Design Requirements for a Digital Aid that Supports Adults with Mild Learning Disabilities during Clinical Consultations

Abstract

Background: It is widely known that adults with mild learning disabilities (MLDs) face a plethora of inequalities when accessing effective healthcare. One aspect that significantly affects the complexity and outcome of primary care is communication. However, patients as well as staff often find it difficult to deliver information in a comprehensible manner, thus leading to a potential misdiagnosis or the individual's needs remaining unknown. To date, research on how to promote communication within consultations involving adults with mild learning disabilities has largely centered on the development of communication booklets.

Objective: This study assessed the potential of using mobile technologies to extract the needs of patients with MLDs and to promote communication during clinical consultations. Due to the lack of similar technologies available, we were interested in obtaining a set of design guidelines from a series of experts in order to shape the development of future technologies.

Methods: The study drew on qualitative data and consisted of a 3-stage design process. Firstly, we extracted an initial set of design requirements from a purposive selection of experts in learning disabilities including 4 academics, 3 governmental advisors, 2 General Practitioners and a full-time support worker. We then designed a technology probe using these requirements and subsequently presented it to a subset (n=4) of the aforementioned experts during a round of usability studies. The feedback received was used to update the initial set of requirements extracted during stage 1.

Results: A set of guidelines have been produced that may assist in the development of medical applications that target the complex needs of adults with mild learning disabilities. Factors that must be considered during the design process include: the specific health needs of the target population; consumers' cognitive, motor, auditory and visual abilities; and literacy levels. Furthermore, such technologies should enable customizations to be made to its interface but should restrict patients in changing the content embedded within.

Conclusions: The experts involved in the study were optimistic about the potential of embedding mobile technologies within the consultation process. They believe that such technologies could significantly improve communication by displaying information in a form understood by both practitioners and patients. The information provided may also be used by staff to shape the questions presented throughout thus alleviating potential time constraints. The guidelines identified throughout this paper will help to ensure more appropriate technologies are developed in the future.

Keywords Learning disabilities; intellectual disabilities; communication impairments; AAC technologies; clinical consultations

Introduction

Since the turn of the millennium, greater scrutiny has been placed on the healthcare needs of people with learning disabilities (LD). This has led to the introduction of international policies [1] that compel mainstream services to offer access to improved, unprejudiced care. Consequently, an increase in the general health of those affected by LDs has been
recognized [2]; however, discrepancies in the life expectancy of the LD population (compared to that of the general public) remain prevalent throughout the developed world [3].

Previous literature has identified a variety of barriers that patients with learning disabilities must overcome when accessing healthcare services (4-5), many of which contribute to the above discrepancy. These include difficulties in identifying the need for and accessing healthcare services, undereducated professionals, and insufficient collation and use of health care data. Nevertheless, the most widely cited barrier to effective healthcare is the breakdown in communication between medical professionals and patients.

Howells suggests that the “art of general practice lies in the ability to communicate with patients” [6 in 7]. However, many adults with LDs have complex communication needs that influence their ability to participate within conversations [8]. Cognitive deficiencies impede an individual's vocabulary and sentence formulation skills, and this will have an adverse effect on the patient’s capacity to describe a condition accurately. Additionally, these patients tend to have a limited knowledge of the human body and may not be able to recognize, and therefore inform others of, symptoms crucial to the formulation of a diagnosis [9].

On the contrary, people with learning disabilities often have better receptive skills [8], although they may be unable to comprehend the use of medical jargon - an issue that seems to be prevalent throughout the medical domain [10]. Furthermore, they require additional time to deliberate information, and this may be difficult to achieve based on the time restrictions placed on consultations.

Impairments in abstract thinking and long-term memory [11] also hinder the patient’s ability to provide an accurate medical history. Consequently, practitioners rely heavily on caregivers to provide such information, although patients tend to object to staff bypassing their views in favor of interacting with carers [11]. The accuracy of the information provided may also be reduced, since caregivers can deliver data they believe to be true but are not if fact the views of the patient. There is also evidence to suggest that paid care workers may be unable to provide sufficient data on the health/needs of their clients [8].

To support them in conveying their needs, patients with mild learning disabilities (MLDs) may utilize Alternative and Augmentative Communication (AAC) devices. Such systems range from low-tech communication booklets to sophisticated technologies that may produce artificial speech at the touch of a button [12]. The authors conducted a separate scoping review to identify the prevalence of these technologies within the consultation process. Search queries consisted of mesh terms relating to communication, intellectual disabilities and clinical consultations, in conjunction with a variety of AAC technologies such as communication passports or voice output communication aids. 626 papers were identified of which 61 met our inclusion criteria. The results of the study concluded that despite the call for digital support being made by practitioners as far back as 1997 [13], low-tech solutions continue to be the primary means used to supplement communication.
High technological solutions developed specifically for use in the medical setting were limited to the findings made by Bostrom and Eriksson [24]. In contrast, significant research has been conducted into using ICT to support the advance of health literacy in other vulnerable populations such as those who are illiterate, including children [14, 15]. One potential reason for this may be the lack of design guidelines available to support academics in the development of appropriate technologies.

We intend to address this gap by investigating the use of tablet technologies to promote communication between practitioners and patients with MLDs. To achieve this, we supplemented the findings made within the review by conducting n=9 semi-structured interviews with a purposive selection of experts in learning disabilities including governmental advisors, General Practitioners (GPs), academics, and support workers. The extensive knowledge held by these experts enabled a set of design requirements for the proposed intervention to be produced. A technology probe was developed and subsequently presented to a subset of the experts described to inform further the extracted requirements. Consequently, a set of design guidelines has been produced to support academics in the development of medical AAC applications that cater for the complex needs of adults with MLDs.

The findings made throughout this paper may also help to support the general population in communicating medical information to practitioners, since vulnerable patients are often considered as a litmus test to the effectiveness of interventions [16]. Overall, we intend to answer the following research questions:

RQ1: What do adults with mild learning disabilities and General Practitioners require from an aid that aims to support them during clinical consultations?

RQ2: What impact may mobile devices have on the clinical consultation process?

RQ3: What are the design guidelines for medical AAC applications that assist adults with MLDs?

**Methods**

**MRC Complex Interventions Framework**

To develop the proposed aid in a systematic manner, the authors have followed MRC’s Complex Intervention Framework shown in Figure 1. Crucially, the framework emphasizes the need to collect evidence to justify decisions made throughout the lifecycle of the intervention, and to ensure its goals are being met. Furthermore, the iterative nature of the process provides multiple opportunities to update the design of the aid, and this has considerable advantages when catering for the complex needs of adults with MLDs – particularly when these needs are difficult to extract.
The authors have focused on the first two stages of the Complex Intervention Framework, “Development” and “Feasibility and Piloting”, and have implemented a 3 stage design process to assist in their completion.

1. During the “Development” stage of the framework we conducted a scoping review (mentioned previously) to identify the communicative challenges that occur during consultations involving adults with MLDs, and the current technologies used to alleviate these barriers. This provided an evidence base for the proposed intervention, since a limited number of appropriate technologies were identified. Furthermore, the studies included in the review enabled a number of requirements for the aid to be identified. We then supplemented these findings during a round of requirements gathering interviews carried out with a number of experts in learning disabilities. This also enabled us to how the proposed intervention may fit into improve current practice.

