Digital Identity Authentication for blind and partially sighted people

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Declaration

This thesis, which is submitted to University of York for examination in consideration of the award of a degree of MSc in Computer Science (by Research), is the author's own research. This thesis has been composed by the author and has not been previously submitted for examination. Furthermore, the author took reasonable care to ensure that the work is original, and, to the best of the author's knowledge, does not breach copyright law, and has not been taken from other sources except where such work has been cited and acknowledged within the text.

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Abstract

Online registration and identity authentication has become increasingly important in recent years. Its relevance and importance have been accelerated with the outbreak of the COIVD-19 epidemic. Yet identity authentication and registration technologies are generally developed without taking into consideration the needs of people with disabilities, especially people with visual disabilities. RNIB reports that as of 2017 around 350,000 people are registered blind or partially sighted in the UK with an estimated 1.7 million people living with some form of sight loss in England. Although a substantial body of literature exists for accessibility in general, there is little literature on the accessibility of digital identity authentication. This programme of research investigated ways in which the NHS login digital identity authentication can be made more accessible for blind and partially sighted people. This programme of research also investigated the advantages and disadvantages of two different remote evaluation methods with blind and partially sighted people.

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Chapter 1: Introduction

The coronavirus pandemic has accelerated the move towards online healthcare, particularly the use of apps by the NHS. National lockdowns in the United Kingdom during the outbreak of COVID-19 significantly increased the use of digital healthcare apps to take pressure off frontline National Health Service (NHS) staff and to minimise transmission of COVID-19 via in-person contact with medical personnel. As the NHS advances developments in technologies that allow direct healthcare access to citizens, it is important to consider how accessible these digital tools are for all citizens. Specifically, this project will investigate how accessible these digital tools are in allowing users to authenticate their identity, thus allowing for safe and secure access to personal healthcare information and services. RNIB reports that as of 2017 around 350,000 people are registered blind or partially sighted in the UK and an estimated 1.7 million people living with some form of sight loss in England. RNIB also reports that these figures are estimated to rise to 2.7 million people by 2030. 80% of blind and partially sighted people are over the age of 60 and are therefore more likely to use healthcare services and less likely to be comfortable with digital technologies. On a global scale, as of 2020 the digital identity solutions market is worth 23.3 billion U.S. dollars and is projected to grow to 49.5 billion U.S. dollars by 2026 (Statista, 2022). Very little exists in the way of research for accessibility in this rapidly growing and increasingly important digital sector. This thesis aims to explore methods for enhancing accessibility in the space of digital identity authentication for blind and partially sighted people by using *NHS login* as a case study.

The NHS is an umbrella term for the publicly funded healthcare systems of the United Kingdom which provides health care for all UK citizens based on their need for medical care rather than their ability to pay for it. The NHS was established in 1948 as one of the significant social reforms following World War II to provide universal and free benefits to all those in need. Formed in 2013, NHS Digital (trading name Health and Social Care Information Centre) was created to become that national supplier for data, information, and IT systems for public health and social care in England. NHS Digital produces digital services for the NHS, including the creation of new services and the management of health informatics programmes, including that of '*NHS login'*. My role within NHS Digital was as a User Researcher within the '*NHS login'* programme. As a User Researcher, my role involved planning, designing, and delivering user research and working with designers and developer to make *NHS login* easy to use for users. My role primarily involved planning research activities and collecting user insights in order facilitate a user-centered design process that would improve the *NHS login* service. During my three and a half years within the *NHS login* team, I utilised a wide range of quantitative and qualitative research activities such as usability testing, analysis of quantitative data, and facilitating workshops. This included planning and facilitating accessibility research activities with blind and partially sighted users.

NHS login is a service that was created for patients and the public to access multiple digital health and social services with a single re-usable login, which includes authentication for returning users. People can use NHS login to prove who they are securely and safely wherever they see the *NHS login* button. As of October 2021, there are 45 apps and e-health services available through *NHS login*, including the NHS app. The NHS app allows people to access records, online, securely, as well as a range of

health and care services. The goal of the app is to give people access and control of as much information about their health as possible, while reducing the burden of NHS staff to arrange in-person access to healthcare services (NHS, 2019). To register to use the app, each user requires official documentation, such as a passport or drivers licence, to prove their identity. Currently this is established via a video or face scan through a separate app called "*NHS login*" to confirm that the person submitting the documentation is the appropriate person (NHS, 2019). There is a growing concern with data protection (Veliz, 2021), which is why this app must balance security with ease of use so users can easily verify who their identity. The NHS app aims to maintain the same level of confidentiality produced and expected by the National Health Services (NHS, 2019). The app was rolled out regionally from 2019 and has gained a large usership across England. In October 2021 *NHS login* reached a milestone of 28 million people creating an account with NHS login, with 57% being fully verified. On February 28th 2022, NHS login passed a milestone of 1 billion logins (total authentications to services).

During the COVID-19 pandemic, several national lockdowns took place which minimised the in-person contact people could have with medical services (Bokolo, 2020). The rapid adoption of technologies was an important means of reducing the transmission of the Coronavirus in medical settings (Hutchings, 2020). As a result of this adoption, there has been a greater use of technology by both staff and service users (Bokolo, 2020.) The same is true for blind and partially sighted patients, thus it is necessary to ensure healthcare technologies accommodate all people, including those with visual impairments. There is also legislation recently introduced in UK statute in 2019 which came into force, which specifically requires organisations to ensure their websites and mobiles apps are accessible to all (Lewthwaite and James, 2020). Despite

this, commentators have expressed concern regarding the rapid changes made to digitalise NHS services available because of the security issues that may result (Hutchings, 2020). In an approach laid out by the NHS Long Term Plan as well as the Secretary of State's (Matt Hancock 2018-2021) vision, NHS login enables innovators to plug in and use the service to benefit healthcare professionals and patients, by means of using Application Programming Interfaces (APIs – the means through which different pieces of software can interact and integrate (NHS Digital, 2022). Success criteria for *NHS login* was both internally and publicly measured by growth of *NHS login* user accounts, as well as the number of digital health services using the *NHS login*. With this success criteria at the forefront, launching quickly and incrementally iterating on design features based on what would yield the highest user growth was the primary way of working. This led to little to no consideration placed on accessibility during the inception of the service. During my time at *NHS login,* my research activates lead to uncovering people with access needs, particularly blind and partially sighted users, having significant problems with using NHS login.

