Exploring the Usability of Gaze-based Mobile Communication in Ghana

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In Ghana, people with communication challenges could benefit from gaze-based Augmented and Assistive Communication devices (AACs), widely used in countries with greater resources. However, there is limited evidence about the potential of such devices by people with communication disabilities in the Global South. Our study sought to evaluate the usability, identifying barriers and facilitators of adoption of a freely available Android-based eye-gaze AAC application called Look to Speak. The study included training of 10 local speech and language therapists and 15 people with communication difficulties. Our findings highlight how, despite some initial successes and the positive opinions of clients, caregivers and speech and language therapists the Look to Speak application largely failed to deliver substantial communication benefits to individual users. This was due to a combination of factors including the high cognitive load, design flaws of the application - such as the lack of optimization of the selection process depending on the chosen interaction mode, and lack of wheelchairs with adequate postural support, which are necessary for users to be able to successfully utilise the application. We contribute insights surrounding the mismatch between expectations and reality of gaze-base AACs, and considerations about the broader ecosystem required to support adoption and impact of such technologies in Ghana.

CCS Concepts: • **Human-centered computing** → **Empirical studies in accessibility**.

Additional Key Words and Phrases: Speech, Disability, AAC, Gaze-Based, Smartphone, Ghana, Global South, Accessibility

ACM Reference Format:

Anonymous Author(s). 2018. Exploring the Usability of Gaze-based Mobile Communication in Ghana. In *Proceedings of Make sure to enter the correct conference title from your rights confirmation emai (Conference acronym 'XX)*. ACM, New York, NY, USA, 20 pages. https://doi.org/XXXXXXX.XXXXXXX

1 Introduction

The first Global Report on Assistive Technology (AT) [44] found that 2.5 billion people need AT today, a figure likely to rise to 3.5 billion by 2050, yet in some countries, access is as low as 3% for those who need it. Therefore, many people are still without access to the AT they need to carry out activities of daily life, and this is especially true for the 28-49% of people globally with communication disabilities [27]. In the last decade, digital devices, and especially smartphones with accessible applications, have become increasingly important as AT for the billion of disabled people worldwide, as they offer a variety of tools that enable people to address access barriers experienced in daily life [7, 8, 48, 49, 57, 58]. In contrast to often more costly and less available dedicated assistive devices such as Braille readers or digital communication boards, low-cost Android smartphones are available in most of the Global South through a variety of different providers [46, 67]. However, to date studies looking at the use and impact of smartphone applications to support the needs of people with communication difficulties in the Global South are still relatively scarce [6, 15, 39].

Impaired speech makes communication challenging and is compounded by stigma, which can isolate or marginalise people [16, 68]. Often, people who have impaired speech will be understood by and communicate with and through trusted individuals, limiting their speech to others due to the risk of 'failing' to communicate within a social exchange,

Manuscript submitted to ACM

leading to a feeling of inferiority and reduced participation in the moment and cumulatively over time [13]. These issues can also be more pronounced in Ghana and other countries in the Global South where disability stigma and other systemic failures contribute to lack of access to support and subsequent further marginalization [24, 70, 71].

People with conditions such as Cerebral Palsy or Stroke can have very limited ability to articulate sounds or may not be able to form any or only some full words. When this is the case, gaze-based communication devices can provide a vital bridge to supporting communication [40]. When used, gaze-based technologies convert purposeful looking behaviours, such as gaze fixations and gaze transfers, to select text or icons on a screen [29, 52, 64], which can then be read aloud by the device.

In Ghana and other West African countries, there is a lack of trained Speech and Language Therapy services with trained therapists (SLTs), and poor access to communication-based assistive technologies [6, 26, 39, 71]. However, there is also a fast-changing technology infrastructure; providing new fundamental approaches to support people with communication difficulties in their day-to-day lives [34]. Whilst gaze-based technologies are largely available in high-resource settings, they are rarely found in low-resource settings [39]. The vast majority of gaze-based technologies are, for many, prohibitively expensive. For example, the Tobii PCEye camera costs approximately £2000 and requires additional software and hardware, while 'all in one' hardware devices with eye gaze and software can frequently cost £8000 or more [1]. People who require these devices are often those from the most marginalised segments of society and, as a result of systemic injustice, including the unaffordable cost of the AACs they require, the ones with the least met needs [14, 39].

For people living with significant physical disability and who can utilise purposeful 'looking' behaviours [52], eye-gaze control technology is argued to support increased autonomy by providing access to computers and speech-generating communication software [25]. This technology may also enable increased environmental control and facilitate participation in a variety of activities, including using social media and listening to music, in addition to supporting communication [30]. Eye-Gaze technology normally utilises an infrared camera, which tracks and responds to eye movements in conjunction with specialist software and applications [69]. The technology enables a person to make selections when deliberately fixing their gaze on a target on the screen for a set period of time. Globally, there appears to be limited literature to support the decision for the most suitable candidates for eye gaze, and how it should be implemented [29].

In a thematic qualitative analysis of narrative responses from 126 professionals supporting people to use eye-gaze devices in the UK, key recommendations for incorporating eye-gaze control technology included: ensuring optimal seating and positioning, involving a multidisciplinary team, tailoring implementation and content to individual needs, engaging in regular practice sessions, supporting communication partners and consideration of motivation and personal preferences [30]. While the emergence of novel gaze-based applications on low-cost Android smartphones can potentially make such technologies more easier to access for people with severe communication disabilities in the Global South, previous studies have pointed to how infrastructural shortcomings and design which fail to account for contextual factors can hinder the ability of individuals to benefit from assistive applications on smartphone devices [6, 7, 9, 28, 46, 50].

Our study sought to evaluate the usability of the free smartphone application Look to Speak, a gaze-based AAC application available for the Android operating system for users with severe communication disabilities in Ghana. Through training and evaluation sessions with 10 Ghanaian SLTs and 15 clients, we examined what are the barriers and

[1]Tobii: https://uk.tobiidynavox.com/products/pceye?variant=37068958793887 and SmartBox: https://hub.thinksmartbox.com/topic/grid-pad/

facilitators that influence the effectiveness and impact of the application, to extrapolate implications for adoption of gaze-based smartphone-based AAC in the Global South. Our results show that while participants had positive opinions of Look to Speak, the application often failed to offer significant advantages for many users. These shortcomings were due to a combination of factors including sub-optimal choices in the design of the application, which are partially dictated by technological constraints but also due to inconsistency in interaction modalities, lack of supporting assistive technologies such as adaptive seating which are needed to offer appropriate postural support, and poor familiarity with gaze-based AAC from stakeholders, which made it difficult to evaluate the suitability of the technology compared to potential alternatives. Based on these results we provide recommendation for more context appropriate smartphone-based AAC applications, as well as broader implications around the need to integrate design-level and ecosystem-level considerations to support the adoption of gaze-based smartphone applications in the Global South.

2 Related Work

2.1 Gaze-based Augmented and Assistive Communication

Overall, AAC is a set of tools and strategies designed to supplement speech and writing if these are impaired [10].Among the high-technology AAC options available, eye gaze technology may enable eye-movement to be used to control electronic devices using only their eyes [37]. This technology may support people living with individuals with severe physical and communication disabilities, potentially enabling greater autonomy for communication and environmental control [12].

The early 2000s witnessed the emergence of dedicated eye gaze AAC devices, marking a significant milestone in the field. In 2003, the first desktop eye gaze communication aid for communication and computer access using eye gaze was launched [21]. Integration with different operating systems, such as Windows and iPadOS, and various devices, including tablets and laptops, has increased the versatility of these systems [34]. Portable and mountable systems have been created to enable use in a variety of settings, including home, school, and work [62]. Many eye gaze systems now include support for symbol-based communication or visual scene displays (VSDs) - beneficial where literacy may be a barrier to access. The recognition that people often employ multiple methods of communication including gesture and vocalisations has also influenced interface design to support a range of expressive options [32].

Eye gaze technology can be used for environmental control - including controlling lights, doors, phones, and other electronic devices in their surroundings [35]. Additionally it can be an input method browsing the internet, sending emails, and engaging in social media platforms [17, 72]. In recent years, the integration of artificial intelligence (AI) and machine learning is being utilized to improve communication rates for people using eye gaze - through more accurate gaze prediction and reduced latency [11, 65].