2. Using the collective knowledge held by a range of experts in learning disabilities, rather than the sole views of the authors, a technology probe was developed in preparation for the “Feasibility and Piloting stage”.

3. During the “Feasibility and Piloting”, we evaluated this probe with a subset of the experts involved in stage 1. These studies were modeled around usability tests proposed by Dumas and Redice[19], and the feedback received was used to inform the requirements gathered previously. Consequently, a set of design guidelines were created to support the future development of medical applications that target the needs of patients with MLDS. All studies described in this paper were conducted under institutional ethical approval.

**Requirements Gathering Interviews**

The target sample size was set at between 10 and 15 participants to ensure a wide range of knowledge and expertise was utilized during the design process. Ten people consented to participate within the study, at which point recruitment ceased since the number of participants fell within the target range. The professions of the experts may be found in table 1, to give an idea of the validity of the data extracted.

<table>
<thead>
<tr>
<th>ID</th>
<th>Profession</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Governmental advisor – Gathers evidence for the Scottish Government on the health inequalities experienced by those who have learning disabilities. Previous</td>
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</tbody>
</table>
support worker for people with severe and profound learning disabilities.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>2</td>
<td>Governmental advisor involved in the coproduction of policies affecting those who have learning disabilities. Previous support worker.</td>
</tr>
<tr>
<td>3</td>
<td>Full time support worker for a learning disability charity.</td>
</tr>
<tr>
<td>4</td>
<td>Academic in social work and social policy.</td>
</tr>
<tr>
<td>5</td>
<td>Governmental advisor involved in promoting Scotland's &quot;Keys to life&quot; strategy.</td>
</tr>
<tr>
<td>6</td>
<td>General Practitioner.</td>
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<tr>
<td>7</td>
<td>General Practitioner.</td>
</tr>
<tr>
<td>8</td>
<td>Academic in inclusive education. Previously involved with a special needs school.</td>
</tr>
<tr>
<td>9</td>
<td>Academic in cognitive psychology. Developed accessible information resources for the NHS</td>
</tr>
<tr>
<td>10</td>
<td>Academic in aging, frailty and dementia. Previously involved with a national LD charity.</td>
</tr>
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</table>

The mean duration of the interviews was approximately 34 minutes, ranging from 25 minutes to 1 hour. The experts were required to discuss in depth many of the key concepts identified throughout the review, and to discuss further requirements for the proposed intervention. Separate question sets were developed for the GPs and the remaining interviewees, since their areas of expertise differed dramatically. These sets may be found in Multimedia Appendix 1.

The interviews were recorded with consent and transcribed verbatim. A framework analysis [20] of the transcriptions was conducted in order to produce a structured summary of the views held by the participants. The codes used throughout the framework analysis process primarily reflected the themes and sub-themes that emerged during the scoping review. However, the interviews were conducted on a semi-structured nature to ensure stakeholders were able to raise and expand on unforeseen topics, meaning a number of codes were created to address this information.

Relevant excerpts from the transcriptions were tagged appropriately by the lead author and transferred to their relevant positions in framework analysis table. This table was comprised of codes, which represented the columns, and individual cases that represented the rows. This enabled the authors’ to scrutinize specific interviews by reading across rows, but also analyze how specific codes were addressed across multiple interviews by reading down columns [21]. These excerpts were then used to justify the decisions made whilst developing the probe. This ensured that the requirements implemented were based around the collective knowledge held by the experts interviewed, and not just the views of the authors.

**Usability Studies**

Invitations to participate in the usability study were sent out to the experts found in table 1, since they had prior knowledge of the project and understood what the probes goals were. Participants 1, 2, 4 and 8 gave their consent to take part. The sample size was set at between 3 and 5 participants, since Dumas and Redice [19] suggested such a sample aids the iterative design process. Key design and usability flaws may be identified and subsequently addressed over a short period of time, rather than having to carry out an
extensive number of studies in order to obtain similar information. Further tests may then be carried out in order to refine the design further.

Participants were required to complete two tasks, designed to explore the various features embedded within the probe, and are described in table 2. No assistance was provided during the completion of these scenarios, except at stages where participants were unable to complete a given task. This ensured that the author refrained from influencing the actions of participants and that key design flaws were naturally identified [19]. Any points of indecision were also observed and noted by the author in order to be explored further at the end of the interview. The total time taken to complete the tasks was over 1 hour, with each session averaging 21 minutes. Once the participants had completed both scenarios, they were prompted to give their views on the probe and its appropriateness for the mild learning disability population. The feedback received was used to inform the requirements extracted during the previous stage. The questions presented, and an explanation of the scenarios chosen, may be found in multimedia appendix 2. Once again, the interviews were recorded and transcribed with consent. The transcriptions were subjected to the same framework analysis process described previously.

Table 2. The symptoms to be selected by the participants during the usability studies.

<table>
<thead>
<tr>
<th>ID</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The participant is suffering from toothache caused by tooth decay.</td>
</tr>
<tr>
<td>2</td>
<td>The participant is not in pain. Instead, they hear ringing sounds and feel dizzy and sick. They are experiencing tinnitus.</td>
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</table>

**Results: Requirements**

A number of key requirements were discussed during the interviews that helped to shape the design of a tablet application that aims to assist adults with mild learning disabilities during clinical consultations. These requirements will be introduced throughout this section and will be supported by the excerpts identified during the framework analysis process. The resulting framework analysis table containing these excerpts may be found using the following web link [http://dx.doi.org/10.15129/7fed3a65-9ac4-4152-953b-b606376b64b5](http://dx.doi.org/10.15129/7fed3a65-9ac4-4152-953b-b606376b64b5). The rows within the table are organized to reflect the participant ID’s found in table 2, with the exception that participant 1 and 2’s views have been combined into the one row (2) since they were interviewed simultaneously.

**Communication Challenges**

All GPs interviewed cited communication barriers as the primary negative influence affecting the care provided to patients with MLDs. They suggested that an inability to describe conditions in a clear manner, both on the physician’s part as well as the patients, may contribute heavily to this breakdown, as described by participant 7; “the person’s understanding of their condition for instance, their interpretation of symptoms may be different, their ability to communicate symptoms may be different. Our ability on the practitioner’s side to elicit those symptoms may be different or more challenging....Ultimately a consultation is based around communication, two way communication and at times aspects of that communication can be difficult whether it be to do with comprehension or to do with abstract thinking or just basic communication.”
Potential strategies discussed by the experts to improve this communication focused on the language used by professionals. Firstly, four of the participants discussed the need to reduce the complexity of the language used, and avoid jargon where possible. Strydom et al. came to a similar conclusion; however, they established that some complex terms (such as brand names) were crucial to the participant’s comprehension [22]. Consequently, developers of medical AAC applications should, at the very least, perform extensive recognition testing with target stakeholders to ensure the language embedded within is understood as intended.