These people have a legal right to access online NHS services (NHS, 2018) Thus, producing an *NHS login* which is accessible to blind and partially sighted users is their right. A decade ago, researchers Saxena and Watt (2009) produced research of the ongoing exclusion of disabled people in relation digital security. They cited a desire to "inspire other researchers to design security solutions keeping in mind not only human abilities but also their disabilities" (p1). Their work had a narrow focus of making authentication technologies which is accessible for blind and partially sighted service users. In addition to this justification for an accessible *NHS login*, there are legal requirements that digital services be made accessible for peoples (Lewthwaite and

James, 2020). When creating products and services NHS Digital, like every other UK digital government branch, works within Government Digital Service Standards. These standards explicitly state that any government digital service must meet government accessibility requirements and even go so far as to outline the Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018. (Gov.UK 2021). With all that considered, because NHS login was not designed from the beginning to be accessible, the *NHS login* research and design team inherited a significant amount of design and accessibility debt, which, as this thesis will explore, proved to be both time consuming and expensive. The aim of the work presented in this thesis was to investigate how to make the *NHS login* accessible and usable for blind and partially sighted users. Usability is defined by the international standard (ISO 9241) as "the extent to which a product [or website] can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, date). Similarly, accessibility is defined as enabling "all people, particularly disabled and older people, can use websites in a range of contexts of use, including mainstream and assistive technologies..." (Petrie et al, 2015, p1.)

The aim of this programme of research is to run two separate user-based evaluations on *NHS login* with blind and partially sighted users. Subsequently, the thesis discusses the issues encountered by the research participants and the recommended accessibility enhancements that should be made to NHS login moving forward.

To achieve this aim, the following objectives were set at the initial stage of this project:

1. What issues within *NHS login* do blind and partially sighted people have the most problems with?

2. How can I use these findings for design and accessibility enhancements for *NHS login*

This Masters by Research thesis aims at highlighting the implications of different research methods with blind and partially sighted users and accessibility enhancements to *NHS login* and the implications of digital identity services. The current state of knowledge and literature within digital identity as it pertains to accessibility is incredibly shallow, with little research on accessibility for digital identity currently existing. This Master's thesis contributes to a significantly unexplored area of digital identity both within academia and industry app development. This paper also gives recommendations based on data for digital identity development teams on how to create a more accessible service for blind and partially sighted users.

The rest of the thesis is organised as follows:

Chapter 2 presents a review of previous research legislation and security, accessibility, the context of digitalising data, as well as empowerment through access.

Chapter 3, a preliminary collection of studies

Chapter 4 presents a remote study was conducted, including moderated and unmoderated portions.

Chapter 5, an in-person study was conducted in a usability lab.

Chapter 6 presents a conclusion

Chapter 2: Related research

2.1 Introduction

In exploring recent research relevant to this thesis, several areas of study will be presented: accessibility and policy; legislation and its relevance to security; the history of digital identity security with particular focus on facial recognition authentication technologies, the relationship between security and accessibility; digitalising data.

2.2 Accessibility and Policy

As discussed in the Introduction, the definition of accessibility used in this thesis is enabling "all people, particularly disabled and older people, [to] use websites in a range of contexts...including mainstream and assistive technologies..." (Petrie et al, 2015, p1). This definition was chosen to be used because it is well received by other researchers, examining the experience of blind and visually impaired users with digital technologies (e.g. Nogueira and Ferreira, 2019). An alternative definition was proposed by the WCAG 2.0 guidelines definition of accessibility, their definition was not utilised because studies revealed that only 50% of accessibility problems fall within the guidelines' definition (Petrie et al., 2015); thus, this definition fails to be inclusive enough for use in this research. Additionally, many researchers are critical of this definition, and the guidelines, because it is has not been founded on large-scale empirical evidence (Lewthwaite, 2014). Moreover, the WCAG definition provided fails to recognise how the contribution that categorisations, like accessible or non-accessible, frames thought around disability and difference (Lewthwaite, 2014). Ultimately, the definition contributed by Petrie et al (2015) was thought to offer a more appropriate understanding of accessibility.

Recent trends, stemming from the Disability Discrimination Act (1995), have shown a desire for society to improve accessibility; with the intention of fully integrating disabled people (Clarkson and Coleman, 2015). Despite legislation attempting to create a healthcare framework which is inclusive and accessible, the NHS has a history of struggling to put this ideology into practise. Studies have shown that only 10% of blind people received letters from the NHS in a format accessible to them (Nzegwu, 2005.) Technologies, like NHS Login, offer a unique opportunity to reformat NHS processes as accessible. The Disability Discrimination Act (1995) inspired a new wave of legislation like the Equality Act (2010; cited by Hepple, 2010). On par with this change of mentality, the British Government instilled 'Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations' (2018; cited by Lewthwaite, 2020). This regulation requires digital accessibility standards to be met by UK public bodies (Lewthwaite, 2020). Despite the honourable intentions of this, the framework has been critiqued for failing to evidence any improvement in user experience for disabled people (Power et al, 2012; cited by Raufi et al, 2015).

2.3 Legislation and Security

Confidentiality in a healthcare setting is of huge concern to NHS healthcare practitioners. "Breach of information security can stem from breach of confidentiality by authorised users, and abuse of their access privileges" (McKinstry et al., 2009). Despite legislation such as the Data Protection Act (NHS Digital, 2019) and NHS policy on patient confidentiality (NHS Digital, 2019), medical services are often accompanied by potential breaches of confidence; this includes in-person services (McKinstry et al., 2009.) Despite the risk of in-person data breaches, some researchers feel concerned

that online healthcare services pose new risks for patient security (Anderson, 1995). In spite of security concerns, in the recent context of the Coronavirus pandemic, the majority of non-emergency medical appointments are now being held online (Webster, 2020.) Thus, researchers are exposed to new concerns regarding the security of online medical services. Despite the potential security risks, using facial recognition technology is accepted in some healthcare settings as “a form of identity verification” and “a fast and simple way” to authenticate someone (Zeng et al., 2019; pg. 479.)

