, approval is often dictated by factors beyond the merit of the device itself, somewhat hindering the ability to compare and evaluate designs based on adoption and recommendation.

3.1.2 Profile of adopters

In terms of adoption rates, results confirmed the initial expectations: 63 % of respondents estimated adoption at 10 % or less, as shown in Fig. 3.

Table 3 lists the characteristics respondents associated with successful adopters, providing also the number of respondents identifying that characteristic. Consistent with previous work on profiling adopters of AAC devices (including but not limited to those with aphasia [24]), respondents described successful adopters as highly motivated individuals who were not only young and tech-savvy themselves, but who additionally had supportive and tech-savvy caregivers.

Although there was less agreement in the particulars of the remaining responses, two common themes were apparent: the absence of an associated (cognitive, motor, or visual) impairment and the presence of a compatible personality (i.e. social, strong communicator, not self-conscious). It is interesting that so few respondents identified the specific cognitive ability of connecting meaning to symbols as has previously been shown to impede successful adoption of AAC devices [32]. This perhaps suggests that while cognitive skill is necessary for successful adoption, social and emotional factors tend to dominate.

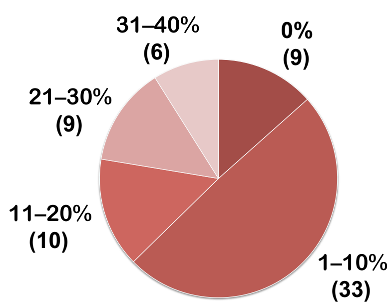

Fig. 3 Breakdown of adoption rate estimates, by number of respondents choosing each range. ($N = 67$)

Table 3 Characteristics of successful adopters, by number of responses listing it

Characteristic	#
Being motivated	27
Having supportive and tech-savvy caregivers	20
Being younger and tech-savvy	14
Having relatively intact auditory comprehension	10
Being social	8
Being an overall good communicator	6
Having strong cognitive skills	6
Having good motor skills	4
Having good vision	4
Not being self-conscious about using an AAC	3
Having the ability to connect meaning to symbols	2

$N = 67$

3.1.3 Factors affecting use

Even among adopters, use was minimal: 71 % of respondents felt that high-tech AAC users rarely rely on their devices for communication, but rather mostly employ other strategies, with use mediated by a number of factors, including location, communicative intent, and social context.

In terms of physical location, respondents felt success was greatest in rehabilitation clinics and support groups, and acceptable at home, in the homes of close friends and family, and at doctors' offices. In contrast, device use was rated least successful in noisy public places such as shopping malls.

Device success was also considered dependant on the purpose or goal of the communication. High-tech AAC use was perceived as most successful for straightforward and easily predictable communications such as simple salutations, brief biographies or introductions, and simple needs requests. On the other hand, high-tech AAC devices were not considered useful for discussing a personal opinion or current events.

Finally, respondents described high-tech AAC success as highest for face-to-face conversation with a single, familiar, partner, and lowest for group discussions, phone calls, and presentations. High-tech AAC was also considered successful with close family members and trained individuals (such as SLPs). They were viewed as somewhat sufficient for use with friends and extended family members, though typically not helpful for communication with acquaintances or unfamiliar partners.

3.1.4 Summary

In sum, the survey results confirmed initial expectations that adoption of high-tech AAC is low and that current devices are not meeting user needs. In particular, a mismatch between the kind of support these devices offer, and the areas where support is most needed was identified. Specifically, current AAC devices enable individuals to have basic conversations with a single partner. Unfortunately, these are the situations in which support is least needed as it is generally more convenient to use gestures, body language, and low-tech AAC in these contexts. One of the respondents summed up the current shortcomings of high-tech AAC as follows:

> “An AAC device is useful when it can be used in harder situations, during group discussions, on the phone, in a noisy environment, and while talking to unfamiliar partners, because that is when it is needed the most!”

3.2 Observation sessions and focus groups

The survey offered a broad, but high-level, view on high-tech AAC use and adoption and chiefly identified a gap between the kinds of support needed and that provided by current devices. Observations of group therapy sessions were then combined with focus groups with clinicians. These activities provided a means for further considering how AAC devices are incorporated into communication, and offer additional context for the survey results. The focus groups followed the observation sessions, and both activities took place across a two-month period from April to May 2011.