Nevertheless, the terms used to describe symptoms will not be suitable for all potential users, as discussed by participant 10; “so if we say to someone “can you tell me where you are in pain?” the term “in pain” might actually not be the right term to use and sometimes that’s more down to local kind of colloquialisms.” Furthermore, people with LDs are at an increased risk of being unable to read text at a basic level, meaning technologies must use alternative formats to represent this information [22]. Alternative methods of representing this information must therefore be provided for such stakeholders. The various modalities that should be targeted will be described within the “Communication Modalities” subsection.

Three further participants revealed that target stakeholders would generally find it difficult to answer broad, open-ended questions such as “How have you been feeling?” Instead, the consultation should be broken down into manageable chunks in which closed questions focusing on solitary ideas are presented, in an attempt to ease the cognitive load placed on patients.

**Communication Modalities**

Adults with mild learning disabilities are heterogeneous in nature and may not respond to information in the same manner as others. For example, 40% of this population have issues with their hearing [23], and may therefore find it difficult to understand information presented via the use of speech. To overcome this issue, the experts suggested that a variety of communication modalities should be targeted to ensure an individual’s complex needs is catered for.

**Pictures**

The bulk of the experts stated that they rely heavily on pictures to convey information and to promote discussion. Images that immediately represent the concept depicted have been proven to increase patients’ comprehension in a variety of health related studies involving people with LDs / cognitive deficiencies [22, 24-25]. They may also act as a concrete referent and aid people in overcoming memory impairments, as discussed by participant 9, “it was just extra prompts to help deal with memory deficits and have a kind of visual record in front of somebody so they can keep track of where they are. And concrete things are very helpful if there’s something there that can be pointed to as a reminder or help, sort of, keep a focus I think that helps.” Representing symptoms embedded within a clinical aid via the use of images, may promote patients with LDs to select manifestations they had previously forgotten about, and is a solution that is more readily processed than using words alone [26].
However, participant 4 revealed that the overuse of pictures could potentially have detrimental effects, “people have a tendency to do is when they’re trying to make something accessible they’re just trying to replace words with pictures...I think there’s a process isn’t there in trying to kind of figure out what the picture actually means. So sometimes, I think the more words you replace with pictures that you’re speaking, you’ll be overcomplicating things. So only use pictures where it’s appropriate I think is what I would say.” Consequently, developers must take into the consideration the cognitive abilities of target stakeholders and balance the number of pictures embedded within a single page to suit their needs.

**Speech**

Patients with learning disabilities may not understand the meaning conveyed by all images immersed within a digital aid. To ensure users avoid selecting incorrect symptoms based on a misinterpretation of the images used; this information must be displayed in alternative formats. Many of the experts discussed the benefits of using speech to extract the views of adults with MLDs providing their needs and skills are taken into account. However, participant 3 revealed that these skills vary dramatically within their workplace, and this may make accommodating for a range of users difficult; “we have people who have quite complex needs and with no verbal communication. And then we have people who are quite vocal and like to be involved in things and help with the decision making, so, and they’re able to express themselves quite easily.” Adhering to the advice

Speech may be incorporated into a digital aid by enabling the user to playback any text displayed on the screen. However, to accommodate for the possible range of users, several of the experts suggested the need to customize the pace at which speech is returned in order to suit an individual’s skills. Furthermore, there is an opportunity to explore how speech recognition software may be used to navigate across an interface.

**Accommodating for a Range of Users**

Combining each of the modalities discussed (pictures, speech, text) to represent potential medical conditions may offer patients with learning disabilities the best possible chance of selecting relevant symptoms. Patients may simply use the modality that makes sense to them during each individual case. This may also be beneficial to the general population, with many patients concluding that the language used by practitioners is both inappropriate and confusing [27].

**Simplistic Interface**

**Digital Exclusion**

Traditional barriers associated with the cost of AAC technologies [28] have been alleviated due to the emergence of mobile phone and tablet applications [28-30]. However, adults with learning disabilities have an increased chance of living in a home seriously affected by poverty [31], and may still be unable to afford such technologies. Consequently, developers must take into consideration the affect that digital exclusion may have on such a population as described by participant 2, “so a lot of people with learning disabilities experience poverty and probably don’t have the iPhones and the iPads and the touch screen stuff...I suppose the consideration for you is the impact of digital exclusion on this population.”
Due to unfamiliarity in using mobile technologies, many stakeholders may be unaware of the common actions required when interacting with touch screen technologies, such as swiping and pinching. As a result, developers should try to limit these actions where possible or provide adequate support when such movements are compulsory. Opportunities to provide digital technologies to those affected by poverty must also be explored, with participant 6 suggesting that such funding may be accessible throughout Scotland, “I've never seen anyone come in with a tablet to aid in communication. Unless there was ring-fenced funding for general practice to, for instance we have things called locally enhanced services or LES... And if that included funding for training and extra time and a lap, a tablet with practice, familiarity in training in how to use the tablet that could be worthwhile”.

**Limiting Clicks**

Operational difficulties are a common barrier to the use of communication aids and lead to high rates of device abandonment [32-33]. Riemer-reiss & Wacker have reported such rates to be as high as 53.3% [32], with users preferring to revert to traditional forms of communication over technologies that are difficult to operate. Several of the experts agreed with this view and highlighted the need for simplicity, with participant ten revealing that the number of steps involved in a process should be limited, "Again it would depend on how easy they were to use but the quicker the better I would say. The shorter the better in terms of how much time someone would have to [complete it]. So if it’s, so easy to use absolutely, reduce [the] number, limited.... as few kind of steps in the process, as few clicks in the process as possible.”

To ensure the number of clicks required to operate the proposed aid is reduced to a minimum, the number of questions presented to patients should be limited. Consequently, a static questionnaire would be unsuitable since stakeholders would be required to answer a large number of questions in order to provide relevant information about their condition. Instead, any information captured should be used to shape future questions to ensure they are relevant to the patient’s health. This strategy closely mimics the consultation process described by participant seven, “I think the first question would be hi how can I help you today? How are you getting on? How, how are you managing? You know how are things? And then it really, each subsequent question depends on that.” Limiting the number of questions presented may also appeal to those who have short attention spans since they will have great difficulty completing overly long questionnaires.

**Limiting Choice**

The experts agreed that the amount of choice available to adults with MLDs should be limited to ensure consumers are not overburdened with information. Participant nine revealed that the learning disability population tend to be excluded from the decision making process, and as a result are indecisive when presented with choice. Consequently, they believe that the options presented should be limited and built upon a consistent framework, “So maybe keeping options kind of limited and that, building it out in a kind of, you know, kind of structure so that when you get to the end point you might have to go the long route rather than the shortcut.”

In contrast, several of the other experts stated that patients with MLDs would be able to cope with more choice and believe that up to three and four options would be suitable. Participant 8 took this a stage further by discussing the potential of altering the number of
options available to stakeholders, “some person might cope with quite a large volume of information and some people might need very, cope with very little you know two or three items... So I think if you were developing something my recommendation would be to develop something that was very flexible that you could adapt to the individual needs of a person.”

Evidently, the experts had conflicting views in this area. Nevertheless, there was an agreement that the maximum number of options displayed on the screen should not exceed four. If a potential condition has a range of symptoms surpassing four, then the aid must break these down into related sets.