Mungoven (2021) discussed how facial biometrics have become an increasingly popular form of cyber security; by way of identity authentication. Mungoven notes a reason for this popularity is a familiar user experience. However, Mungoven’s first point is one that was formed based on his own experience. The experience is not familiar for all users; particularly disabled users (Spiel et al., 2020). As the introduction briefly touched upon, identity authentication services have not been accessible for many people with disabilities. Mungoven’s perception of this issue highlights the necessity for the ‘nothing about us without us’ movement; as he fails to account for experiences outside his own able-bodied existence (Spiel et al., 2020). Secondly, Mungoven notes that this new form of security “removes much...of the friction that users encounter, trying to remember passwords” (Mungoven, 2021; pg.5). Thirdly, Mungoven assesses facial recognition technology as improving; the recognition ability of these technologies has improved by a factor of 50 from 2014 until 2020. Thus, Mungoven recommends the use of these technologies as highly usable, based on his ablebodied understanding, convenient as it does not rely on users’ memory and a perpetually improving system.

Despite Mungover's advocacy, facial recognition is not entirely secure. In 2019, biometric information like facial recognition data was found on a publicly available site (Taylor, 2019; cited by Zeng et al, 2019). This incident validates further concern and considerations about the use of digital services. In approaching these concerns, regarding potential security risks, many systems use facial recognition technology; in a complementary way. In one research study (Mason, 2020) examined biometric authentication methods for healthcare services, authors found a high success rate in cases where two identity methods were used.

2.4 Security and Accessibility

"Current research on "Usable Security" is still in its infancy and usable security solutions are often designed without paying attention to human disabilities" (Saxena and Watt, 2009; pg. 1). In recognition of this, many researchers have studied the current access problems with digital technologies and the potential impacts that these have on disabled users. While Saxena and Watt (2009) described Usable Security as in its' infancy so long ago, the development of accessible and usable digital security has failed to develop at a pace which renders the conversation irrelevant; reflected by the preliminary studies discussed in the introduction.

In uniform with the preliminary research, Saxena and Watt (2009) found particular issue with user authentication. At the time of their study, ASCII and PIN mechanisms were dominant sources of authentication. However, these technologies are being rapidly taken over by new technologies; like facial recognition authentication in contexts where higher levels of verification and security are needed.

Additionally, ASCII and PIN methods of security are not appropriate methods of security for sensitive data; such as NHS health records. This is because PIN is not considered secure enough for Identity Proofing and Verification (IPV) of an individual as stated in GPG45 guidance (GPG45). Saxena and Watt (2009) critique this method of security by noting the increased risk that blind and visually impaired users have for their passwords/PINS to be eavesdropped on. Thus, Saxena and Watt provide a foundation for this study but their research, alone, is inadequate. Their research cannot position itself considering the newer developments in technologies, new security risks and contemporary contexts.

In later years, Haque et al (2013) proposed a new security technology, claiming it was securer for blind and visually impaired users. Similar to Saxena and Watt (2009), Haque et al (2013) notes the ability for people to eavesdrop on passwords and PINS. They provide a suggested solution for new security methods which are accessible and secure. Through proving that every person had a unique gait (Haque et al, 2013), they prompt for the tracking of the walking activities of people as a source of identity authentication [via accelerometer]. While their assertion that disability and digital security is an underexplored area is valid (Haque et al, 2013), they fail to consider accessibility problems in their own prospective solution. The use of gait and walking patterns to prove identity fails to account for non-walking service users; such as those who use wheelchairs or those who have a temporary or long-term leg injury. When considering accessibility, this suggestive methodology fails in considering the needs of disabled people with other forms of disability or people experiencing an additional disability; alongside their blindness or visual impairment. Thus, this research further

proves a need for the production of accessible facial recognition authentication security.

Supporting blind people during their photo taking process was not taken into consideration during the development process for NHS login. However, there has been work from researchers in the domain of human-computer interaction and digital accessibility on ways in which automatic computer vision technology can be used to give blind people feedback on their pictures. Bigham, Jayant, Ji & White (2011) discussed methods in which two different applications (EasySnap and PortraitFramer) aid low-vision and blind users in framing their photo as well as providing real time environmental information. [An evaluation of EasySnap with six visually impaired people asked them to take three photos each of people and objects with and without EasySnap feedback. The resulting photos were rated by 31 in depended sighted participants, who judged the EasySnap version “better” (meaning better centred and taken at a better distance) in 58% of cases and no different in 12% of cases (70% in total). Only in 29% of cases were the EasySnap photos judged worse than the control versions. The six visually impaired participants were asked to rate their user experience with EasySnap on a series of 5 point Likert items. They rated it positively as easy to use, that it helped them take better pictures, and that they understood the directions that EasySnap gave.

PortraitFramer was subjected to a formative evaluation which resulted in some refinements to the system and then a summative evaluation. Seven visually impaired particiapnts were involved in the summative evaluation. Participants were asked to take photos of three faces (staged on cardboard cutouts) and centre them. Stragely, no evaluation of the appropriateness of the photos is mentioned in this evaluation. Participants were asked again to rate their user experience, this time on a 7 point Likert items. They rated liking the application 6.2, and whether they would use the application as “close to 6”

Other researchers have also explored how technology can allow blind users and visually impaired users aquire spatial information about nearby objects without physical contact. Zeng, Simros, Weber (2017) investigated how electronic travel aids (ETAs) can help blind and visually impaired users explore unknown spaces and enable users to recognise objects of interest without physical contact.

Ultimately, the research provided in this area provides valid criticisms of current security being inaccessible for disabled users. However, these researchers fail to provide an alternative form of security which is accessible and suitably secure for NHS patient data. Thus, our research has a proven relevance is a marked as essential in securing the data of blind and visually impaired service users in a way that is accessible to them.