Both the focus groups and the observation sessions were audio-recorded and transcribed. For the observation sessions, field notes supplemented the recordings, capturing non-verbal aspects of the group interaction. The focus group data were analysed section-by-section, question-by-question, across sessions, coding for themes of interest, while still allowing for new, inductive themes to emerge [9]. The observation session data were then analysed based on the themes identified in the focus groups. The themes were created in consultation with an independent member of the authors' laboratory to help ensure they were being applied fairly; this person was not on the research team, but attended one of the focus group sessions.

A total of seven group therapy sessions were observed. Five of these were of three different groups from a centre in Toronto, and two (each from a different group) were from a centre in Ottawa. Each therapy session in Toronto consisted of 5–8 participants. In Ottawa, sessions contained 20–25 participants, divided into tables of approximately 6, with each subgroup assigned a facilitator (who could be a trained volunteer, an SLP, or a CDA). Group therapy was selected as the setting for the observations because, as indicated by the survey results, they are one of the most successful contexts for high-tech AAC use. They also enabled the examination of a range of individuals with differing impairments and levels of high-tech AAC expertise in a relatively compact period of time.

The semi-structured focus groups provided further insight and helped to contextualize observations. Each session lasted approximately an hour and half (Toronto 98 min, Ottawa 77 min). Table 4 provides a breakdown of the participant demographics in each focus group, showing occupation, education, and years of experience working with aphasia. It is also noteworthy that the centre in Toronto had a greater technology orientation; the clinicians there reported allocating 75–80 % of their time to preparing devices for clients, training clients, and periodically revising and updating content. Although the centre in Ottawa was knowledgeable about different high-tech AAC devices, they did not consider themselves experts as their focus was more on the development of low-tech resources (such as life history books), and on training individuals to use no- and low-tech strategies. Though the clinicians in Ottawa were less enthusiastic about traditional high-tech AAC devices, they expressed a growing enthusiasm for the iPad and iPod touch.

The SLPs in both centres stressed the role of group therapy in regaining confidence. They indicated that some individuals are at the “sound” level and not even at the “word” level when they first join the group. Observing more senior members helps give them the motivation and confidence to work on their speech and to try different techniques and devices.

In the therapy sessions, AAC use ranged from low-tech aids such as alphabet boards, to traditional high-tech devices, including the DynaVox and Tellus Smart, to smart mobile devices, namely the iPod Touch and the iPad. Notably, only more able-bodied individuals with minimal cognitive difficulties were using the iPod Touch (with Proloquo2go), though clients and facilitators at both locations were enthusiastic about smart devices, especially the iPad.

Table 4 Demographics of the focus group participants, including occupation, education, and years of work experience

Occupation	Education	Years
Toronto		
Speech-language pathologist	Masters	10
Occupational therapist	Masters	7
Assistive technologist	Bachelors	5
Communicative disorder asst.	Bachelors	5
Communicative disorder asst.	Bachelors	1
Communicative disorder asst.	Bachelors	1
Ottawa		
Speech-language pathologist	Masters	20+
Occupational therapist	Masters	14
Speech-language pathologist	Masters	8

$N = 8$; Toronto: 5; Ottawa: 3

3.2.1 *Traditional high-tech AAC devices*

One of the most interesting observations was that although many of the participants had an AAC device, none used them except for introducing themselves to strangers. A facilitator from Ottawa explained that devices are often abandoned due to insufficient content. This problem was exemplified by an individual in the Toronto session who needed to switch between his AAC device and a communication book to introduce his son, because the device did not have the right information.

Stigma was again emphasized as a key detractor from adoption. One clinician in Toronto compared the use of high-tech AAC devices by children to their use by adults, noting that children are more accepting of devices with colourful pictures and symbols, while adults do not want to appear unsophisticated. Participants were optimistic that mainstream devices could be more acceptable due to their widespread adoption. However, the development of applications with age-appropriate picture sets would still be needed.

An added challenge that the clinicians described was the need for customization, and the difficulties associated with this task. Clinicians from Toronto estimated that it takes about 30–40 h for them to set up a device, and though customization tools and instruction are provided, 99 % of devices are returned as sent out. They explained that there is a huge cognitive and language component to programming a device that is beyond the capabilities of most of their clients.