Declining Access to Support
Literature suggests that GPs have a tendency to rely on caregivers to facilitate conversations between themselves and patients who have learning disabilities [11], with a lack of appropriate training being cited for this dependency. Both practitioners interviewed agreed with this statement and believe that carers play a key role in such consultations, as discussed by participant six, “The only difference I would say is if a person has got severe difficulties with communication, and you are not able to understand what the symptoms are, or how long they’ve been there you sometimes do have to rely on their overall behavior which you can ask the carers.”

This may ease the potential time restrictions placed on consultations, since caregivers are likely to use strategies that effectively extract information from the patient. However, participant five revealed that due to a lack of funding adults with MLDs are progressively having to make do without access to support, “the hardest population would be the ones that don’t have support... increasingly support isn’t available. For adults with learning disabilities, the eligibility criteria tightened in most parts of the country [Scotland] and some places it’s like life and limb. You know unless you’ve got some kind of critical risk to your health, you don’t get support...So I can see why it would make sense to try to facilitate communication between doctor and patient”

As a result, medical aids should be developed in a way that enables autonomy in its use to be achieved. Where this is not possible, alternative forms of support must be explored, since you may not assume that caregivers will be present during the consultation.

Individualization
Seven of the experts interviewed stated that AAC technologies should be customizable to ensure the abilities and needs of stakeholders are catered for. This was aptly summed up by participant one who disclosed that “I think just to highlight one of the things that was said is that it’s not a one size fits all approach, it is a tailored, you can tailor it to each individual needs. So that’s something that’s quite important.”

Some of the requirements described previously attempt to achieve this. Firstly, symptoms should be conveyed via the use of a variety of modalities, meaning the user may select the option that makes sense to them during each individual case. The speech embedded throughout an aid must also be customizable to suit the needs of stakeholders. For example, patients should be able to alter both the pace and volume in which speech is returned to ensure various hearing and cognitive impairments are catered for.
Further opportunities discussed by the experts centered on the ability to change the aesthetics of the aid. Many adults with learning disabilities have additional handicaps that mean they are sensitive to color. To assist these stakeholders in reading text, many of the experts stated that contrasting color schemes should be used, and these colors should be made interchangeable depending on the needs of the user, as summed up by participant 4, “depending on the kind of condition they have perhaps [they] have different requirements, but yellow is the kind of standard one. But normally if someone needs a different color for whatever reason they’ll tell you. So I don’t know if there’s something that you [can] change.”

The devices in which the software is run on should also refrain from being restricted, as described by participant eight, “if it’s a tablet for example are you going to ask them to hold it? Is it going to be mounted or whatever... I would do it around the basis of the individual you know, what works for that particular individual.” Instead, patients should be able to use the technologies most suited to their complex needs. For example, those who have visual or motor deficiencies may require larger than normal tablets to operate the application effectively. Practices may also be able to purchase the devices they feel to be most appropriate, thus increasing the likelihood of them investing in the intervention.

However, participant eight also emphasized the dangers of over-customization and urged developers to consider the ability to share such technologies across a range of stakeholders, “I do worry about things getting too individualized, you know, like, you know it’s so that it can’t be shared in any way.”

Co-design
Much of the literature highlights the need to the include target stakeholders within the overall lifecycle of a system [34]. People with learning disabilities require a multitude of complex needs to be met, and at times extracting these requirements may be extremely difficult. Thus, enabling adults with MLDs to provide their views at multiple points throughout a project may ensure a more appropriate interface is developed. Four of the experts agreed with this and suggested that a number of probes be developed and subsequently tested with a variety of stakeholders, as discussed by participant 2, “obviously the more diverse that group is the better because you can the start to say well that works with that group of people but maybe not for that group of people.” This conforms to the MRC Complex Intervention Framework in which evidence is collected at multiple points throughout the lifecycle of an intervention, and is used to update the design of the aid.

Questions
The health needs of adults with mild learning disabilities differ dramatically from that of the general population [23, 31]. Consequently, this evidence must be used to select the symptoms that are to be explored by the aid to ensure potential questions are relevant to users, as discussed by participant 2, “the content needs to be informed by the specific health experiences of people with learning disabilities. So people with learning disabilities have different patterns of diseases to people in the general population so more, different kinds of cancers for example are more prevalent in the population of learning disabilities.” GPs require support in identifying conditions that tend to be overshadowed [31], thus embedding such conditions within digital aids may result in an overall increase in the accuracy of diagnoses.
The practitioners interviewed also discussed a range of information they deem relevant to formulating a diagnosis. Participant six briefly described the first five questions they would propose during consultations, “The first thing I’d ask is why are they here today? Then whatever they describe, what their perceived problem is you ask for duration, if that has happened before and if there are any other symptoms and how they generally.” Four distinct categories of questions were extracted from this excerpt and should subsequently be embedded within assistive technologies where appropriate: 1. Questions designed to extract symptoms experienced by the patient. 2. Questions designed to extract the duration and intensity of symptoms. 3. Questions designed to extract the history of symptoms. 4. Questions designed to extract the overall health of patients, particularly focusing on their mental well-being with NICE reporting that up to 40% of adults with learning disabilities have undiagnosed mental health problems [35].

Content Presentation
To accommodate for stakeholders with visual impairments, the experts suggested that a minimum font size of 14 should be used; however, they also stated that text should be as large as possible throughout the aid. Objects conveying information should therefore be stretched to fill any unoccupied space on the page when appropriate to do so.

Participant 10 revealed that in certain cases the use of color had an adverse effect on an individual’s ability to complete a task, “I tried using the kind of emoticons, smiley faces, sad faces for someone on one occasion and they only saw the color so they weren’t able to recognize the facial expressions.” Therefore, in situations where color is used in novel ways extensive user testing must be carried out to ensure that patients comprehend its meaning as intended.

The need for consistency was emphasized by participant 3, “I think repetition actually is really important so if you have something in a written format that you want to give someone it’s probably important to talk to them about it first and then give them the information away with them so they’ve got something they can use to kind of jog their memory.” Therefore, the interfaces embedded within medical AAC applications should be consistent to enable users to navigate across the aid effectively. An unstructured layout may result in situations where consumers are unable to progress, and this could contribute to the high percentage of device abandonment mentioned previously [32].

Patient Histories
Besides effective communication, the success of consultations involving adults with mild learning disabilities also relies heavily on the use of patient histories, as described by participant six, “the second thing you tend to utilize is previous records. Anything in particular for example if they have a particular health problem then you can anticipate certain problems. And, the third thing you try to utilize is history from their carer or family members which often gives you cues to work beyond.”

From this excerpt, you may assume that all symptoms selected throughout the aid should be stored for subsequent retrieval. However, participant seven believes that this is not necessary and instead only significant symptoms should be stored, “our role is largely often
an interpretive role translating people's symptoms alongside any investigations, alongside what we know about probability of conditions prevalence etc. into a formulation of what things going on... So to that extent you know I don’t always document every single symptom that someone mentions in the consultation and I don’t know how helpful that might be.” Consequently, the proposed aid should store significant symptoms extracted from a patient and enable GPs to retrieve this information at will during future consultations. This information may then be used to help formulate a diagnosis but may also provide a means for defending any decisions made throughout a consultation.