Eye gaze technology as AAC has been utilized across a diversity of aetiologies that affect communication and motor control. People living with Amyotrophic Lateral Sclerosis (ALS), a progressive neurodegenerative disease, frequently use eye gaze AAC, as do people living with Cerebral Palsy, spinal cord injuries, muscular dystrophy, and other conditions that result in severe motor impairments [12]. However, compared to high-income countries, the availability and adoption rates of eye gaze technology for AAC in Africa remain limited [18]. Limited resources, including financial constraints for purchasing relatively expensive eye gaze devices and providing ongoing intervention, pose a significant barrier in most of the Global South [66]. This includes the cost of the devices themselves, the specialized software required, and often necessary accessories like mounting systems. There is also a lack of trained professionals and local expertise in both AAC in general and the specialized area of eye gaze technology [66]. In 2014, for example, the first study in the

African region on gaze-based technology was reported by the Centre for Augmentative and Alternative Communication (AAC) at the University of Pretoria in South Africa, which claims to be the only centre in Africa providing assessment, training, and conducting research in AAC, including gaze-based technology [66].

Compounding this issue is the shortage of speech-language pathologists, occupational therapists, and assistive technology specialists who possess the necessary training and expertise in AAC, particularly in the specialized area of eye gaze technology [6, 26, 39, 66]. Infrastructure limitations, such as unreliable electricity supply and limited internet connectivity, can impact the practicality and sustainability of high-tech devices in many regions [53]. Moreover, the cultural and linguistic diversity of the African continent requires the development of culturally appropriate and multilingual AAC solutions, which are often lacking [39, 63]. Many existing systems are primarily English-based, which can be a significant barrier in multilingual environments [63]. Culturally relevant vocabulary, symbols, and interaction styles that resonate with local communities are also required [2, 42]. When selecting hardware, consideration must also be given to local terrain and climatic conditions, as some imported devices may not be suitable for these environments [53]. Ultimately, in many low-income contexts, low-tech AAC options often still represent a more immediate accessible and sustainable approach [39, 42, 53].

Despite these challenges, there are also opportunities to leverage the increasing penetration of mobile technologies across Africa and to develop more affordable and contextually relevant AAC solutions [6, 26]. The increasing integration of eye tracking capabilities into mainstream mobile technologies like smartphones and tablets represents a particularly significant emerging trend for low-resource settings [1, 34, 45, 72]. The development of AAC applications that can run on these readily available and relatively affordable devices reduces the reliance on dedicated and expensive hardware. Leveraging the ubiquity of mobile technology in many low-income countries might be on factor for wider adoption and integration of eye gaze AAC into everyday digital interactions [39, 45]. In the following section we look in more details at studies that have documented the design and deployment of AAC applications in the Global South utilizing low-cost smartphones which might be more easily accessible to users.

2.2 Mobile-based AAC applications in the Global South

Mobile-based AAC applications can help overcome stigma and usability issues associated with traditional AAC devices [38]. They are also particularly well suited to the Global South where mobile phone penetration rates are relatively high and access to traditional healthcare services such as speech and language therapists alongside stand-alone AAC devices are low [6, 24, 26, 39]. However, despite increased technological possibilities, concrete advances towards the development and widespread adoption of mobile-base AAC applications is still limited. This is in part due to *"an urgent need to develop AAC options in local languages with culturally appropriate and relevant vocabulary"* [39].

To date, there are some examples of mobile-based AAC applications which satisfy this criteria. One example Avaz AAC – a mobile application made in India for Indian Language speaking individuals that provides picture and text-based vocabulary with predictive text and supports six Indian languages – Hindi, Tamil, Kannada, Malayalam, Telugu, and Marathi, it can also be personalized for Gujarati and Bengali. Avaz AAC has been trialled successfully with people with Cerebral palsy [61], non-verbal autistic children [60], and stroke survivors with aphasia [19].

Recently Ayoka et al. [6] have assessed the local suitability of a an Automatic Speech recognition application developed to understand atypical speakers based predominantly on a US-English model of atypical speech. Although the application was developed in the Global North it has been launched in several Global south countries including Ghana where the study took place [6]. Whilst it demonstrated usefulness as a tool, it fell short of being a solution for people's everyday commination needs due to a lack of local language integration [6]. The authors recommended

future iterations of the application move beyond English and develop applications in the languages used in different regions for everyday communication. An example where this has been attempted is in a recent use of the Qfrency – a TTS technology developed by South Africa's Council for Scientific and Industrial Research [41]. The model generates synthetic speech that closely mimics human speech, including articulation and accent, for the eleven official South African languages. These voices have been successfully integrated into a commercial AAC device the Grid 3 in a pilot study [56]. However this Text-to-Speech model South African languages has not been implemented on a mobile device. In fact, the scoping review of Augmentative and Alternative Communication (AAC) interventions in the Global South by Muttiah et al. [39] found only six studies which focused on the use of mobile-based AAC applications out of the 18 included.

We were only able to find one study which proposed the development and deployment of gaze-based AAC through a smartphone application in the Global South, specifically India [45]. Pai and Bhardwaj [45] created the E-ACE application, and AAC that features different thematic boards, each containing a set of standard words and phrases that might facilitate communication in daily life. The user select a board via a pre-defined eye movement and can then chose between four different options in each board, by directing their gaze in the direction of the desired card (up, down, left, right). The system was positively rated by both people wiht ALS and those with experience as patients in Intensive Care Units of a hospital to support communication of basic needs. Despite the initial promising results, we found no evidence of other publication that evaluated the usability and feasibility of the application in out-of-the-lab conditions. Our work seeks to contribute to the current research in gaze-based AAC in the Global South by evaluating the usability and suitability of a freely available Android application in Ghana.

3 Methods

3.1 Positionality

As a collective of authors, we represent a diversity of identities and values and have worked collaboratively together across several years. Part of the team is Ghana-based, some UK-based and one member is currently in Japan. All of us have benefited from higher education and work experience in relevant sectors which we recognise as a privilege and an opportunity to develop deep insight. Some of us experience impairments ourselves, including difficulty in articulating speech, and some of us have clinical experience, while others of us have a background in global health or technology for development. Across the group, we offer disciplinary experience in Engineering (including computer science) and Inclusion (social, economic, political and disability justice). This research is part of a trajectory of collaborations in Ghana, as part of the [project name annonymised for review], which seeks to understand how to leapfrog barriers to AT access for people living in lower-income settings to enable inclusion.

Our normative position aligns with other work on feminist HCI, postcolonialism, and disability justice [6, 23, 31, 33, 43], was not to find ways to make the existing technology work for the people that need it, or worse attempt to teach disabled participants how to adapt to the technology. Instead, it was to objectively and kindly establish how and if it was useful as a tool to enable communication for those that need it. In keeping with our overarching research intention, we sought to understand 'what works' and what does not in the context we examined.

Like any study such as this, complexities arise and are handled as the work progresses. We sought to keep the question *'Are we being too optimistic about the usefulness of the technology?'* intentionally held as we navigated the research. The results presented in this paper tell the story of our evolved understanding and this critical reflection. As

we believe that the work presented in this paper is made possible by expertise and contribution as a collective and with no hierarchical order, we present all authors as equal contributors and simply list ourselves in alphabetical order.

3.2 Look to Speak Application

. Look to Speak is an Android application developed by Google Creative Lab. Designed to assist individuals with speech and motor impairments, the app enables people to communicate by selecting images or pre-written phrases using eye movements alone. Using the smartphone's front-facing camera, users can navigate through a customisable list of images or phrases by looking left, right, or up, which the app then vocalises aloud.