2.5 The Context of Digitalising Data

The need for this study to take place is further justified using the context of the Covid19 pandemic. It is necessary to digitalise services to reduce the number of people accessing healthcare settings, where they are at increased risk of contracting the virus or passing the virus onto vulnerable people (Hutchings, 2020). Despite this need, it is important to consider how accessible online services are, both in general and for our targeted demographic. Schlesinger et al (2017) essentialists an approach to Human-Computer Interaction studies which considers individual and collective identities; alongside multiple identities. In understanding the importance of including multiple identities in research, it is important to consider the following:

The Coronavirus pandemic, or rather the resulting reliance on technologies which allows social distancing, has made apparent the extent of the digital divide amongst

different socio-economic groups (Zheng and Walsham, 2021). In the UK, an estimated five million people do not have access to the internet (Allmann, 2020; cited by Zheng and Walsham, 2021.) There is an established link between class and the digital divide; as some working-class people do not have the material resources to access online spaces (Zheng and Walsham, 2021). Additionally, people who are blind or visually impaired have an increased likelihood of being at a lower economic level (Lansingh et al., 2012.) Based on this information, we can deduce an inevitable failing of the prospective project. Regardless of the accessibility of NHS login, through the intended measures, there will still be unavoidable inaccessibility for a large number of blind or visually impaired people. Those who cannot access technologies, with or without visual disabilities, cannot access NHS login. It is important to recognise this failing of the research, but the research remains essential. While this project cannot negotiate space around this issue, it is reflective of a need to incorporate economic policy into human-computer interaction. In addition to the context of COVID-19, the transition into digital services was becoming essential because of an oversubscription of services. Allowing for data to be accessed remotely, without the input of NHS staff, lessens the burden of work on staff and allows for staff to refocus on important aspects of their employment.

2.6 Empowerment through Access

Health policy and NHS policy pays particular focus to the importance of empowerment within healthcare (McAllister, 2012). The concept of empowerment is present in both health discourse and computer science discourse (Risling et al, 2020). McAllister et al (2012) list the various components to defining empowerment like the

enabling of choice and control, being educated on issues of the self, and accessing knowledge. Despite little consensus on the definition of empowerment, the World Health Organization asserts the importance of patient empowerment in the improvement of clinical outcomes (Risling et al, 2018). There are some people who criticise the concept of patient empowerment as a form of reducing responsibility of healthcare providers at the expense of patient wellbeing (McAllister et al, 2012). While McAllister at al dismiss this concern, it is important to reflect on this criticism during the research. Blind and visually impaired patients should be able to access both support and independence. The introduction of an accessible NHS Login simply acts to provide an additional option for accessing patient records independently; not removing the responsibility of healthcare providers.

Attempts to empower blind and visually impaired patients are being made in other aspects of healthcare. Shetty et al (2021) noted that prescriptions were beginning to be printed in braille. The aim of this was empowering blind and visually impaired patients to have knowledge on the medication that they were taking. Digital technology has a similar capacity to empower blind and visually impaired individuals, if it is made accessible. Risling et al (2018) found a positive correlation between the use of digital technology, to access data, and feelings of patient empowerment. The participants in the study noted a feeling of empowerment out of knowing more. Access to personal digital records would allow people to know more about themselves; and feel empowered through accessing that knowledge.

Chapter 3: Preliminary Studies of the accessibility and user experience of *NHS login* for blind and partially sighted users

3.1 Introduction

Two preliminary studies of *NHS login* were undertaken to assess accessibility, security, and user experience for blind and partially sighted users. Firstly, accessibility audits were carried out by the Digital Accessibility Centre (DAC) located in Skewen, Wales. Digital Accessibility Centre is a non-profit social enterprise and one of the leading providers of web accessibility services. These accessibility audits were commissioned by the NHS login programme to better understand what accessibility problems the application might have as well as understand the scope for areas of improvement. These accessibility audit reports were carried out by accessibility experts employed by DAC. Three DAC audits were commissioned in 2018, 2019 and 2020. For the purpose of summarising this data, only high priority areas of their report will be discussed.

Secondly, a drop-in session was carried out at Kirkless Visual Impairment Network (KVIN) in Huddersfield, UK in which me and blind and partially sighted research participants met to carry out an informal review of *NHS login*. This drop-in session involved reviews of *NHS login* early in its development by blind and partially sighted people.

Finally, a Collaborative Heuristic Evaluation (CHE) was undertaken at the Department of Computer Science at the University of York in collaboration with members of the HCI Research Group.

3.2 DAC Accessibility Audits

The accessibility audits conducted by the accessibility experts employed by the Digital Accessibility Centre (DAC) served as background that informed the foundational elements of this programme of research. The DAC reporting team, which for these reports comprised of a Project Lead, User Testing Lead, Technical Auditing Report Author, and Quality Checker, measure the accessibility of online services by measuring their compliance with the Web Content Accessibility Guidelines (WCAG, ref) (Digital Accessibility Centre, undated.) The Digital Accessibility Centre was commissioned to assess *NHS login* in 2018, 2019 and 2020 (Appendix 2). These accessibility audit reports provided insight into the various accessibility problems with *NHS login*.

3.3 Kirklees Visually Impaired Network Drop-in Sessions

I wanted to investigate blind and partially sighted users actual experience with *NHS login* so I engaged with Kirklees Visually Impaired Network (KVIN), located in Huddersfield, UK. I ran two an informal accessibility sessions so that I could observe how blind and partially people interact with *NHS login*. I completed two sessions, one in February 2019 and the second in June 2020. I did this so that I could get ongoing feedback to accompany the changes that were being make to NHS login.

3.3.1 Method

During the user recruitment phase of this informal drop-in study, for both sessions participants were recruited via KVIN social media channels and offered a monetary incentive of a GBP £50 (approx. USD $65, €55) Amazon gift voucher for 1 hour of their time. In total 5 participants took part in the first study in February 2019 (Table 3.1) and 5 participants took part I the second study in June of 2020 (Table 3.2). All participants used their own device for each study. For each session I recorded participant use of *NHS login* using a mobile IPEVO V4K Ultra High-Definition Camera running on my MacBook Pro (2018 edition) while a colleague of mine would observe and silently take notes.