**Requirements Gathering Summary**
The experts discussed a variety of requirements for a digital aid that assists adults with mild learning disabilities during clinical consultations. A summary of the most significant requirements is provided in table 3. The participant ID of those who discussed each requirement will also be presented in order to highlight the frequency in which they were proposed.

Table 3. A summary of the requirements identified during the semi-structured interviews.

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirement Description</th>
<th>Participant ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Text used to convey symptoms should be developed in conjunction with the views of target stakeholders. Medical jargon should primarily be avoided but some phrases (such as brand names) may be crucial to user comprehension.</td>
<td>2, 3, 8, 10</td>
</tr>
<tr>
<td>2</td>
<td>A variety of communication modalities should be targeted. As a result, symptoms should be represented by text, speech and images where appropriate.</td>
<td>1, 3-5, 7-10</td>
</tr>
<tr>
<td>3</td>
<td>Any images used should be immediately identifiable to the user and be developed in conjunction with the views of target stakeholders.</td>
<td>5, 8</td>
</tr>
<tr>
<td>4</td>
<td>The user should have the option to have text played back to them. The pace at which the text is played back should be customizable to suit an individual's needs.</td>
<td>2-5, 8</td>
</tr>
<tr>
<td>5</td>
<td>The layout of pages must be repeated throughout the aid.</td>
<td>4, 9-10</td>
</tr>
<tr>
<td>6</td>
<td>Questions presented to the user should be small and straightforward and focus on solitary ideas. All potential options should focus on a single subject.</td>
<td>1-2, 4</td>
</tr>
<tr>
<td>7</td>
<td>The number of clicks used throughout the aid should be reduced to a minimum, to aid users who have limited attention spans etc.</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>A dynamic questionnaire should be implemented. Future questions should be shaped by the information previously supplied by the user.</td>
<td>7, 9</td>
</tr>
<tr>
<td>9</td>
<td>The number of potential options displayed on screen should be limited to a maximum of 4.</td>
<td>3-4, 9-10</td>
</tr>
<tr>
<td>10</td>
<td>The aid should port easily across a number of operating systems and screen sizes.</td>
<td>8, 10</td>
</tr>
<tr>
<td>11</td>
<td>The aesthetics of the aid should be made customizable to</td>
<td>4-5, 8, 10</td>
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</table>
address the complex and individual needs of stakeholders. The content should remain unchanged.

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>12</td>
<td>The symptoms presented to stakeholders should be informed by the specific health needs of adults with learning disabilities, rather than that of the general population.</td>
</tr>
<tr>
<td></td>
<td>1, 2, 10</td>
</tr>
<tr>
<td>13</td>
<td>Questions should aim to extract the symptoms experienced by patients, the duration and history of these symptoms and the overall health of patients.</td>
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<tr>
<td></td>
<td>6-7</td>
</tr>
<tr>
<td>14</td>
<td>Questions should be presented one at a time.</td>
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<td></td>
<td>3-4, 9-10</td>
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<tr>
<td>15</td>
<td>A minimum font size of 14 should be used throughout. Text should be made as large as possible.</td>
</tr>
<tr>
<td></td>
<td>3-5, 8-9</td>
</tr>
<tr>
<td>16</td>
<td>Contrasting colors should be used in order to ensure text stands out and can be read easily. The user should be able to select the color scheme that addresses their needs best.</td>
</tr>
<tr>
<td></td>
<td>3-5, 8, 10</td>
</tr>
<tr>
<td>17</td>
<td>The aid should provide symptoms experienced by patients in advance of consultations.</td>
</tr>
<tr>
<td></td>
<td>2, 4-5, 7</td>
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<tr>
<td>18</td>
<td>Significant symptoms identified by the application should be stored for future retrieval by GPs. This will require the personal details of patients to be captured in order to act as keys within a database.</td>
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<tr>
<td></td>
<td>6-7</td>
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<tr>
<td>19</td>
<td>All feedback provided should be simple and constructive with a consistent help feature available in order to increase autonomy.</td>
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<td></td>
<td>9</td>
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<tr>
<td>20</td>
<td>The overall process should be broken down into manageable chunks.</td>
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<td></td>
<td>2, 4</td>
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</table>

To ensure that the extracted requirements match the needs of patients with MLDs, the Complex Intervention framework states that the intervention must be piloted before being embedded within the target environment. To achieve this, the requirements were embedded within a technology probe in order to be evaluated by a subset of the experts interviewed during this stage.

**Technology Probe Design**

Technology probes may be considered as a representation of a device that is utilized by stakeholders in order to inspire the design process by exposing them to new experiences [18]. Thus, presenting probes to the experts during a series of usability studies enabled them to shape significantly the requirements identified. The design decisions made whilst developing this interface will subsequently be discussed; however, the aid focused solely on the features utilized by patients, meaning those used exclusively by practitioners are not implemented.

**Adaptability**

From the offset, portability was prioritized as one of the most important features of the application. Consequently, we developed the probe using HTML5, CSS3, PHP and JavaScript in order to be cross platform. This has a considerable advantage over native applications since patients may use the device most suited to their complex needs. Practices may also purchase the tablet they deem to be most appropriate rather than limiting them to a set device.
The need to limit the number of questions presented to patients with MLDs was also discussed in depth during the requirements gathering interviews. To achieve this, an adaptive stack based questionnaire was implemented similar to that proposed by Bouamrane et al. [36]. A main questionnaire stack is created based on the primary symptom selected by the patient, for example pain in their eye. This stack contains key questions that have been designed to extract vital information pertaining to the patient’s health. The questions are popped sequentially and presented providing the user uphold certain preconditions. The data provided by patients may then result in additional questions being pushed to the top of the stack. For example, the questions that have been designed to extract the symptoms of blepharitis may only be presented if the patient indicates that they have itchy red eyes. Consequently, the adaptive questionnaire has the ability to reduce significantly the number of irrelevant questions being presented, since many are only added to the stack providing the user uphold certain preconditions. However, those deemed vital to determining the root of the patient’s condition are always asked since they are included within the main questionnaire stack.

**User Interface**

Using the collective knowledge held by the experts interviewed, we have developed a specialized interface to accommodate for the complex needs of adults with mild learning disabilities. This subsection presents a brief overview of the key design decisions made whilst developing this interface.

As shown in figure 2, all options available to stakeholders have been conveyed via the use of a variety of modalities. These include pictures that closely match the options available, simplified text, and speech that may be accessed by pressing the audio buttons (denoted by a speaker symbol) located near a passage of text to be played back. Individual patients may
make use of the specific modality that makes sense to them for each symptom, thus increasing user comprehension. However, both the passages of text and images used may be considered as placeholders. We intend to develop a set of resources in conjunction with the views of target stakeholders during future studies.