The device needs to be positioned at eye level, ensuring the front camera can clearly detect eye movements. Ideally, the phone should be mounted on a stand. The Look to Speak interface displays images/phrases divided into two columns: left and right (see Figure 1, step 1). To select a phrase, look off-screen in the direction (left or right) corresponding to the column containing the desired phrase. This action narrows down the choices (see Figure 1, step 2)

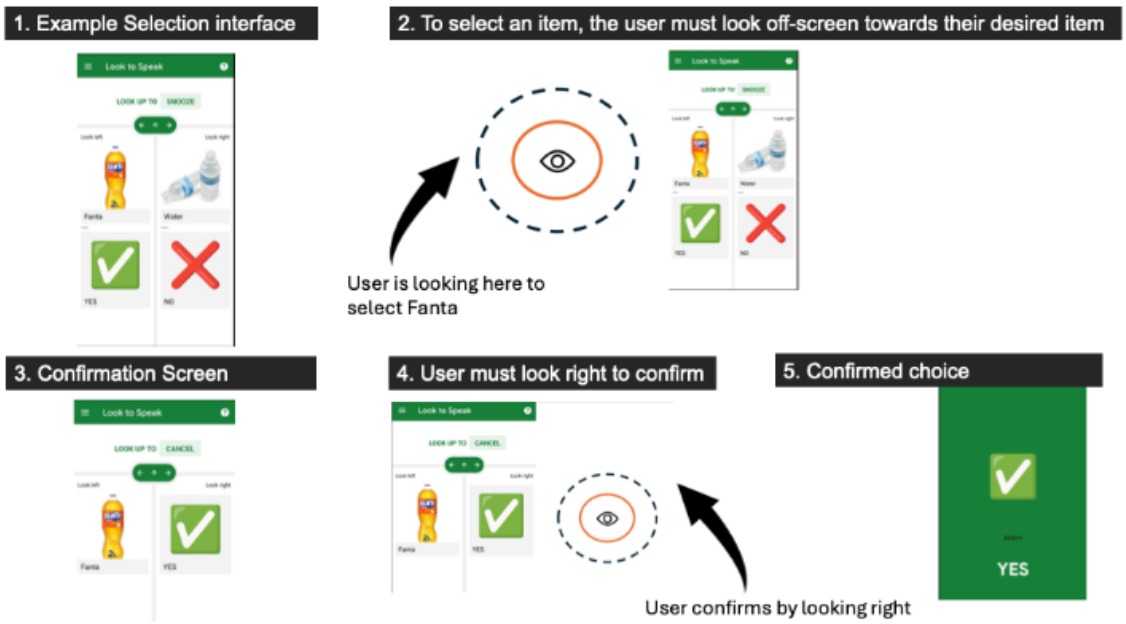

Fig. 1. Workflow for a user in selecting an item using Look to Speak application

Once the application detects the selection, all the items on the relative side of the screen are rearranged across the two sides, and the system waits for the user to use their eye movement to make a new selection (see Figure 1, step 3). The process is repeated until the user makes the final selection, and then the associated phrase is spoken aloud by the app (see Figure 1, step 4). A confirmation screen is shown when a final selection is made (see Figure 1, step 5). Looking upwards pauses the app or cancels the current selection, and to resume, glance left and then right.

A settings tab enables customization of images or phrases, adjusts gaze sensitivity, and practice using the app. This cannot be accessed using eye movement.

Look to Speak Includes a basic set of words that can be displayed in writing, as icons, or using pictures loaded by the user. New words, expressions, and icons can be added according to the individual's needs, and the system simply reads aloud in English the words or sentences typed by the user when configuring a particular icon.

Operating Look To Speak can feel counter-intuitive in at least two ways: firstly to select an item you have to look away from the item off the phone screen, rather than looking at it. Additionally, an item is not selected immediately, only the available options on the side of the screen that the item sits on according to the procedure explained above. This means that if there are multiple objects to choose from (there can be up to 16) then multiple steps of looking left or right off the screen may be required to choose a single item, up to three selections if one is using all 16 available slots.

3.3 Collaboration with local SLTs

To ensure that participants would be supported beyond the duration of the project, we used our connections to recruit ten SLTs operating in different parts of Ghana and who had experience working with a variety of clients living with severe physical and speech limitations due to a variety of conditions, including Cerebral Palsy, Parkinson's Disease, and Stroke. The SLTs participated in a training session to go through the operation and customisation of Look-To-Speak.

At the start of the session, our team provided an overview of the Look to Speak application, illustrating how one can create and add words to the application, arrange existing items, customise settings depending on individual preferences, as well as verifying and adjusting the position of the phone using the provided adjustable holds procured by our team to ensure that the camera would be able to track the eyes of the users, and discuss potential challenges that might arise due to light variation especially in outdoor environments. After familiarising themselves with the interface, the SLTs then worked in pairs to configure Look To Speak, role-playing how they would introduce the tool to a new client. An image of the SLTs practising with the application is shown in Figure 2.

Our experience is that the operation of Look To Speak can take some time to learn, and the cognitive skill required to learn is sometimes a barrier to practical use. We discussed these challenges in the training sessions and that they should be considered ahead of introducing Look To Speak to a client. Based on our previous clinical experience we recommended the SLTs configure Look To Speak with only two available selections initially and provide scaffolded support to help the client get used to how Look To Speak works. Additional selections can be configured as the client's confidence in using the tool grows. We also recommended making the selections something that each client might find relevant and might choose in daily life, not an abstract option or concept unrelated to their lived experience.

Additionally, as no Ghanaian language is currently available in Look To Speak, we recommended that the SLTs use the 'Text Free Mode', which enables photos, symbols or images to be selected rather than only text (Text Free Mode also allows both images and text be displayed at the same time if preferred). However, once an image is selected, text describing the item will be 'spoken' in the default language of the phone setting (English in this case) – there is no way of turning the read aloud feature off in the settings, and simply displaying the chosen image to a conversational partner. The only strategy is reducing the volume of the phone to zero.

3.4 Participants

The local SLTs recruited participants identified as having severe motor and speech limitations who may benefit from eye- movement-based phrase selection and who had the cognitive skills to operate Look To Speak. To qualify for participation, individuals had to be over 18 years old, be able to provide informed consent, and be able to communicate in English or a Ghanaian language spoken by at least one of the SLTs. There was no restriction on aetiology.

Fig. 2. Three SLTs practising the use of the Look to Speak application during the training session

Fifteen people participated in the study. Twelve are living with Cerebral Palsy, two with Stroke and one with Parkinson's Disease. Seven identify as male, and eight as female. The youngest person was 18 years old and the oldest 78 years old. Before this research, none of the SLTs or participants were aware of or had used Look To Speak. All participants had access to a mobile phone, but several did not own a smartphone with the required specifications to download and use the Look To Speak application. If participants' mobile phones did not meet the minimum specification (Android version 8), we provided them with a Samsung A05, which they could retain beyond the end of the project. If participants already 10 possessed a smartphone meeting the required characteristics, we provided the equivalent compensation of approximately 120 USD. In our exchanges with the ethics committee at «annonymised for review» we identified the potential risk of coercing participants to join the research out of interest in obtaining a phone or receiving substantial compensation. To mitigate this, we leveraged the connection and existing relationships of trust that participants had with local organisations and SLTs. Participants were explained how joining the study was voluntary, and they could withdraw at any time and retain their phone or the compensationprovided as an alternative. Their participation in the study would also not affect any SLT services they were already receiving or would request in the future. However, prolonged engagement with the research team could mean that we could provide support with the

application if they needed it and help get their voices heard as we planned to lobby for requested changes with the Google Look To Speak team.

3.5 Procedure and Data Collection

Onboarding sessions with participants were carried out at the office of the SLT in the local hospital or clinic, or at participants' homes, depending on their preference. Onboarding sessions were conducted by the treating local SLT with support from at least three members of the research team. Participants were invited to bring along a family member or a support person if they wished to do so. After obtaining informed consent from participants and setting up their mobile phones and Google accounts, we downloaded the Look To Speak application from the Play Store. The local treating SLT then worked with the client and carers to identify items familiar to the client to set up in Look To Speak so that the client could initially train on 2 items, progressing to 4 and more as and when the client demonstrated ease of use.

The local SLT led the session, talking in the client's preferred language, and demonstrated how Look To Speak could be operated, selecting on the app images of items that the client is known to choose to have frequently (for example, a drink or a snack). One research team member is a physiotherapist and supported the carers with positioning the app in the most accessible way for the client when assistance was needed.