Table 3.1: Demographics of KVIN drop-in participants in the February 2019 Evaluation

ID	Gender	Age	Visual Status Registration and Brief Description	Device Used	Assistive Technologies Used
Mod1	M	52	Registered Blind. Born without vision	iPhone 5 with detached mobile keyboard	Detached mobile keyboard & text-to-speech software
Mod2	M	29	Registered Blind	iPhone 6	Onceover screen reading software
Mod3	M	50	Registered Blind	Android	Textscanner
Mod4	F	71	Registered Blind. Born without vision	iPhone X	iPhone text-to-speech enablement
Mod5	M	56	Registered Blind	iPhone X	Mobile keyboard with iPhone

Table 3.2: Demographics of KVIN drop-in participants in the June 2020 Evaluation

ID	Gender	Age	Visual Status Registration and	Device Used	Assistive Technologies Used

			Brief Description		
Mod1	M	55	Glaucoma since 1984	Sony Experia ZX Premium	Uses a magnifying glass while browsing on mobile device
Mod2	M	51	Visually impaired (senstivite to light)	Samsung tablet	Likes using zoom text
Mod3	F	30	Registered Blind – Retinitis Pigmentosa	iPhone 6	Supernove magnifier and iPhone text-to-speech
Mod4	M	72	Registered Blind. Blind since birth	iPhone 7	Jaws
Mod5	M	64	Cataracts	Samsung Galaxy	Magnified text

For both studies I discussed to purpose of the session and had participants sign an informed consent form (Appendix 3.4) prior to starting the session. In adhering to the discussion guide for these studies (Appendix 3.5) I had each participant start with discussing their digital habit, such as what apps they use, how often they use digital devices, and if they ever seek assistance when using digital apps. After introductions and gaining feedback on their digital habits, I would guide them to open *NHS login* on their device and give them a scenario in which they downloaded NHS App and are trying to set up an account using *NHS login* to authenticate their identity. As they worked through *NHS login* I prompted them to think out loud while they worked through the application. While observing their use with *NHS login* I would follow up with probing questions to gain more depth and understanding of any issue they encountered. Once finished I would finish each session by asking participants if they

had any final thoughts they'd like to share. After each session ended a KVIN employee would give each research participant their Amazon gift voucher inventive.

3.3.2 Usability Problems

In both the first and second drop-in sessions at KVIN there were several consistent usability problems observed. One of the most consistent usability issues was that blind and partially sighted people struggled to properly align their identity document to take a clear and acceptable picture. Several registered participants voiced their frustration of the photo taking portion of *NHS login* due to the lack of auditory guidance.

The password confirmation portion was also a problem area for many users, with 7 research participants making errors in the password confirmation box in which they need to enter their password twice to ensure it was correct. Accessibility issues related to incorrect auditory feedback from text-to-speech software and the form field failing with screen readers was a key theme for the password portion of *NHS login*.

The portion of NHS login in which users need to put their face in an oval to take a face scan or video selfie was also not usable for any research participants that relied on screen readers. This portion proved to be inaccessible for almost all research participants due to the fact this biometric authentication portion of *NHS login* had no auditory instructions.

3.4 Collaborative Heuristic Evaluation of the NHS login

3.4.1 Introduction

A Collaborative Heuristic Evaluation (CHE) was also conducted of the *NHS login* in December 2019. A Collaborative Heuristic Evaluation is a group evaluation method. The method involves evaluators working as a group and has a distinct way of dealing with differences between evaluators and preserving the different views of different evaluators. Evaluators are all asked to propose potential usability problems. A scribe or one of the evaluators, constructs an agreed description of the problem. Then each evaluator rates the severity of the potential usability problem privately. If an evaluator does not think this potential problem is a problem, they simply rate the severity of the problem as zero. This means that the number of problems from each evaluator may be different, even when they do accept that there is a problem. (Petrie, H.L & Buykx, L, 2010).

I had this evaluation conducted to gain a deeper understanding of the accessibility and usability problems of *NHS login* that could be provided by accessibility and usability experts and to complement the data provided by the DAC audits and the observations of blind and partially sighted people made at KVIN. It also gave me the opportunity to learn a new HCI evaluation method by participating in the CHE.

3.4.2 Method

Three usability and accessibility experts from the HCI Research Group of the Computer Science Department at the University of York, conducted the CHE. All had at least five years' experience of conducting accessibility and usability evaluations, including experience with CHE. I acted as the "driver" of the login, guiding the experts through the login and explaining how it worked. The experts worked through the NHS

login process guided by myself, all proposing potential accessibility and usability problems and agreed a definition of the problem. They then privately assigned a severity rating on each problem; if they felt a potential problem was not actually a problem.

At the end of the process, all potential problems and ratings were combined and a consolidated set of problems and ratings was produced, these can be found in Appendix 3.7.

3.4.3 Results

As seen in the results in the CHE (Appendix 3.7) one of the biggest problem areas was the fact that *NHS login* gave no explanation to users as to *why* they need to prove who they are. Instructional content at the beginning of the identity verification process with *NHS login* tells users that they need to authenticate their identity to gain full access, but never expands as to why they need to do so.

Another major problem area was the fact that *NHS login* never gives any form of user feedback to indicate that users will be logged out if they don't do something for an extended period. The system never gives users indication of this or gives them an option to extend their time.

A problem area related to users with visual impairments, was the fact that, while *NHS login* does give users an alternative path if they are visually impaired, this message comes far too late in the sign-up process.

3.4.4 Discussion and conclusions

A recurring theme in the CHE was the lack of information provided to users to explain why actions were required, which meant users would lack motivation to continue the process. There was as well a lack of context in term of the benefits the service would provide users. The information that the NHS login was a onetime task was not conveyed to users. There was an assumption in the design of the login that users would have the necessary background to know why they should sign up for the service. A further important problem was that the *NHS login* did not make clear if international forms of identification would be accepted. The CHE provided important information, that the other preliminary studies had not elicited and thus was a useful and key component of the initial work.

Based on these preliminary studies, I wanted to identify ways in which the *NHS login* could be made accessible and usable by blind and partially sighted people and to verify those improvements with user studies. However, the onset of the Coronavirus pandemic shortly after I had completed the analysis of the CHE changed, my plans entirely.