Common illnesses and pains experienced by adults with MLDs may have an abundance of symptoms that could conceivably affect patients. Rather than presenting all of these symptoms at one, the application restricts the number of options displayed to a maximum of four. This helps ease the cognitive load placed on the user by limiting the amount of choice available to them, and as a by-product accommodates for those stakeholders who have significant motor defects, since the area of space allocated to clickable objects is significantly increased. The area assigned to text may also be enlarged to allow those who have visual deficiencies to read it more clearly. A function has been implemented that stretches these elements to fill unoccupied space, thus ensuring they are as large as possible.

The application attempts to split the conditions embedded within into one of two categories pain and non-pain. This further restricts the number of irrelevant questions being presented since many of the conditions experienced by patients [31] may be placed exclusively into one of these categories. Consequently, an abundance of symptoms may be disregarded based on the scale of pain experienced by the patient. Some conditions such as constipation may be placed into both categories since pain may not be prevalent in all instances.

As discussed in the previous section, adults with MLDs respond particularly well to concrete objects in which they may point to. Therefore, at stages where the patient has indicated they are in pain, an image of the body is presented to enable them to specify the exact area causing them distress. However, this process relies heavily on the user possessing the motor abilities required to tap on small sections of the screen. Due to the prominence of motor impairments in the learning disability population, the probe prompts the user to confirm their selection by presenting all body parts situated in the proximity of the tap. This also enables those that were unavailable for selection in the original image i.e. the back etc. to be presented.

Forcing patients into selecting one of the options displayed may result in practitioners using incorrect information to form a diagnosis. Consequently, a skip button has been embedded and has been designed to accommodate for the majority of stakeholders. Since text may not be relied upon to convey information [22], the button implemented makes use of an arrow to represent naturally the ability to move onto the next question/page. The success of this image will be discussed in depth in the next section.

Other design decisions included breaking the consultation process down into manageable steps by presenting closed questions that focus on solitary ideas. This strategy allows patients to focus on particular aspects of their health that are causing them concern. The symptoms displayed have been grouped into related sets of four to try to ease the amount of choice placed on the user. Clickable elements are large and placed relatively far apart in an attempt to reduce the amount of accidental clicks that occur due to motor impairments.
Results: Technology Probe Evaluation
To update the extracted requirements, a series of usability tests were carried out with a subset of the experts described in table 1. Participants 1, 2, 4 and 8 partook in the studies and the resulting framework analysis table has been made available: http://dx.doi.org/10.15129/3c176b30-9287-46a0-b3be-a55fcd07843e. Row 2 reflects the views of expert 8, row 3 experts 1 and 2, and row 4 expert 4.

Communication

Focus
Many of the barriers described throughout this paper have centered on the patient’s inability to provide an accurate medical history, as well as the use of inappropriate language and sentence structures [8, 10]. Participant 4 believes that the probe will be able to assist patients in overoming such barriers by enabling them to focus on the particular aspects of their health they wish to discuss, “sometimes if you give someone a blank canvas to start off with their mind just goes blank and they’ve not, they don’t know how to, where to begin. Cause I think this is a good way to focus people for the conversation… I just think it would really help someone to clarify what it is the points that they want to convey.”

By presenting short, closed questions that focus on solitary ideas, the application prompts the user into providing information on specific conditions. The data extracted is then used to shape future questions to ensure they are relevant to the individual’s health. The use of images supports patient’s with MLDs in understanding complex information, since they may select images that depict the symptoms they are experiencing. Presenting closely related conditions together may result in patients selecting conditions they had forgotten about, or had deemed irrelevant, thus resulting in in-depth and accurate histories.

Patients can use the extracted information to rehearse the details they wish to convey, and this may increase their confidence in conversing with medical professionals; as discussed by participant 4 “whoever the carer was they could sit and go over this together before they went in and it would actually give someone confidence when they went in ‘cause I think sometimes people feel quite intimidated. Some GPs don’t have the best bedside manner so it gives someone the confidence to actually get their points across.”

Consultation Times
GPs are heavily restricted by the amount of time afforded to consultations involving adults with MLDs [37]. Medical professionals may therefore rush these appointments and provide substandard care in an attempt to finish in the allotted time. Three of the experts believe that such time constraints are a primary obstacle to the success of consultations, and suggested that the proposed aid has the potential to alleviate such barriers, as described by participant 4, “that’s a big problem isn’t it [consultation times]… they do require longer with these kind of things. I think a lot of GPs now they have extended consultation times for people with learning disabilities but that would mean they could make the most of that time rather than spending the first half of it trying to actually figure out what the person’s symptoms were.” Presenting a list of pre-selected symptoms to practitioners may enable them to shape the questions presented, and therefore focus on particular areas of interest for longer.
**Improvement**

Participant four discussed the need to include a second summary page in a format suited to the complex needs of the LD population. “But actually it would be quite a kind of respectful, kind of empowering thing would be for the patient to have a summary of it as well so that they can then use it when they go in for the consultation. So the GP gets the summary but the person also has a little prompt for themselves in terms of all the things that they were feeling.” Such a page must include the pictures used to describe the conditions as well as an option to playback all text as shown in figure 3. This may enable adults with MLDs to use the summary as a visual prompt in order to emphasize the information they wish to convey to the practitioner.

![Figure 3. Summary pages for General Practitioners and patients.](image)

**Communication Modalities**

The placeholders used throughout the probe were deemed overall to be appropriate for the target population. Each of the experts interviewed agreed that the combination of pictures and speech may be crucial to the patient’s understanding of the symptoms conveyed. However, some aspects may be improved upon. Expert eight believes that stakeholders may have difficulty understanding some of the symptoms relating to the condition of tinnitus, “the one about tinnitus of the, you know if they had, it said at the end, for example, do your ears feel stuffed up they might not know quite how to describe it.” Providing the image used to convey a blocked ear is also unclear, patients with MLDs may not understand the option presented, and therefore fail to select it when appropriate to do so. This emphasizes the need to include target stakeholders in the development of such resources to ensure they are understood as intended.

Two of the experts also suggested that certain images may be taken too literally by the target population, as discussed by expert 1, “Probably the skin one though [shown in Figure 4]...people might be very literal in their interpretation i.e. I don’t have any [of] that, so the thing that is wrong with me doesn’t look like that, that’s wrong to click that.” Patients who have other skin conditions, such as eczema, may refrain from selecting this image since their condition looks different to those displayed. Therefore, a more appropriate alternative would be to display an image of skin to encourage individuals with any skin condition to select the option.
One feature within the application was deemed inappropriate for the target population. The skip button (shown in Figure 2) was developed with the use of an arrow to ensure all stakeholders, including those who are unable to read, could profit from its use. However, many of the participants were unsure of its function and required an intervention from the lead author to explain that questions may be skipped if no appropriate options are available. This then resulted in the button’s intention becoming clear, as discussed by participant 4, “see when you point it out it’s like of course it’s obvious but I suppose I’m just looking at these options and then thinking oh it’s none of them but I didn’t automatically register that arrow was there. So I do think that someone with a learning disability might find that tricky. Like there’s a, some kind of connection that you have to make so you look at the options and then you have to make a connection between none of them and knowing that you have to press that button to get more options.”