Finally, we conducted semi-structured interviews with participants and their supporters to understand their existing communication difficulties in daily life, their aspirations for more equitable and accessible communication in various aspects of life, their expectations for the application, the difficulties encountered during the onboarding session, and any other feedback about the session or the application. As most participants had extremely little if any residual speech, we relied on supporters and their SLTs to provide details as needed and invited participants to express themselves either verbally or non-verbally to their prefer extent. Some participants and supporters also showed us short videos, pictures, meaningful objects and in one cases even their social media profiles to illustrate specific episodes of relevance in relation to their communication modalities in everyday life, their thoughts on the application and aspirations for appropriate communication tools. When external digital material, such as pictures or videos, belonging to the participant the researchers took notes and detailed descriptions to record the information while preserving the privacy of the participants as much as possible. Onboarding sessions were video recorded with the consent of participants and their supporters consent.

3.6 Data Analysis

Our data corpus consists of notes, pictures, videos and transcribed recordings of semi-structured interviews and debriefing sessions with SLTs. We analysed data collaboratively using reflexive thematic analysis with a bottom-up approach, with members of the research team reflecting on codes individually and discussing them with the other members during debriefing discussions after each session with a client and for a total of 4 group meetings that took place after data collection was completed. After conducting the four meetings, data had been organised in 85 codes grouped under three different themes: Application promises and shortcomings, Ecosystem successes and failures, Knowledge gaps and awareness of workarounds. For example, the theme *"Application promises and shortcomings"* categorized the ways in which the Look to Speak application would support participants communication needs as well as the way in which particular design features, or lack thereof, caused unnecessary usability challenges or breakdowns in communication. Examples of codes included in the theme are: *"Lack of language support"*, *"Confusing support of multimodal interaction"*, and *"Hear my voice"*.

4 Results

As none of the clients, supporters or SLTs had previous practical experiences with gaze-based AAC, they were all understandably excited by the prospect or trailing the Look to Speak application. However, results from our trials indicate that while most of the clients were able to operate the application, at least to a point, Look to Speak was unlikely to become a functional tool for communication in daily life. This is due to a variety of factors that affected if and how participants could utilize Look to Speak, how well it would fit their contextual circumstances, and what impact it could have on their lives. In the following sections ,we present the insights that emerged from our research, conceptualised across three different teams.

4.1 Application promises and shortcomings

Of the 15 clients who took part in our study, the majority had little or no functional residual speech, with most being able to consistently produce basic vocalizations to communicate with their supporters (P2, P4, P5, P6, P8, P11, P12, and P15), others being able to occasionally utter some simple words in daily communication (P1, P13, P14), two who had limited issues with speech articulation and were primarily affected by challenges with word finding or incoherent speech due to aphasia (P7, P9), and two who had no functional residual speech or vocalization (P3, P10).

The Look-to-Speak application was particularly suited for clients with varying conditions and degrees of residual speech, especially those with little or no speaking abilities. After learning about the application and seeing their Speech and Language Therapists (SLTs) demonstrate its use, all clients showed interest in trying it.. However, during the introduction of the project with both P7 and P9 it became clear that their verbal abilities likely exceeded the ones that Look to Speak could provide,. Despite this both clients as well as their accompanying supporters expressed an interest in trying out the application to evaluate if it could offer any advantages in daily life. For some participants and their supporters, the primary motivation was that Look-to-Speak was the first tool they encountered that could help clients communicate with people unfamiliar with them. This can be seen by P2's mother and P9:

"When P2 moves or makes a sound I know what she wants to tell me because I am her mother, but other people never understand or listen if I don't explain. I think this thing can help her say things to others when she wants" - P2's mother

"Saying what I want is hard sometimes and maybe this program in the phone could help me" - P9

Others were more cautious, wanting to explore whether the application would indeed be helpful.

A few participants displayed a fast understanding of how to operate the Look to Speak application using their eye movements, with P4 being able to master selections with more than two items on the screen after a remarkably short time. P4 is a 25-year-old power wheelchair user who lives at home with her family. She is a frequent social media user and was able to post and exchange messages with friends, using her tongue to type out messages into a smartphone positioned on a tray table in front of her wheelchair, which she was keen on demonstrating to the researcher to show she could interact with the phone in various ways. After trialling Look To Speak, P4 showed how she could use eye movement to call her carer and ask for a drink using the synthesised voice in English. Both P4 and her cousin, who was one of her carers, did not feel that Look to Speak would substitute daily communication, but stated that it could be a useful tool to call when specific needs arise or when she wanted to use repeated common sentences.

"This can help me and P4 when I am in the kitchen as she can tell me what she wants, and it is easy for me to understand because I have understanding of English" - P4's cousin

As mentioned by P4's cousin, when pronouncing selected words Look to Speak utilized English. More specifically Look to Speak currently supports 17 languages through the speech to text interface embedded in the Android operating

system. However, none of these are languages commonly spoken in Ghana, with the exception of English. Most of the clients and supporters stated that they would have preferred for the application to speak in their own local Ghanaian language ("I do not know any English, and nobody in the village does, so they could not communicate with my brother if he uses this phone. Only he could understand." - P10 sister). To support clients, SLTs experimented with phonemic spellings of words to try to enable Look to Speak to respond using words that were better suited to the client and their communication partners. Although this was judged to be partially successful - the spoken words were often understandable even though they were pronounced incorrectly - it would have clearly been better for the languages spoken by Ghanaians to be available in the first place.

Although the communication opportunities that Look to Speak supported often did not meet functional requirements for many situations, the simple experience of being able to select and speak the desired words represented a meaningful opportunity to connect for clients and their caregivers. P1 for example is a 19-year-old girl with Cerebral Palsy who has almost no functional speech. She had been abandoned as a child because of her disability, but thanks to the support of the local church, she lives, together with her two adopted brothers P2 and P3, who had a similar background, in a house in Accra where their three adoptive mothers help to care for them. After experimenting with simple "Yes" and "No" options to gain confidence. When asked which words she wanted to add, she pointed at her mother and mimicked a kiss, indicating that she wanted to add the words "I love you". Using Look to Speak, she was able to express her love for her parents by saying the words *"Mum, I love you" - P1*, causing her mother to hug her warmly, both smiling with joy at being able to share such a moment. The mother of P2, who was also present, stated:

"We know that our children want to say many things, but it is so different when they can say what they want" - P2's mother.

P2, in a similar fashion to P6, P11, and P13 and P15 preferred utilizing the touch screen to make selections with their fingers rather than using their eye movement, as shown in Figure 3. This is actually a possible option, as Look to Speak does not deactivate the touch screen so participants can make selections by touching the corresponding side of the screen (left, right, or up to snooze the application), following the exact same procedure they utilized to make gaze-based selections. However, the application does not provide different settings depending on the interaction modality, meaning that the camera would still detect their eye movement, causing unwanted selection or snoozing which generated frustration ("I think he is getting tired because the application makes mistakes when he is trying to chose" - P15's mother). Although we attempted to cover the smartphone front camera to minimize mistakes, this caused Look to Speak to snooze itself as the application could not detect the eyes of the user.

4.2 Ecosystem successes and failures

The creativity displayed by SLTs and clients' supporters in experimenting with phonemic spelling to overcome the language limitations of the Look to Speak application showed how, as documented in previous research on mobile technology in the Global South [7, 8, 55], the human infrastructure can often step in to bridge the gaps left by technological mismatches. Supporters and SLTs also helped users to customise the options, for example adjusting for the often preferred 'text-free' option over the 'text only' option for the user interface. SLTs explained how this was sometimes due to the low literacy of their clients, but also because when utilizing the phonemic spelling for the local Ghanaian, especially for words that included characters not used in English such as ε, seeing the word written would only cause confusion.