Moreover, communication demands are greater for those with aphasia due to their lifelong experience with language. Participants noted that needs-based communication is not sufficient, with one participant emphasizing that the life of a person with aphasia is far more complex than going to the bathroom or wanting a cup of coffee. When taken in combination, these comments drive home that high-tech AAC use is complicated: even when devices can be programmed to appear more sophisticated and provide more advanced options, these features remain insufficient for most users.

Beyond the individual drawbacks noted, clinicians again affirmed a mismatch between the support provided and needed. Both groups remarked that most individuals, even those with severe aphasia, do not use an AAC device with close communication partners because for those partners low- and no-tech options are faster and more efficient. As such, high-tech devices are mostly needed for communicating with unfamiliar partners; however, as revealed by the survey, this context is not well served by existing devices.

Many devices are thus abandoned. According to a clinician in Toronto, 50 % of their clients do not renew their lease. One in Ottawa described this mismatch as follows:

> "I think if a technology exists and it is introduced ...in an environment that supports that culture—if it is not taking off, if they are not using it, there is something about it. It is not useful. There is a reason behind it. Because they are desperate to communicate and there is so much they want to say. If there is something that will work for them, they will run with it."

3.2.2 *Adoption of smart mobile devices*

Both groups were enthusiastic about the potential for using smart mobile devices as AAC, including both phones and tablets. Perhaps reflecting the differing emphases and clienteles of the two centres, it was noteworthy that smartphones featured more prominently in the Toronto focus group discussions, while tablets were emphasized more in Ottawa.

Though both groups were optimistic about the use of consumer devices, this enthusiasm was balanced with concern over their size and sturdiness. Form factor was a complex issue. On the one hand, individuals want lightweight portable devices. Yet on the other, there was concern consumer devices break too easily, and that many individuals have motor or visual impairments that make small devices hard to use. In this case, iPads were specifically noted as a promising compromise between portability and ease of use, but inappropriate for people with motor impairments, decreased dexterity, or low vision. They are not as sturdy or rugged as dedicated devices built for clinical populations, and their loudspeaker volume is too low for noisy environments. The Toronto group specifically drew attention to size as an important consideration, particularly for older adults, noting that before the iPad there were no portable lightweight devices on the market that were big enough for anyone older than 60 years to see the screen.

3.2.3 *Smartphones and mobile communication*

With respect to smartphones, clinicians noted that the iPod Touch, though not a phone, is more popular as it is cheaper and the additional features offered by phones are mostly inaccessible anyway. Though a few individuals with aphasia will use a phone to call a very familiar communication partner who knows how to facilitate a simple conversation (such as one based on asking yes/no questions), phone accessibility is limited for this group. That is not to say that there is no interest in communication technology: there was a strong desire to see the development of tools which integrate AAC support into telephone calling.

SMS text messaging is also difficult, though it can be useful for those with other communication impairments [39]. What clinicians found frustrating in this respect, was that in their opinion, there is obvious potential for making text messaging accessible to people with aphasia. One clinician noted that icon sets already exist as texting shortcuts. If they could be improved they could be a powerful way of enabling mobile communication for individuals with aphasia.

3.2.4 Mobile applications for AAC

Although it was clear that smartphones (as well as the iPod Touch) were being adopted as AAC, the bulk of the enthusiasm was directed at tablets due to their larger size. Dominant in this category was the iPad.

In discussing the iPad, it quickly became apparent that enthusiasm was for the hardware itself, not for iPad-based AAC applications. Clinicians emphasized that the options available (including VocaBeans and Proloquo2Go) still require much improvement before they would be useful to individuals with aphasia. What was instead enthusing them was the vast array of *non-assistive* applications available. In particular, clinicians described four types of applications that they found useful.

Calendars A calendar application can be useful for a person with aphasia as dates and temporal references are commonly used in conversation, but challenging for many with aphasia. Focus group respondents described how the spatial layout of a calendar or planner can be leveraged by individuals to make references to time during conversation.