Since the experts believe that the button is appropriate after its initial use, much of the advice on how to improve the skip feature focused on making its intention clear. Participant 4 suggested that a help feature should be implemented across all pages to ensure patients are able to obtain advice when unsure on how to progress. This matches the views of Medhi et al. who believe that help features should be available throughout digital technologies that cater for users with illiteracy [38]. The instructions on how to navigate across the interface should once again target a variety of modalities. Additionally, previous literature has proposed the use of avatars and videos to deliver such content [14, 39]

A further option involving the use of audio was also proposed by two experts, and was summed up aptly by participant four, “yeah the other option would be if most people ended up doing it by audio you could have a voice saying “or press the arrow for more options.””. Currently, the automatic audio function highlights and plays back all text displayed on screen on completion of page loads. The improvement proposed would ensure that the skip button is also highlighted before a description of its function is played back. Once again, this matches the views of Medhi et al. who state “voice feedback should be provided for all functional units” [38]. However, such a feature would only be appropriate for those patients who rely on audio and will not have an effect on those who do not use the automatic playback function. Further options must be explored in regards to the image used to convey the skip functionality.

**Individualization**

Three of the participants revealed that the opportunity to change the colors used within the application is crucial to addressing the individual needs of users, as highlighted by participant 4 “That might be a good idea [changing the background color] because people
do depending on what their particular issue/condition is there are certain colors that work better but the most common one is yellow.” A range of manifestations may also be accounted for by altering the pace and volume in which speech is returned. However, the content within the questionnaire should remain the same and this will be discussed further in the next section.

Expert eight had an issue with the sensitivity of the screen and felt that this may cause serious complications for those stakeholders who have motor deficiencies, “there was one when it was, it seemed to be very sensitive ‘cause I didn’t realise I had clicked on it. So the problem with that is they might click the wrong one by mistake.” iOS and Android operating systems enable adjustments to be made to settings such as screen sensitivity and averaged activation [40]. However, the process of changing these settings may be too complex for people with learning disabilities, and an accessible solution to this must be explored.

Additional Features

Return Function
All participants disclosed the need to supply a return/confirm function to ensure any mistakes made by patients are accommodated for. Two of these experts discussed the possibility of embedding a confirm function within the application that enables users to corroborate their selection, as proposed by expert 2 “I was wondering maybe a box that says did you mean, “Is it your sight, is it correct yes or no” and if no it would go back”. However, participant four suggested that potential stakeholders might find this feature irritating and thus fail to complete the questionnaire, “so it’s always good to have a back. So if you go oh no I’ve made a mistake you can press the back button but every time you don’t make a mistake you get a pop up saying “are you sure you meant this” that could get quite annoying.” Consequently, a more preferable option would be to offer the user a choice to return to a previous page providing a mistake has been made. Overall, the experts failed to provide advice on how to achieve this; however, a viable alternative to the skip button discussed previously may also provide a means to implement this feature.

Scale of Pain
Participant one raised a potential issue where patients confuse discomfort with pain in certain conditions such as tinnitus, “they might confuse it with pain though I wonder, discomfort, if they confuse discomfort with pain.” One potential method to overcome this problem may be to introduce a Wong Baker smiley face pain scale at points where the patient is required to select a body part causing pain. Answers that gravitate towards the lower end of the scale may then be accepted as discomfort, at which point appropriate questions should be displayed to the patient. This also conforms to the type of questions described expert 7, with GPs interested in the duration and intensity of symptoms.

Technology Probe Evaluation Summary
The experts involved in the evaluation study suggested a number of improvements to the developed probe. The most significant of these requirements have been listed in table 4.

Table 4. The most significant improvements discussed by the experts.

<table>
<thead>
<tr>
<th>ID</th>
<th>Improvement</th>
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</table>
A summary page listing the symptoms selected should also be provided to the patient. The information included should be conveyed via the use of a number of communication modalities.

General pictures should be used to represent options that have a range of permutations. For example, a picture of eyes may be used to represent visual deficiencies.

Audio feedback should be provided for all functional units and not just potential options.

A return function should be provided to ensure the user is able to undo potential errors.

A scale of pain should be presented where appropriate. The information extracted should be used to shape future questions.

Overall Discussion
A wide range of literature has explored the various barriers patients with learning disabilities must overcome when accessing effective healthcare [2, 4, 31]. Within these studies, it was clear that communication plays a primary role in the success of clinical consultations. Despite an obvious need to supplement this communication, there has been a surprising lack of research conducted into the role digital technologies may play in advancing the health literacy of adults with MLDs. Similar studies have instead focused on using digital questionnaires to extract the mental health status of children with LDs [24], and utilizing virtual reality to provide health care-related information to people with intellectual disabilities [41].

We aimed to address this gap by exploring the use of tablet technologies to support stakeholders during clinical consultations involving adults with MLDs. The study found that the GPs were willing to embed such devices within consultations providing the benefits of doing so are made explicit, as discussed by expert 6, “I guess it’s not the sort of thing which as yet has become routine practice. I don’t know if anyone’s ever come to me in a consultation with symptoms from an app but in theory if it was easy for the individual to use and they were going to use it I can’t see any reason why that wouldn’t be beneficial.”

The bulk of experts suggested that the tablet application should aim to extract symptoms from a patient in advance of the consultation. This strategy would ease the crippling time restrictions [2, 4, 10] placed on consultations by enabling practitioners to shape the questions presented throughout, and therefore focus on particular areas of interest for longer. Patients may also have adequate time to deliberate the questions presented and this may result in accurate and in-depth data being provided.

Nevertheless, participant 6 believes that such aids may be met with resistance, “I guess you’re getting potentially into the territory of using you know computer algorithms on symptoms to more or less tell you what’s going on based on computer probabilities and that might be useful but I think it might be met with some resistance...ultimately people exist in a social context and many of their symptoms are socially patterned in social form and an understanding of that context is crucial to interpreting those symptoms and you might not get that from a computer algorithm.” Therefore, it is crucial to disseminate the evidence.
collected at various points throughout the Complex Intervention Framework to ensure the aids benefits are known and are accepted.

Due to the wide range of expertise held by the participants, a variety of requirements was identified. Consequently, it was important to distinguish those that would apply to the majority of stakeholders. We achieved this by implementing the requirements that occurred as common themes across the interviews conducted. Traits disclosed by individual participants were embedded within the probe providing they had been supported by previous literature. As a result, we believe the probe has been developed to better suit the complex needs of adults with MLDs.

The inappropriate use of language by practitioners, as well as patients, was highlighted throughout the interviews, and this supports the conclusions made in past literature [10-11, 42]. Consequently, the experts revealed that the language embedded within medical technologies should be reduced to its simplest form. However, Strydom et al. concluded that some medical jargon (such as brand names) was crucial to user comprehension [22]. This highlights the need to involve stakeholders in the development of such information to ensure it is understood as intended. Further requirements pertaining to language centered on the production of appropriate questions. All questions embedded should be closed, and focus on solitary ideas to ease the cognitive placed on patients. This conforms to the design guidelines presented by Cremers et al., on how to develop questionnaires for low literate users [14].