"Some of the clients don't read well so looking at the pictures is easier, and if you write the Ghanaian words they sound correct but this is not how you normally write them" - SLT of P8, P9, and P12

Fig. 3. P11 attempting to use look to speak using his hands as assisted by the SLT and researcher

Supporters and SLTs would also play a huge role in helping, participants practice, provide encouragement as they learned to navigate through the selection process, and offer suggestions which could facilitate their loved ones in selecting words that were meaningful to them (*"I want to try use the world football and Jollof rice as my brother is amazing at football and he likes to eat a lot of rice that our mother cooks" - P12's younger sister*). Supporters would also step in to provide reassurance when the technology failed to meet the needs of a client. This was evident in the case of P7, a 66-year-old man who lives at home with his wife. P7 has been diagnosed with Parkinson's disease for more than three years and often requires extended time to start speaking or find the right words – frequently more than a minute or two. His voice is often low volume - a near whisper, making communication with his wife very challenging for both of them (*"Early in the morning he can communicate more when he is refreshed, but as the day goes and he becomes tired sometimes he cannot say things anymore" - P7's wife).* Both of them hoped that Look to Speak could be useful to speed communication especially when he became tired. However, after testing the app, it was clear that the progression of Parkinson's had affected P7's eye movements – shifting gaze from one point to another during the selection of phrases was particularly difficult and fatiguing. The SLT and researcher advised exploring other AAC options, such as a touch-based communication device with pre-programmed phrases, or a communication board which could provide

more reliable support as the disease progressed. P7 was visibly discouraged by the faillure of Look to Speak, but his wife was quick to offer support *"Don't worry, this is not your fault, this application does not work but with [name of the SLT] we can try other things that are easier for us" - P7's wife.*

Despite the dedication they demonstrated there was one substantial issue which was experienced by P5, P14 and P15 which supporters and SLTs could not address during the trials. Look To Speak requires stable positioning so that the phone camera can always see the face of the user to allow them to select items (See Figure 4). This was a particular difficulty for these clients who had complex postural support needs, did not have appropriate seating or a wheelchair, and experienced muscle spasms which required frequent and recurrent repositioning by carers. One of our team is an experienced Physiotherapist and was frequently able to support with the positioning in the sessions and offer advice to carers about how to use common cushions to provide some postural support. However, available strategies could not address clients needs satisfactory. As an example, P14 who is 19 years old and lives with her mother in temporary housing within a camp originally designated for refugees. As the mother explained ("She has Cerebral Palsy, so she cannot talk and moving is difficult. But she can understand me when I talk to her in English. She can sit, but she gets uncomfortable and her back hurts so she prefers to stay on the floor in the hour because she moves more freely" - P14). P14 does not have access to a wheelchair and was seated in a communal child car safety seat to try Look To Speak. Due to frequent involuntary movement, we were unable to consistently position Look To Speak so that she could easily select items. It was clear that P14 understood how to operate Look To Speak wanted to communicate through it and has the cognitive skills to use it, but the need for consistent repositioning, made the application too cumbersome for her and her mother. This was further exacerbated by the lack of feedback from Look to Speak in case of misalignment. While the application provides a warning message on the screen (in English only) when the phone camera cannot see a face, it does not offer help when the positioning can be improved. This lack of feedback makes it extremely challenging for clients and supporters to what the cause of a problem may be when someone looks away from the screen to select an item and nothing happens as it could be due to incorrect positioning as much as by the user having difficulty performing the correct eye movement.

4.3 Knowledge gaps and awareness of workarounds

Although some participants experienced some degrees of success when operating Look to Speak, for most of the referred clients, the initial assessment and trials showed that alternative approaches for AAC or communication support, such as direct access touch based communication boards, would have likely been preferential. Six clients demonstrated very significant cognitive communication difficulty and could not operate or access Look to Speak or the smartphone at all, by any modality. For example, P8 is a 60 years old woman who is living with a stroke that has severely affected her communication and left her with significant muscle weakness on her right side. P8 experienced aphasia as a result of the stroke which makes it difficult for her to find and articulate words ("Sometimes she gets very upset as she wants to say something but cannot" - Carer in the facility where P8 lives). Although the SLT, P8 and the carers at the facility hoped that Look to Speak could help her express her desires more clearly and communicate with others, after several attempts, it was clear that the cognitive challenges to use the app were a barrier for her as she struggled to move her gaze to make selections. We discussed with P8 and her team what might be some alternative AAC options, such as simplified boards with icons, continued use of non-verbal communication, as well as the use of simple signs.

P8 was not an isolated case, and for the majority of the clients, even those who were willing to continue attempting to use Look to Speak for daily life, we discussed with clients and supporters potential alternatives which could be more functional in everyday life. The high rate of unsuccessful referral from SLT was partially due to the lack of knowledge

Fig. 4. P4 operating the Look to Speak application while sitting on her wheelchair, showing good alignment between the position of the eyes and the camera

concerning the strengths and limits of this type of AAC, which is difficult to acquire without direct experience ("At the start of the project, even with the explanation and training it was hard to know which clients might benefit from the application. Now that I have seen many assessments I can think better of which client needs the application can meet - Participating SLT).

An additional reason for referral which was discussed with the SLT of P12 was linked to the lack of success or availability of other AAC approaches and 'trying out' eye gaze as a possibility. This has been documented in other contexts as well [20], where eye gaze may be seen as something to try when the SLT and clients have run out of possible alternatives. Moreover, P12's SLT explained how sometime excessive perseverance could be due to fear of stigmatization from parents or supporter who pushed for the use of technology in the hope their loved ones could overcome their speech difficulties.

"The mother is very worried about her son being bullied if he cannot communicate with words, so when we suggest using signs, they would still prefer the app even if it is not the best solution" - P12

Although it is good practice to try out different options based on the strengths and needs of the client, technology should only be included where it fits the needs of a user. This may indicate that training may be beneficial - in client

needs-based AAC and options for communication strategies in addition to AAC - such as conversation partner training. Moreover, although fear of stigmatization and the desire for verbal communication is understandable, pushing a person with communication difficulties to persevere with a technology that does not address their needs will simply cause unnecessary frustration to the individual, often with individuals blaming themselves for technological failures, and preventing them from exploring more beneficial strategies.

5 Discussion

To the best of our knowledge, our study was the first attempt to assess the usability and feasibility of the Look to Speak Android application for Ghanaian users who experience communication disabilities. Our findings highlight how, despite a small number of participants being able to operate the application to engage in communication, Look to Speak did not meet the needs of the majority of the clients. This was linked to a variety of reasons that included shortcomings in the design application, excessive complexity for those experiencing impaired cognition, ecosystem failures such as the lack of adequate postural support, and knowledge gaps of SLTs around gaze-based technologies which prevented them from identifying who would and would not benefit from the technology. Based on our results we propose ways to improve contextual appropriateness of Look to Speak and other AAC technologies, as well as highlight necessary gaps that needs to be addressed from an ecosystem point of view to enable people with speech difficulties in the Global South to access and benefit from gaze-based AAC devices.

5.1 Develop more context appropriate AAC apps

One significant limitation of Look to Speak, as well as other mainstream AAC developed in most of the Global North is the lack of support for local languages and dialects spoken in much of the African region [6, 39]. In multilingual societies, especially in the Global South, this presents a substantial barrier to effective use [5, 63]. Many potential users, including persons with disabilities and their caregivers, may have limited literacy in dominant or official languages. Incorporating local language options would not only enhance usability but also support cultural relevance and user dignity. As emphasized by scholars, clients and practitioners, integrating cultural and linguistic dimensions into the localization of assistive technologies is essential for ensuring meaningful interaction and user engagement [39, 54, 63]. When AAC tools are available in users' native languages, they become more intuitive and inclusive, particularly for individuals with limited exposure to formal education or digital technology. As we acknowledge the difficulties and time necessary to develop appropriate Text-to-Speech models for all minority languages in the Global South, we also suggest that a possible work around for quickly enabling users themselves to make the application more contextually relevant do exist. In the case of Look to Speak it would simply require the addition of an option that removes the reliance on Text-to-Speech and allows the users to record messages directly to be read aloud when an item was selected. This would mean that the message would be spoken in the correct way with the appropriate accent and construct suited to the communication environment. This approach has a secondary benefit in that someone could record a message longer than the maximum 40 characters allowed by the application for text based messages.

Contextualization was not only related to the available language of the application, but also the words and icons displayed on the user interface. When installed and opened for the first time Look to Speak comes with a default selection of suggested items to choose from, and it is up to the user to customise this set based on their needs and preferences. As shown before in other studies in different region of the Global South when deploying AACs with culturally irrelevant images [3, 4, 51], for our participants in Ghana, many of the items needed to be replaced with more appropriate options, taking time and adding a barrier to usability 'out of the box'. One option to offer a more

contextually relevant experience from the beginning would be to specify the default setup by country. For example a Ghana setup could include popular phrases, food items, places and things, with relevant representative images, such relatively simple adjustment would enable for an easier onboarding of new users.