Drawing applications Drawing on paper is a common low-tech AAC strategy. However, a drawback to the low-tech approach is lack of reuse. An SLP in Ottawa described having to photocopy papers for individuals, as individuals often want to be able to refer to a previous drawing in later conversations. For example, an individual may want to reference a drawing from her group therapy session in describing her day to a spouse or caregiver. Digital records more readily support such reuse.

Audio recorders Audio recorders can be used by individuals to record a complicated conversation or a list of instructions (e.g. at the doctors office). This can enable them to review the information later, either on their own, or with the help of a caregiver.

eReaders For some individuals, reading is easier when the visual task is reinforced with audio [13]. However, audiobooks can be cumbersome as they are difficult to stop and rewind. By comparison, eReaders tend to be easier to control and provide additional features such as variable font sizes and the ability to highlight words as they are read.

Though there was strong enthusiasm for these applications, it was also clear that improvement is needed. Of the many options available in these categories, clinicians had found their favourites. However, they were also aware that these applications were not designed as assistive technology. In particular, clinicians noted that those with attention, memory, or cognition impairments can find it difficult to switch between applications, learn how to use each of them, and change their settings. Applications could be further improved with increased text size and greater use of images and icons to support feature recognition and navigation. They also suggested that it would be ideal to have one aphasia-friendly application, combining all these features into a single, consistently designed, application.

4 Discussion and future work

Throughout this research, a consistent theme emerged, revealing a gulf between the type of support currently offered by high-tech AAC devices and the kinds of support most needed by individuals with aphasia. The survey results described high-tech AAC as being most successful for face-to-face, one-to-one conversations, in supportive locations such as rehabilitation clinics, and with familiar conversation partners such as spouses. Even when these conditions are met, support was still limited to basic conversations such as greetings. Unfortunately, these contexts are where help is least needed; low and no-tech AAC options are generally faster, easier, and more engaging. Moreover, close conversation partners are often skilled in supporting conversation and likely focused on more intimate forms of communication aimed at building and maintaining their relationship with the person with aphasia.

This mismatch may help shed some light on the low adoption rate of high-tech AAC. On the whole, these devices are expensive in relation to the limited support they offer. Individuals need supports that are useful in harder situations, such as on the phone, with unfamiliar communication partners, or in group or noisy environments. Support also needs to be flexible and dynamic. It needs to be able to adapt to evolving conversations.

It was interesting that clinicians were forging ahead of developers, creatively appropriating tools from elsewhere. Particularly in the Ottawa-based centre, which historically had not encouraged high-tech AAC use, there was enthusiasm for using consumer devices (and especially the iPad) to leverage and complement low-tech techniques such as drawing.

4.1 Design opportunities

The findings presented have identified a number of design opportunities that are described in this section.

4.1.1 Build on low-tech proficiencies

Though clinicians are already appropriating everyday applications for this purpose, room remains for developing specific applications aimed at enhancing low-tech strategies. Note that this direction is very much in line with the findings of Davies et al. [13] in their exploration of using an off-the-shelf PDA. The findings of that work also pointed to the use of technology to leverage low-tech strategies such as drawing, to provide additional support for tasks such as reading, and for use as a capture and replay device for supporting communication over time. What has, perhaps, changed in the decade since that earlier work is that technology has improved to the point where it is no longer necessary to be highly motivated and technologically savvy to use technology in this way. Rather we are reaching a point where this approach will be accessible to a broader range of individuals with aphasia.

Although technological proficiency is increasing, it is important to keep in mind that most individuals with aphasia are older. Although older adults are increasingly technologically literate, age-related sensory, motor, and cognitive declines can hinder computer use. These declines are even more pronounced in individuals with a stroke-related aphasia, underlining the needs for designs that minimize cognitive, sensory, and motor demands. Interestingly, respondents did not often directly mention age. This is perhaps because age and aphasia are so tightly coupled that respondents did not differentiate between aphasia-related and age-related needs.

4.1.2 Enable users to selectively choose supports

In line with the clinicians use of multiple applications, the authors envision the future of high-tech AAC as an integrated suite of small apps that can be selectively chosen to aid in communication. The emphasis here should not be on *creating* conversation; that is, devices should not be thought of as a means for constructing stand-alone thoughts (by, e.g., constructing sentences by iteratively selecting from a picture dictionary). Rather, the focus should be on supporting communication, much like a power-point presentation supports a speaker at a conference, but does not replace him or her.