Due to the heterogeneous nature of adults with MLDs, the experts revealed that text may not be solely relied upon to convey information in AAC applications. Previous attempts to support comprehension in the extraction of mental health illnesses [24], as well as the process of taking medication [22], have relied upon the use of imagery. The experts also advocated for this use of imagery and suggested that pictures should be used to convey complex concepts such as medical symptoms. Additionally, symbols should be used to represent buttons; however, extensive user testing should be made to ensure their functions are depicted accurately.

Furthermore, the use of speech should be embedded in order to accommodate for the higher levels of illiteracy within the LD population. Similar to Bostrom & Eriksson [24], we have implemented the option to play back all text displayed on screen; however, we highlight the passage being read out in order to distinguish it from the rest of the page. The experts interviewed also discussed the need to highlight functional units, such as the skip button, and play back its function, and this matches the views held by Medhi et al [38]. We also enable a single passage of text to be played back by tapping on the appropriate speaker button. Using a combination of speech, imagery, and text to convey symptoms will result in increased comprehension, since the patient may make use of the modality that makes sense to them during each individual case.

Similar work by Bostrom & Eriksson resulted in a survey consisting of 43 questions [24]. The experts suggested that a questionnaire of such length may be problematic for patients with learning disabilities, due to a variety of reason including cognitive deficiencies and short attention spans. Prior et al. attempted to solve this problem in a project that aimed to
extract the needs of adults with LDs during their admission to hospital [43]. They restricted the questions presented based on aspects such as the user’s gender. We have built upon this work by using all information extracted from the patient to shape possible future questions, and have implemented a stack-based questionnaire similar to that proposed by Bouamrane et al. [36] to achieve this.

Generally, AAC technologies enable the user to customize the interface to suit their complex needs [29, 44]. This includes adapting the number of potential options displayed on screen. Nonetheless, our design has taken a different approach. The experts revealed that many adults with learning disabilities continue to be excluded from the decision making process and as a result struggle with choice. Consequently, they suggested that the number of options available be limited to four to ease the cognitive load placed on users. There are a number of additional benefits to reducing this choice. Firstly, the elements used to represent these options may be increased in size and this has considerable advantages for those affected by motor and/or visual impairments. The need for technology related actions, such as scrolling, is also reduced since all options may be scaled to fit on the screen space available. This may ease the demands placed on users who face digital exclusion and are not familiar with tablet technologies. One downfall, however, is the need to present additional questions to ensure the range of potential symptoms is displayed.

Overall, the authors suggest that the customization process be restricted to the aesthetics of medical AAC application, as well as the rate in which verbal feedback is returned. The conditions included within such devices should be based upon available evidence pertaining to the health needs of the learning disability population [23, 31]. As such, the ordering of questions may be crucial to extracting certain conditions and should remain the same for all users. Furthermore, the language and images used to convey symptoms should be developed using the views of target stakeholders and may be therefore be critical to user comprehension. There is perhaps an opportunity to edit this information in versions that are used exclusively by an individual.

By using the requirements identified throughout this paper, supplemented by research conducted with similar populations [14, 24, 38] the authors have developed the following design guidelines:

<table>
<thead>
<tr>
<th>ID</th>
<th>Profession</th>
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<tbody>
<tr>
<td>1</td>
<td>The overall consultation process should be broken down into manageable chunks by presenting small, closed questions that focus on solitary ideas.</td>
</tr>
<tr>
<td>2</td>
<td>Questions should focus on the health needs of target stakeholders rather than that of the general population since these may differ greatly.</td>
</tr>
<tr>
<td>3</td>
<td>Questions should aim to extract the symptoms experienced by patients, the duration and history of these symptoms and the overall health of patients.</td>
</tr>
<tr>
<td>4</td>
<td>Information provided by stakeholders should be used to shape future questions in an attempt to limit the number of irrelevant questions being presented.</td>
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<tr>
<td>5</td>
<td>Information should be conveyed via the use of a number of communication</td>
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modalities including simplified text, immediately identifiable imagery and speech.

<table>
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<tr>
<th>6</th>
<th>The language and imagery used to convey information should be developed in conjunction with the views of target stakeholders to ensure they are understood as intended. In general, medical jargon should be avoided but this may not be the case for all situations.</th>
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<tbody>
<tr>
<td>7</td>
<td>The number of options available to the user should be limited. We recommend a maximum of 4.</td>
</tr>
<tr>
<td>8</td>
<td>Elements should be large in size and spaced far apart in order to accommodate for potential visual and motor deficiencies.</td>
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<tr>
<td>9</td>
<td>Key navigational and decisions points should not be conveyed solely with the use of text.</td>
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<tr>
<td>10</td>
<td>A consistent layout should be provided including the option to access a help feature at all times.</td>
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<tr>
<td>11</td>
<td>The aesthetics of such aids should be customizable; however, the content should remain the same.</td>
</tr>
<tr>
<td>12</td>
<td>A record should be kept of all the key activities made within the aid. Both, patients and medical staff should have access to this information, represented in a format suitable to them.</td>
</tr>
<tr>
<td>13</td>
<td>The software should be portable to ensure stakeholders are able to use the device most suited to their needs.</td>
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**Limitations**

The main limitation within this study was the number of General Practitioners interviewed during the requirements gathering stage (2). As a result, further medical professionals should be interviewed during future studies in order to determine their preference as to how AAC technologies may be embedded within the consultation process. It is also important to note that this research has resulted in the creation of an initial set of guidelines that may assist in the development of clinical aids suited to adults with MLDs. These guidelines utilize the knowledge held by a variety of experts, meaning there is some scope for them to be updated by extracting the views of target stakeholders. Further opportunities for future work include developing, in conjunction with the views of the learning disability population, a set of images and descriptive phrases that represent common symptoms. There is also some scope to explore how the answers provided by patients may be triangulated within an aid to ensure accurate information is being provided to practitioners.

**Conclusion**

Our study has demonstrated the potential of using tablet technologies to promote discussion between practitioners and adults with mild learning disabilities. We aimed to develop the first high-technological research-based aid to achieve this by utilizing the extensive knowledge held by a variety of experts in learning disabilities, as well as the conclusions made during similar studies. This has resulted in the creation of a set of guidelines that will be instrumental in assisting developers in the future implementation of medical applications that cater for the complex needs of adults with MLDs. The conditions embedded within such aids should exploit the evidence available on the health needs of people with learning disabilities. A number of modalities (including text,
speech and imagery) should be targeted to represent this information and should be developed in conjunction with the views of target stakeholders to increase user comprehension. Both the questions and options presented to patients should be limited in an attempt to ease the cognitive load placed on adults with MLDs. The user interface should take into consideration the various motor, visual and audio impairments experienced by stakeholders. Opportunities to customize this interface should be limited to its aesthetics and should refrain from extending to the content embedded within. The extracted symptoms should be presented in a format understood by patients to act as a visual prompt throughout the consultation. Finally, the application should be portable to ensure patients are able to use the device most suited to their complex needs.

Acknowledgements
The authors would like to thank the Digital Health Institute for funding the research carried out in this paper. We would also like to acknowledge the contributions of the 10 experts interviewed. Without their expertise, it would not have been possible to develop an aid that addresses the complex needs of the target population.

Conflicts of Interest
None declared.

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