Finally, our study aligns with previous research which highlights the importance of correct positioning for optimal use of gaze-based AAC and other interfaces [12, 30]. While ensuring appropriate seating and postural support falls outside the responsibilities of design teams of mobile AACs, providing feedback about erroneous user input is something that should be included. Unfortunately, Look to Speak only notifies the users if the camera does not detect the face, but if the eyes are not placed in a central position, which might influence the sensitivity of left vs right movements, no feedback is provided to the person. Moreover, we argue that when users are attempting to interactive with something cognitively complex such as gaze-based AACs, each actions they undertake should result in an outcome: either a successful selection, or feedback that the selection has been unsuccessful and steps to remedy. We observed many occasions when a client appeared to do an action successfully (for example looking off the screen left or right), with no result, but Look to Speak provided no feedback about potential mistakes. What would be more helpful would be for the application to show it recognizes that the client is doing something (like looking left off the screen) and provide a clear indication of how much longer or how much further left (or both) the client would need to perform the action in order to successfully complete the selection. As previous studies with clients and practitioners have documented, eye-gaze interfaces are complex and often hard to understand for people, relying on small movements that is challenging to perform correctly and receiving appropriate feedback from the interface is essential for the users to be able to learn more quickly [20].

5.2 Acknowledging Ecosystem Requirement of gaze-based AACs

Our results show the importance of understanding the human and technical infrastructure within which an application such as Look to Speak will be used. Previous work has highlighted the increased work on human infrastructure that is often necessary in the Global South to overcome the lack of technical infrastructure [7, 8, 47, 55]. This was also the case in our study. Additionally, we found that the lack of integrated healthcare systems particularly the provision of wheelchairs with appropriate postural support to enable correct positioning of clients, could hinder the usability of Look to Speak, even if the person was able to correctly execute the interactions and would ha benefited from using the technology. In the accessibility and HCI research community there is increased awareness about the dependencies between multiple assistive technologies which are often used by a single person [8, 22, 47, 59]. However less attention is paid to the diverse service ecosystems on which the user depends on to access the assistive technology in the first place.

Within the assistive technology domain, scholars have offered significant contributions to map this, for instance, in the SMART matrix approach [36], which takes a micro (user) meso (service provider) and macro (inter/national) level view of the systems levels. According to this framework, Ghana would be seen as a minimally functioning market – where at an individual level, people find it difficult to get products that match their needs, with limited person-centred assessment and prohibitive costs. This is in part due to problems at the meso level – where there are limited services to provide and maintain assistive devices due to problems at the macro level – a lack of national level procurement and limited innovation. Within this framework, Technology such as Look To Speak might have been thought to be an innovative solution that could leapfrog the system's challenges. Ideally, this would have been the case, as it is in places such as Ghana that there is real demand and the possibility of transformative impact if we, as HCI researchers, are able to design for and, in this context, understand the limitations of infrastructure and knowing what is within our power to change.

Finally, integral to the ecosystem is the SLT. They play a critical role in identifying and recommending appropriate AAC tools to individuals with complex communication needs. As noted by van Niekerk and Tönsing [66], awareness of eye gaze technologies among professionals is a key determinant of their adoption and implementation. It was clear that by the end of our sytudy SLTs had a much greater understanding of the use cases where Look to Speak could be useful, as well as the potential of the technology to raise hopes, and then not meet these. There is a need for SLTs to be aware of the existence and functionality of digital assistive technologies such as Look to Speak. As well as for tools that can help them identify available options depending on the needs of different clients to be able to make more informed recommendations about which technologies might or might not be most suitable to them. Engagement between the accessibility and AAC development community with SLTs in the Global South is a crucial step in facilitating the creation of such a tool for organizing knowledge and their integration clinical practice which would ultimately promote better outcomes for clients with speech disabilities.

6 Conclusion

In conclusion, our research into the novel free-to-use Look To Speak gaze-based AAC application with people living in Ghana with communication challenges demonstrated that while the application offered some positive experience to a number of clients, it did not sufficiently meet the needs of the majority of participants for a functional communication aid. For many the application was too cognitively demanding, and the lack of local language support made it difficult for people to to be understood by others. Participants and their supporters often developed strategies, such as utilizing phonemic spelling to produce audio in local language, to bridge certain design shortcomings in the application, but challenges including lack of postural support necessary for correct positioning, could not be adequately addressed. Finally, due to low familiarity with the technology, local SLTs struggled to identify potentially suitable clients, which highlights the need for better training about gaze-based interfaces and other AAC amongst professionals in the Global South.

References

[1] S Adithyan, G Dhyaneshwar, S Shivani, Varshini Karthik, and Ashok Kumar. 2020. Eye Tracking as a form of Alternate and Augmentative Communication for people with Speech, Language and Communication Needs. In *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)*. IEEE, 945–948.

[2] Erna Alant. 2007. Training and intervention in South Africa. *The ASHA Leader* 12, 10 (2007), 11–12.

[3] Rebecca Amery, Abirami Thirumanickam, Ruth Barker, Anne Lowell, Deborah Theodoros, and Parimala Raghavendra. 2022. Developing augmentative and alternative communication systems in languages other than English: A scoping review. *American Journal of Speech-Language Pathology* 31, 6 (2022), 2900–2919.

[4] Rebecca Amery, Julie Gungungbuy Wunungmurra, Gurimaŋu Bukuatjpi, Rachel Dikul Baker, Farrah Gumbula, Elah Yunupingu, Parimala Raghavendra, Ruth Barker, Deborah Theodoros, Howard Amery, et al. 2022. Designing augmentative and alternative communication systems with Aboriginal Australians: vocabulary representation, layout, and access. *Augmentative and Alternative Communication* 38, 4 (2022), 221–235.

[5] Natalie R Andzik and Hannah N LaMarca. 2024. Multilingualism and augmentative and alternative communication: A review of the literature. *Perspectives of the ASHA Special Interest Groups* 9, 3 (2024), 642–651.

[6] Gifty Ayoka, Giulia Barbareschi, Richard Cave, and Catherine Holloway. 2024. Enhancing Communication Equity: evaluation of an automated speech recognition application in Ghana. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*. 1–16.

[7] Giulia Barbareschi, Catherine Holloway, Katherine Arnold, Grace Magomere, Wycliffe Ambeyi Wetende, Gabriel Ngare, and Joyce Olenja. 2020. The social network: How people with visual impairment use mobile phones in kibera, Kenya. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–15.

[8] Giulia Barbareschi, Ben Oldfrey, Long Xin, Grace Nyachomba Magomere, Wycliffe Ambeyi Wetende, Carol Wanjira, Joyce Olenja, Victoria Austin, and Catherine Holloway. 2020. Bridging the Divide: Exploring the use of digital and physical technology to aid mobility impaired people living in an informal settlement. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. 1–13.

[9] Kasky Bisimwa, Irwin Brown, and Kevin Johnston. 2018. Mobile phones use by urban refugees in South Africa: Opportunities and challenges. (2018).

[10] LJ Burkhart. 2011. What is AAC? International Society for Augmentative and Alternative Communication. https://isaac-online.org/english/what-is-aac/. [Accessed 16-04-2025].

[11] Shanqing Cai, Subhashini Venugopalan, Katrin Tomanek, Ajit Narayanan, Meredith Ringel Morris, and Michael P Brenner. 2022. Context-aware abbreviation expansion using large language models. *arXiv preprint arXiv:2205.03767* (2022).

[12] Szu-Han Kay Chen and Michael O'Leary. 2018. Eye Gaze 101: what speech-language pathologists should know about selecting eye gaze augmentative and alternative communication systems. *Perspectives of the ASHA Special Interest Groups* 3, 12 (2018), 24–32.

[13] Zoë Charlotte Clarke, Simon Judge, Kate Fryer, Stuart Cunningham, Jonathan Toogood, and Mark S Hawley. 2023. A qualitative study exploring the effect of communicating with partially intelligible speech. *Augmentative and Alternative Communication* 39, 2 (2023), 110–122.