Chapter 4: Remote moderated and unmoderated evaluation of NHS login by blind and partially sighted users

4.1 Introduction

Based on the preliminary studies, I was planning to do a series of face-to-face studies looking at how to improve the accessibility of *NHS login.* However, as I was planning these studies the COVID-19 pandemic hit the United Kingdom. Due to government social distancing mandates and lockdown measures that were imposed at the beginning of spring 2020, any form of in-person studies was not possible. Therefore, I had to revaluate the research methodology that would be feasible in a socially distanced context. Given the difficult circumstances, remote studies were the only feasible option. I set on a path of constructing a research plan that utilised remote methods that would not only keep participants safe while during this unprecedented pandemic but also yield actionable data. This study was designed employing moderated and unmoderated remote evaluations to investigate more about the accessibility of *NHS login* at this point in time, as well as to investigate the advantages and disadvantages of doing remote evaluations in these two different ways, with blind and partially sighted people.

Prior to the pandemic this type of research was not particularly common. Only a few researchers had carried out and discussed remote research with disabled people. Very little existing literature regarding remote research with disabled people currently exists. The practicalities and consequences of conducting evaluations remotely has been explored to some extent in the literature, but rarely with people with disabilities.

Despite this type of evaluation having been discussed since the 1990s, this methodology has not been used widely (Hartson et al, 1996). This was a surprising realisation, as remote evaluations would appear to be an effective way to include people with disabilities in research, as there is a record of struggling to recruit disabled participants, particularly visually impaired people (Duckett and Pratt, 2001). The problems of including representative users in accessibility research have well documented. Sears & Hanson (2011) note that researchers in the field of human-computer interaction often overlook recruiting research participants who have a unique set of abilities or experiences which may affect how they approach and perform a given task. They go on to state that use of non-representative users is often justified, explicitly or implicitly, because of difficulties associated with recruiting representative users. Disabled users may be distinctly difficult to recruit locally, however remote methods allow for a far wider participant recruiting pool, given that research participants do not need to be in a fixed location and can take part in research from anywhere as long as they have an internet connection and appropriate device, as noted by Bruun, Gull, Hofmeister, & Stage, J. (2009). Although remote evaluations have been used successfully with disabled participants, including blind people by Petrie, Hamilton, King, & Pavan (2006), remote usability evaluations with blind and partially sighted people remains a substantially under explored area in human-computer interaction.

The rationale for running an unmoderated control for this study was to have research participants in their own environment using their own device and any assistive technologies as they would in real life, with no moderation or assistance from a

research professional. The unmoderated control was as close as I could get to complete ecological validity in constructing an evaluation, given that participants were using NHS login in their own environment, with their own device and assistive technologies, and at a time that suited their convenance without a research professional observing the session live of whom they could ask questions. Although users were aware that they were in a research study and being recorded which may have impacted their behaviour, this methodology reflected the participants realistic real-world environment as closely as possible. As a researcher, I had no control and could not give any assistance to the participant in the unmoderated condition if they were unable to proceed with *NHS login*. I also relied entirely on them to complete the think aloud protocol without any prompting.

The rationale for running the moderated condition was to be able to prompt participants during their think aloud protocol in real time, as well as to be able to help them through any areas of *NHS login* they may not have been able to complete after attempting on their own and to ask them questions immediately after they attempted the login. Running both moderated and unmoderated conditions struck a balance between ecological validity and the ability to interact with participants as well as control the remote research session. Later, I was able to compare the data from the two conditions.

The general research questions for this study were:

RQ1: what problems will participants encounter in registering an account with NHS *login*?

RQ2: What differences in effectiveness will there be between the moderated and unmoderated conditions?

4.2 Method

4.2.1 Design

Two methods of remote evaluation were compared: moderated evaluation in which the participant and I worked together in a synchronous environment via Microsoft Teams; and unmoderated evaluation in which the participant worked by themselves and recorded their session on Microsoft Teams for later analysis.

The moderated evaluation was conducted synchronously on Microsoft Teams and included the involvement of both myself and the participant. I would facilitate the research session over Microsoft Teams at an agreed upon time and the research participant would share their screen with me as they worked through undertaking the tasks. The research session was broadcast in real time to the *NHS login* development team at NHS Digital via a password protected channel. The unmoderated evaluation was conducted by the participant alone in their own environment at a time that suited them. Each participant was emailed task instructions to work through independently, as well as pre and post-session surveys. Each research participant would

independently work through tasks given to them while recording their interaction of setting up an *NHS login* account and verifying their identity on Microsoft Teams.

Due to the fact a prototype version of *NHS login* cannot accurately represent key features of the interaction, such as the facial scan and face matching to a real identity document, it was necessary to run this study using the live version. In designing the materials for the study, I made sure to include information in the recruitment screening process, and once more in the consent form prior to the study, that participants would need to use their real identification and personal mobile phone to create a real NHS account during this evaluation. In collecting the data for this study, each research participant was also informed that recordings of their research session may be shared with the *NHS login* development team as well as researchers and advisors associated with this research programme at the University of York. Before launching this study, I received ethical approval from NHS Digital that data from this study could be shared internally and with the University of York, if:

1. Research participants gave explicit informed consent (either verbally or written) to have their research sessions recorded and shared.

2. All personally identifiable information (i.e. ID document details, names, etc) be obscured when sharing and storing video files.

4.2.2 Materials and Equipment

For the moderated condition, participants were emailed an instruction sheet several days prior to their research session (see Appendix 4.1), asking them to have their identity document on hand and to download the NHS App onto their preferred device. They were given instructions not to set up an account or attempt to sign up for the app prior to their research session. Instructions included the time of their session, the general purpose of the session, guidance on how to share their screen and broadcast on Microsoft Teams, as well as my phone number and email if they had any further questions. An NHS Digital informed consent form for research was also included in the email as an attachment. Users were original expected to download the attached NHS Digital consent form, fill it in on their device, and email it back prior to their session.

For the unmoderated condition participants were emailed an information sheet. This email included the general purpose of the study, guidelines how to set up Microsoft Teams in order to share their screen and record their session, as well as instructions to download NHS App (see Appendix 4.2). They were also asked to have their mobile phone and identity card to hand. I also included my email and phone number if any participant had any questions, particularly related to setting up Microsoft Teams, prior to their research session. Instructions were provided on how to setup an account and to verify one's identity while conducting a thinking aloud protocol. The email also included a link to pre and post session online surveys (deployed in Qualtrics) to complete. Participants were asked to complete their research session within one week.