Consistent design across applications will be needed to aid accessibility. Though both aphasia centres were using a range of applications with success, it was clear that learning different applications, and having to switch between them, was a roadblock for many individuals. An aphasia development framework could act as a standard structure for developing applications for people with aphasia. It would define standard graphical user interface (GUI) elements such as menus, buttons, fonts, and colours that are all aphasia-friendly. Individuals could selectively add the applications that they need, growing their set of tools as they develop expertise and comfort with the system.

Features should also be integrated in a way that enables functionality to be shared across applications. One particular area where individuals with aphasia are currently underserved is with respect to the use of mobile devices for their core feature: communication. Systems are needed that can enable users to leverage communication support during phone calls. Support for text messaging is also needed. Though most individuals with aphasia cannot easily construct a text message, it seems possible to craft icon sets that would enable the sending of short text messages. Such a system could substantially contribute to increased independence for individuals with aphasia by giving them a method of remaining connected while mobile. Symbol sets have already been created for travellers[6], which may serve as a good starting point.

4.1.3 Ease learning and customization demands

In general, a move towards the use of consumer devices should markedly reduce the investment needed to adopt a high-tech AAC device, especially as smart devices continue to gain market penetration and as individuals increasingly develop experience and proficiency prior to acquiring aphasia. Up-front investment could be further reduced by crafting sets of features such that they can be selectively chosen and grown over time. For example, an individual might start by using just a doodle application as a way of recording their drawing-based communications, but as they become more proficient with the technology, this could be extended to more complicated applications such as voice recording.

It is also worth thinking about approaches that do not require large custom databases to be developed or to think creatively about how these corpora can be developed with minimal demands on caregivers, who may themselves be novice users of technology. In this regard, one can find inspiration from Write-N-Speak, a digital-paper toolkit for end-user creation of custom speech-therapy materials [34]. The approach taken in this work not only reduces the need for technical expertise on the part of the therapist, but also focuses on how to integrate the creation of materials with existing practices.

6 http://www.icoon.eu/icoon.html.

4.1.4 Facilitate collaborative and partner-supported use

At the beginning of this article, it was observed that, to date, most technology for aphasia is designed to be used as a personal tool, driven independently by the person with aphasia to help him/her communicate. However, this approach only addresses the needs on independent communicators with strong auditory comprehension and overlooks the opportunities for technology to support the needs of partner-dependent communicators and those with comprehension deficits.

The therapists observed were integrating consumer devices into therapy in a much more collaborative fashion, in which both the clinicians and the patients would use the device to reinforce communication. By sharing control of the device, both independent and partner-dependent communicator needs can be supported. Moreover, by using the device to support their own words, the clinicians were able to also address comprehension needs.

4.2 Remaining challenges

Beyond the above design opportunities lay larger challenges. Foremost among these is reconciling the paradox between addressing unique needs and the desire to use non-specialized devices. In particular, it was found that a strong motivator for adopting consumer devices was that they are a general tool, an indicator of sophistication and normalcy. However, these technologies had clear technical limitations, in terms of audio output capabilities and ruggedness. It seems unlikely that these issues will be easily addressed by technology producers who are focused on the needs of the average target consumer.

5 Conclusion

With mobile technology becoming increasingly prevalent, along with increasing computer literacy among target users, there are many new possibilities for designing for users with aphasia. The survey and focus group data confirm that SLPs have recently started recommending devices such as the iPod Touch and the iPad to some of their clients. According to the focus group participants, their clients are enthusiastic about adopting these devices because they do not carry the stigma of traditional AAC devices and they are portable and light. These devices are also cheaper than traditional options.

Surprisingly, the clinicians in this study were not as enthusiastic about the AAC applications available for these platforms. Instead, they were appropriating generic applications and using them as a complement to other AAC strategies. While these applications were successful, accessibility issues were apparent. From these findings, opportunities for design were identified based on leveraging the user's existing low-tech proficiencies and creating an integrated suite of applications that could be selectively adopted to ease learning and reduce the up-front customization needed to set up an AAC device. If these challenges can be met, affordable low-cost smart mobile devices could significantly aid communication and improve the quality of life of millions of individuals worldwide who have aphasia.

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