[14] Shakila Dada, Harsha Kathard, Kerstin Tönsing, and Michal Harty. 2017. Severe communication disabilities in South Africa: Challenges and enablers. *Inclusion, disability and culture: An ethnographic perspective traversing abilities and challenges* (2017), 169–193.

[15] Karla de Oliveira, Jefferson Junior, Jefferson Silva, Nelson Neto, Marcelle Mota, and Ana Oliveira. 2016. VoxLaps: A free symbol-based AAC application for Brazilian Portuguese. In *Universal Access in Human-Computer Interaction. Interaction Techniques and Environments: 10th International Conference, UAHCI 2016, Held as Part of HCI International 2016, Toronto, ON, Canada, July 17-22, 2016, Proceedings, Part II 10*. Springer, 129–140.

[16] Sylvia Dickson, Rosaline S Barbour, Marian Brady, Alexander M Clark, and Gillian Paton. 2008. Patients' experiences of disruptions associated with post-stroke dysarthria. *International Journal of Language & Communication Disorders* 43, 2 (2008), 135–153.

[17] Hilary O Edughele, Yinghui Zhang, Firdaus Muhammad-Sukki, Quoc-Tuan Vien, Haley Morris-Cafiero, and Michael Opoku Agyeman. 2022. Eye-tracking assistive technologies for individuals with amyotrophic lateral sclerosis. *IEEE Access* 10 (2022), 41952–41972.

[18] Tanja W Effing, Amy Litton, Charlene Cullen, Suzanne C Hopf, Josephine Ohenewa Bampoe, Clancy Conlon, and Karen Wylie. 2024. Building AAC capacity in Majority World countries: protocol for a pilot study evaluating the feasibility of an AAC implementation approach in Ghana. *Journal of Clinical Practice in Speech-Language Pathology* (2024), 1–13.

[19] Mohammed Eliyas and Sivaranjani Balasubramanian. 2021. AAC intervention for stroke survivors–An anomic aphasic case study. *International Journal of Health Sciences and Research* 11, 12 (2021), 152–156.

[20] Tom Griffiths, Simon Judge, and David Souto. 2024. Use of eye-gaze technology feedback by assistive technology professionals: findings from a thematic analysis. *Disability and Rehabilitation: Assistive Technology* 19, 7 (2024), 2708–2725.

[21] Dynavox Group. 2024. Company History — dynavoxgroup.com. https://dynavoxgroup.com/pages/our-history. [Accessed 16-04-2025].

[22] Florian Güldenpfennig, Peter Mayer, Paul Panek, and Geraldine Fitzpatrick. 2019. An autonomy-perspective on the design of assistive technology experiences of people with multiple sclerosis. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–14.

[23] Christina N Harrington, Aashaka Desai, Aaleyah Lewis, Sanika Moharana, Anne Spencer Ross, and Jennifer Mankoff. 2023. Working at the intersection of race, disability and accessibility. In *proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility*. 1–18.

[24] Shyamani Hettiarachchi, Gopi Kitnasamy, and Dilani Gopi. 2020. "Now I am a techie too"–parental perceptions of using mobile technology for communication by children with complex communication needs in the Global South. *Disability and Rehabilitation: Assistive Technology* 15, 2 (2020), 183–194.

[25] Eva Holmqvist, Gunilla Thunberg, and Marie Peny Dahlstrand. 2018. Gaze-controlled communication technology for children with severe multiple disabilities: Parents and professionals' perception of gains, obstacles, and prerequisites. *Assistive Technology* 30, 4 (2018), 201–208.

[26] Lorraine Hudson, Clement Amponsah, Josephine Ohenewa Bampoe, Julie Marshall, Nana Akua Victoria Owusu, Khalid Hussein, Jess Linington, Zoe Banks Gross, Jane Stokes, and Róisín McNaney. 2020. Co-designing digital tools to enhance speech and language therapy training in Ghana. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.

[27] Caroline Jagoe, Caitlin McDonald, Minerva Rivas, and Nora Groce. 2021. Direct participation of people with communication disabilities in research on poverty and disabilities in low and middle income countries: A critical review. *Plos one* 16, 10 (2021), e0258575.

[28] Jasmine Jones and Joyojeet Pal. 2015. Counteracting dampeners: understanding technology-amplified capabilities of people with disabilities in Sierra Leone. In *Proceedings of the Seventh International Conference on Information and Communication Technologies and Development*. 1–10.

[29] Petra Karlsson, Abigail Allsop, Betty-Jean Dee-Price, and Margaret Wallen. 2018. Eye-gaze control technology for children, adolescents and adults with cerebral palsy with significant physical disability: Findings from a systematic review. *Developmental neurorehabilitation* 21, 8 (2018), 497–505.

[30] Petra Karlsson, Tom Griffiths, Michael T Clarke, Elegast Monbaliu, Kate Himmelmann, Saranda Bekteshi, Abigail Allsop, René Pereksles, Claire Galea, and Margaret Wallen. 2021. Stakeholder consensus for decision making in eye-gaze control technology for children, adolescents and adults with cerebral palsy service provision: findings from a Delphi study. *BMC neurology* 21 (2021), 1–24.

[31] Lynn Kirabo, Elizabeth Jeanne Carter, Devon Barry, and Aaron Steinfeld. 2021. Priorities, technology, & power: Co-designing an inclusive transit agenda in Kampala, Uganda. In *Proceedings of the 2021 CHI conference on human factors in computing systems*. 1–11.

[32] Judy A Lariviere. 2015. Eye tracking: eye-gaze technology. *International handbook of occupational therapy interventions* (2015), 339–362.

[33] Shaimaa Lazem, Danilo Giglitto, Makuochi Samuel Nkwo, Hafeni Mthoko, Jessica Upani, and Anicia Peters. 2021. Challenges and paradoxes in decolonising HCI: A critical discussion. *Computer Supported Cooperative Work (CSCW)* (2021), 1–38.

[34] Janice Light, David McNaughton, David Beukelman, Susan Koch Fager, Melanie Fried-Oken, Thomas Jakobs, and Erik Jakobs. 2019. Challenges and opportunities in augmentative and alternative communication: Research and technology development to enhance communication and participation for individuals with complex communication needs. *Augmentative and Alternative Communication* 35, 1 (2019), 1–12.

[35] Alexander Liu Cheng, Néstor Andrés Llorca Vega, and Galoget La Torre. 2019. Development of an eye-and gaze-tracking mechanism in an active and assisted living ecosystem. In *Proceedings of the 36Th International Symposium on Automation and Robotics in Construction*.

[36] Malcolm MacLachlan, Joanne McVeigh, Michael Cooke, Delia Ferri, Catherine Holloway, Victoria Austin, and Dena Javadi. 2018. Intersections between systems thinking and market shaping for assistive technology: the SMART (Systems-Market for Assistive and Related Technologies) thinking matrix. *International journal of environmental research and public health* 15, 12 (2018), 2627.

[37] Sandra Masayko, Joy McGowan, and Namrata Grampurohit. 2024. Parents' Perceptions of Eye-Gaze Technology Use by Children With Complex Communication Needs. *American Journal of Speech-Language Pathology* 33, 3 (2024), 1254–1265.

[38] Karyn Moffatt, Golnoosh Pourshahid, and Ronald M Baecker. 2017. Augmentative and alternative communication devices for aphasia: the emerging role of "smart" mobile devices. *Universal Access in the Information Society* 16 (2017), 115–128.

[39] Nimisha Muttiah, Jessica Gormley, and Kathryn DR Drager. 2022. A scoping review of augmentative and alternative communication (AAC) interventions in low-and middle-income countries (LMICs). *Augmentative and Alternative Communication* 38, 2 (2022), 123–134.

[40] Andrew Myrden, Larissa Schudlo, Sabine Weyand, Timothy Zeyl, and Tom Chau. 2014. Trends in communicative access solutions for children with cerebral palsy. *Journal of child neurology* 29, 8 (2014), 1108–1118.

[41] Thapelo Nthite and Mohohlo Tsoeu. 2020. End-to-End Text-To-Speech synthesis for under resourced South African languages. In *2020 International SAUPEC/RobMech/PRASA Conference*. IEEE, 1–6.