Participants used their preferred digital device (see Table 4.1). I used a MacBook Pro (15 inch, 2018) running Microsoft (MS) Teams to record and facilitate each of the moderated sessions. For both the moderated and unmoderated conditions, participants used Microsoft (MS) Teams to record the session.

4.2.3 Evaluation task

Both conditions asked participants to an NHS *login* which involves 12 steps:

1. Enter your email address.

2. Create a password. (must have 8 characters or more, 1 capital letter or more)

3. Open email inbox.

4. Open email inbox and confirm email the automated authentication email sent from NHS sent to email address entered.

5. Enter your mobile phone number into NHS login.

6. Enter the 6-digit code sent to the phone number entered in Step 5.

7. Take a photo of ID (passport, driving license, European ID card).

8. Confirm photo of ID meets requirements

9. Upload photo of ID to NHS login.

10. Take scan of face or take a selfie authentication video.

11. Submit face video if face scan fails or if the user is unable to complete the facial scan.

12. Enter address postcode.

4.2.4 Participants

A commercial recruitment agency based in Leeds, UK, was used to recruit participants during the spring of 2020. Inclusion criteria were that participants be aged 18 years or

older, registered blind or visually impaired, use a computer or smartphone and have not previously registered an account with the *NHS login* service. 22 people took part in the study, 10 in the unmoderated condition and 12 in the moderated condition. 12 participants were originally recruited for the unmoderated condition, with 2 participants dropped out leaving 10. The sample included 11 women and 11 men. The mean age of participants was 42.5 years (range 22 – 76 years). 10 of the participants were registered blind and 12 were registered visually impaired. Participants were asked by the recruitment agency to rate themselves on a digital literacy scale, using the Gov.UK Digital inclusion Scale as the scale for self-reporting (1 = not at all confident to 9 = expert), the average rating was 7.0 (standard deviation: 1.34). Participants all used their preferred digital device for both conditions. Table 4.1 summarizes the demographic information of the participants for both the moderated and unmoderated conditions. Participants in the moderated condition were offered GBP £50 (approx. USD $65, €55) for their time and effort, those in the unmoderated condition were offered GBP £60 (approx. USD $78 / €66). The higher level of compensation for the unmoderated condition was due to the slightly longer setup time for the unmoderated study, as well as the additional time for notifying me via email that they had completed the study.

Table 4.1: Demographics of participants in the evaluation

ID	Gender	Age	Visual Status Registration and Brief Description	Digital Literacy Self-Rating	Device Used
Mod1	M	53	VI: blurring of detail, esp. text	6	Samsung Galaxy S10

Mod3	F	28	Blind: light/dark perception only	8	iPhone XR
Mod4	F	22	Blind: light/dark perception only	8	Samsung Galaxy S10
Mod5	M	27	Blind: very limited vision	8	iPhone 11 Pro Max
Mod6	F	54	VI: difficulty with contrast	6	iPhone 6S
Mod7	F	38	Blind: no vision left eye, minimal right	3	iPhone X
Mod8	F	35	Blind: no vision right eye, severe short sight left eye	8	Samsung Galaxy S10
Mod9	M	31	VI: blurred vision, sensitive to light	8	Laptop PC/Windows
Mod10	M	33	VI: tunnel vision	8	iPhone 8
Mod11	F	25	VI: blurred vision, problems with colour	8	iPhone 8 Plus
Mod12	M	75	Blind: can't see light or dark	6	Laptop PC/Windows
Mod14	M	31	VI: blurred vision	8	Sony Xperia XZ Premium
UnMod2	M	38	Blind: light/dark perception only	8	iPhone 8
UnMod3	M	76	Blind: no vision	8	iPhone 7
UnMod4	F	63	Blind: limited central vision	6	Samsung A5
UnMod5	M	27	Blind: light/dark perception in 20% of field	6	iPhone X
UnMod6	F	48	VI: blurred vision, floaters	6	Sony Xperia XZ1
UnMod7	F	35	VI: tunnel vision	8	iPhone 7
UnMod8	F	68	VI: blurred vision, short sighted	6	iPhone 7
UnMod11	M	32	VI: no information	8	iPhone SE
UnMod13	F	40	VI: blurred vision, inability to focus	8	Samsung Galaxy J3

UnMod14	M	55	VI: blurred vision	6	Samsung Galaxy S8

4.2.5 Procedure

4.2.5.1. Procedure for the moderated condition

At an arranged time, myself, the participant, and any observers from the development team logged on to the Microsoft Teams session. After introductions to build rapport, and a reminder of the purpose of the evaluation, the participant was asked the questions in the Pre-Study Questionnaire. They were then asked to follow the link provided in the information sheet to the registration for *NHS login* and to set up their account. I requested that they provide a think aloud protocol while doing this, talking me through what they were doing and any problems they encountered If necessary, I prompted the participant to explain what was happening if they fell silent for more than 20 seconds. Prompts in this context mainly consisted of me asking the participant; *"What are you thinking about now?" "What are your thoughts?" "Can you give feedback on what's happening?".* As the participant used *NHS login*, I would also intervene as they shared their thoughts with prompts related to specific steps and features such as *"Is that what you expected to happen?" "What did you think of the photo taking process" "how did you find the selfie video process".* If the participant was unable to progress at any point after one minute, I helped them progress. This usually involved sharing a link to the next step in the registration process if technical difficulties hindered progress. If progress was hindered by a user error rather than a technical issue, I would give the participant a hint on how to proceed.

4.2.5.2 Procedure for the unmoderated evaluation

For the unmoderated evaluation, each participant was emailed an information pack which included the information sheet (Appendix 4.2), informed consent form (Appendix 3.4) During the research evaluation of *NHS login*, the participant was I requested that they provide 'a think aloud' protocol, verbalizing their thoughts as they work thought the tasks (Dumas & Redish, 1999).

The participant was asked to complete the pre-session questionnaire, undertake the task and complete the post-session questionnaire within one week of receiving the email. Fortunately, in Microsoft Teams, a recording is automatically saved to the cloud, so participants did not have to upload any files related to the evaluation itself. Participants were encouraged to contact me if they had any queries or problems with understanding how to proceed with Microsoft Teams or if they had any questions about the evaluation prior to starting.