[42] Inge Odendaal and Kerstin M Tönsing. 2025. Augmentative and alternative communication for individuals with post-stroke aphasia: perspectives of South African speech-language pathologists. *Augmentative and Alternative Communication* 41, 1 (2025), 56–64.

[43] Chinasa T Okolo, Dhruv Agarwal, Nicola Dell, and Aditya Vashistha. 2024. " If it is easy to understand then it will have value": Examining Perceptions of Explainable AI with Community Health Workers in Rural India. *Proceedings of the ACM on Human-Computer Interaction* 8, CSCW1 (2024), 1–28.

[44] World Health Organization and United Nations Children's Fund. 2022. *Global report on assistive technology*. World Health Organization.

[45] Sharan Pai and Anish Bhardwaj. 2019. Eye gesture based communication for people with motor disabilities in developing nations. In *2019 International Joint Conference on Neural Networks (IJCNN)*. IEEE, 1–8.

[46] Joyojeet Pal, Priyank Chandra, Terence O'Neill, Maura Youngman, Jasmine Jones, Ji Hye Song, William Strayer, and Ludmila Ferrari. 2016. An Accessibility Infrastructure for the Global South. In *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development* (Ann Arbor, MI, USA) *(ICTD '16)*. Association for Computing Machinery, New York, NY, USA, Article 24, 11 pages. https://doi.org/10.1145/2909609.2909666

[47] Joyojeet Pal, Priyank Chandra, Terence O'neill, Maura Youngman, Jasmine Jones, Ji Hye Song, William Strayer, and Ludmila Ferrari. 2016. An accessibility infrastructure for the Global South. In *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development*. 1–11.

[48] Joyojeet Pal, Anandhi Viswanathan, Priyank Chandra, Anisha Nazareth, Vaishnav Kameswaran, Hariharan Subramonyam, Aditya Johri, Mark S Ackerman, and Sile O'Modhrain. 2017. Agency in assistive technology adoption: visual impairment and smartphone use in Bangalore. In *Proceedings of the 2017 CHI conference on human factors in computing systems*. 5929–5940.

[49] Joyojeet Pal, Anandhi Viswanathan, and Ji-Hye Song. 2016. Smartphone adoption drivers and challenges in urban living: Cases from Seoul and Bangalore. In *Proceedings of the 8th Indian Conference on Human-Computer Interaction*. 24–34.

[50] Joyojeet Pal, Maura Youngman, Terence O'Neill, Priyank Chandra, and Cyprien Semushi. 2015. Gender and accessibility in Rwanda and Malawi. In *Proceedings of the Seventh International Conference on Information and Communication Technologies and Development*. 1–9.

[51] Eliada Pampoulou and Donald R Fuller. 2020. Exploring AAC graphic symbol choices: a preliminary study. *Journal of Enabling Technologies* 14, 3 (2020), 171–185.

[52] Erin Perfect, Elizabeth Hoskin, Samantha Noyek, and T Claire Davies. 2020. A systematic review investigating outcome measures and uptake barriers when children and youth with complex disabilities use eye gaze assistive technology. *Developmental neurorehabilitation* 23, 3 (2020), 145–159.

[53] Vineetha Sara Philip, Swathi Geetha, and Anitha Naittee Abraham. 2025. Aided Augmentative and Alternative Communication (AAC) interventions in India: A scoping review and quality appraisal. *Augmentative and Alternative Communication* (2025), 1–13.

[54] Tan Ping Ping, Chiu Po Chan, Hamizan Sharbini, and Azlina Ahmadi Julaihi. 2011. Integration of cultural dimensions into software localisation testing of assistive technology for deaf children. In *2011 Malaysian Conference in Software Engineering*. IEEE, 136–140.

[55] Nithya Sambasivan and Thomas Smyth. 2010. The human infrastructure of ICTD. In *Proceedings of the 4th ACM/IEEE international conference on information and communication technologies and development*. 1–9.

[56] Georg I Schlünz, Ilana Wilken, Carmen Moors, Tebogo Gumede, Willem van der Walt, Karen Calteaux, Kerstin Tönsing, and Karin van Niekerk. 2017. Applications in accessibility of text-to-speech synthesis for South African languages: Initial system integration and user engagement. In *Proceedings of the South African Institute of Computer Scientists and Information Technologists*. 1–10.

[57] Suraj Singh Senjam, Souvik Manna, and Covadonga Bascaran. 2021. Smartphones-based assistive technology: accessibility features and apps for people with visual impairment, and its usage, challenges, and usability testing. *Clinical optometry* (2021), 311–322.

[58] Donghoon Shin, Jaeyoon Song, Seokwoo Song, Jisoo Park, Joonhwan Lee, and Soojin Jun. 2020. TalkingBoogie: collaborative mobile AAC system for non-verbal children with developmental disabilities and their caregivers. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.

[59] Kristen Shinohara and Jacob O Wobbrock. 2011. In the shadow of misperception: assistive technology use and social interactions. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 705–714.

[60] Jay Vijay Sonawane and Hansa Varshneya. 2020. AVAZ application (trial version)-A voice for the nonverbal children with autism spectrum disorder: A pilot study. *The Indian Journal of Occupational Therapy* 52, 1 (2020), 8–11.

[61] Sita Sreekumar. 2014. Using AVAZ to enhance communicative abilities of a child with cerebral palsy. *Disability, CBR & Inclusive Development* 25, 1 (2014), 95–102.

[62] Know the ADA. 2025. the-future-of-eye-tracking-in-assistive-technology. https://know-the-ada.com/the-future-of-eye-tracking-in-assistive-technology/. [Accessed 16-04-2025].

[63] Kerstin M Tönsing, Karin Van Niekerk, Ilana Wilken, and Georg Schlünz. 2019. Multilingualism and augmentative and alternative communication in South Africa–Exploring the views of persons with complex communication needs. *African Journal of Disability* 8, 1 (2019), 1–13.

[64] Gillian S Townend, Peter B Marschik, Eric Smeets, Raymond Van de Berg, Marille van den Berg, and Leopold MG Curfs. 2016. Eye gaze technology as a form of augmentative and alternative communication for individuals with Rett syndrome: experiences of families in The Netherlands. *Journal of developmental and physical disabilities* 28 (2016), 101–112.

[65] Stephanie Valencia, Richard Cave, Krystal Kallarackal, Katie Seaver, Michael Terry, and Shaun K Kane. 2023. "the less i type, the better": How ai language models can enhance or impede communication for aac users. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. 1–14.

[66] Karin van Niekerk and Kerstin Tönsing. 2015. Eye gaze technology: A South African perspective. *Disability and Rehabilitation: Assistive Technology* 10, 4 (2015), 340–346.

[67] Jane Vincent. 2017. *Smartphone Cultures* (1 ed.). Routledge, London, England.

[68] Margaret Walshe and Nick Miller. 2011. Living with acquired dysarthria: the speaker's perspective. *Disability and rehabilitation* 33, 3 (2011), 195–203.

[69] Krista M Wilkinson and Teresa Mitchell. 2014. Eye tracking research to answer questions about augmentative and alternative communication assessment and intervention. *Augmentative and Alternative Communication* 30, 2 (2014), 106–119.

[70] Karen Wylie, Bronwyn Davidson, Julie Marshall, Josephine Ohenewa Bampoe, Clement Amponsah, and Lindy McAllister. 2020. Community service providers' roles in supporting communication disability rehabilitation in Majority World contexts: An example from Ghana. *International Journal of Speech-Language Pathology* 22, 4 (2020), 414–424.

[71] Karen Wylie, Lindy McAllister, Bronwyn Davidson, Julie Marshall, Clement Amponsah, and Josephine Ohenewa Bampoe. 2017. Self-help and help-seeking for communication disability in Ghana: Implications for the development of communication disability rehabilitation services. *Globalization and health* 13 (2017), 1–13.

[72] Xiaoyi Zhang, Harish Kulkarni, and Meredith Ringel Morris. 2017. Smartphone-based gaze gesture communication for people with motor disabilities. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. 2878–2889.

Received 20 February 2007; revised 12 March 2009; accepted 5 June 2009