4.3 Results

Both moderated and unmoderated studies uncovered recurring usability problems with NHS login related to form fields and email confirmation. However, by far the most problematic usability issues were related to the section asking users to take a photo of their ID document as well as the section where users are asked to either take

a scan of the face or short video saying an authentication number as outlined in Table 4.3.

Many users of both the moderated and unmoderated condition struggled in taking a clear picture of their photo identity as well as completing the biometric face matching process, in which they are required to take a selfie video saying an authentication code. Some participants voiced frustration and confusion as to why there was no auditory guidance and that the procedure that is asked of them from *NHS login* is inaccessible. Of the 14 research participants in the remote moderated control, 6 participants were unable to take a clear photo of their identity document and 6 were unable to complete taking an acceptable selfie authentication video (one participant failing due to a technical issue).

Table 4.3: Results of identity document photo step & biometric face matching step

ID	Gender	Age	Visual Status Registration and Brief Description	Photo of ID document	Biometric face matching process
Mod1	M	53	VI: blurring of detail, esp.	Clear	video clear

			text		
Mod3	F	28	Blind: light/dark perception only	Unclear (glare & facing upside down)	Unable to complete process
Mod4	F	22	Blind: light/dark perception only	Clear	Unable to complete process
Mod5	M	27	Blind: very limited vision	Unclear (edges cut off and upside down)	Unable to complete selfie video (Camera facing wrong direction)
Mod6	F	54	VI: difficulty with contrast	Unclear (edges cut off)	Selfie video unclear (face obstructed)
Mod7	F	38	Blind: no vision left eye, minimal right	Unclear (text not legible and corners cut off)	Unable to complete selfie video (cannot see authentication numbers)
Mod8	F	35	Blind: no vision right eye, severe short sight left eye	Photo clear	N/A (technical error)
Mod9	M	31	VI: blurred vision, sensitive to light	Photo clear	Selfie video clear
Mod10	M	33	VI: tunnel vision	Unclear (edges cut off)	Unable to complete selfie video
Mod11	F	25	VI: blurred vision, problems with colour	Photo clear	Selfie video clear
Mod12	M	75	Blind: can't see light or dark	N/A	N/A
Mod14	M	31	VI: blurred vision	Photo unclear (text not	Selfie video clear

				legible)	
UnMod2	M	38	Blind: light/dark perception	N/A technical issue	N/A technical issue
UnMod3	M	76	Blind: no vision	Photo unclear (facing wrong way)	Unable to complete selfie video
UnMod4	F	63	Blind: limited central vision	Photo unclear (glare and text not legible)	Unable to complete selfie video
UnMod5	M	27	Blind: light/dark perception in 20% of field	Photo clear	Selfie video clear
UnMod6	F	48	VI: blurred vision, floaters	Photo clear	Unable to complete selfie video
UnMod7	F	35	VI: tunnel vision	Photo clear	Selfie video clear
UnMod8	F	68	VI: blurred vision, short sighted	N/A unable to complete email authentication	N/A unable to complete email authentication
UnMod11	M	32	VI: no information	Photo unclear (glare and text not legible)	Unable to complete selfie video
UnMod13	F	40	VI: blurred vision, inability to focus	Photo unclear (edges cut)	Selfie video clear
UnMod14	M	55	VI: blurred vision	N/A trapped in Hotjar overlay	N/A trapped in Hotjar overlay

After all sessions finished, the qualitative data was analysed internally by the NHS login development team. We wanted to explore similarities and relationships between different areas of the data. Being that we were working remotely at the time, we worked collaboratively within Miro, a popular cloud-based project management and design platform. We translated participant quotes and participant actions from these

research sessions by using an inductive approach to thematic analysis in which we allowed the data to determine the themes. The NHS login development team worked collaboratively and grouped themes of the participant feedback with digital sticky notes. We used these insights to group themes and inform areas for usability enhancements and content design iteration to future improvement of NHS login. As mentioned, participant quotes were used in this thematic analysis, with participant numbers accompanying their quote on the digital sticky note. Descriptive labels were used in each category. After generating initial themes and reviewing them, 4 major areas emerged, which were the following:

Absents of photo framing:

Seven participants in total mentioned that a frame overlay when they opened their camera would have been helpful in guiding them to align their identity document and remove ambiguity regarding which portion of their passport to take a photo of. During the process of taking a photo, many vocalised that having a frame to help guide them on where to take a photo would have been useful. Participant #8 in the moderated control found that having a photo frame in the photo taking portion would have been useful, she stated: “it doesn’t give you an idea how to frame it, I’m not sure if you can see my camera but it doesn’t say what the angle should be or how wide the edges should be.” Participant #9 in the moderated control stated “it would have been useful if it showed me where to frame my photo, kind of like how Monzo does it for their process”. In the process of trying to take a photo of their identity document Participant #10 in the moderated control mentioned “I’m unsure where to line it up, it doesn’t tell me where to place the document or where to frame it”. He ended up

taking a photo with the edged cut off. Participant #6 in the unmoderated control stated “why does it not give guidance on where to frame the photo?”

Lack of instructional clarity regarding passport photo taking:

Five participants in total vocalised confusion around the photo taking process for taking a picture of a passport. Participant #7 in the moderated control took a picture of his full passport of both pages and found the instructions unclear, which is one of the factors that lead her to failure in getting authenticated. When brough to the page stating she failed the participant exclaimed “This page asked if you can see two faces? Well of course! There are two faces on the passport, because the pages have two faces in it! Participant #1 in the moderated control also stated he was unsure which portion of the document to take a photo of stating “I’ll have a crack at opening the camera, it’s telling me capture image, that’s fine, I’m going to open the camera…now I have not got any guidance on which part to take a photo of. I think that will be fine I hope, but I’m not sure if this is what it wants.” Participant #4 in the moderated control mentioned “now I’ve opened my camera, and now that I’ve taken the picture, it is asking me if ‘can you see all four edges of the passport’, but I don’t know if they mean the whole passport or just the one page!” In the unmoderated control, participant #5 mentioned “now I’ve taken the photo of my passport, but it is of the whole document, I hope that is acceptable. I’m not 100% sure if that is what they want.”

Length of signup process:

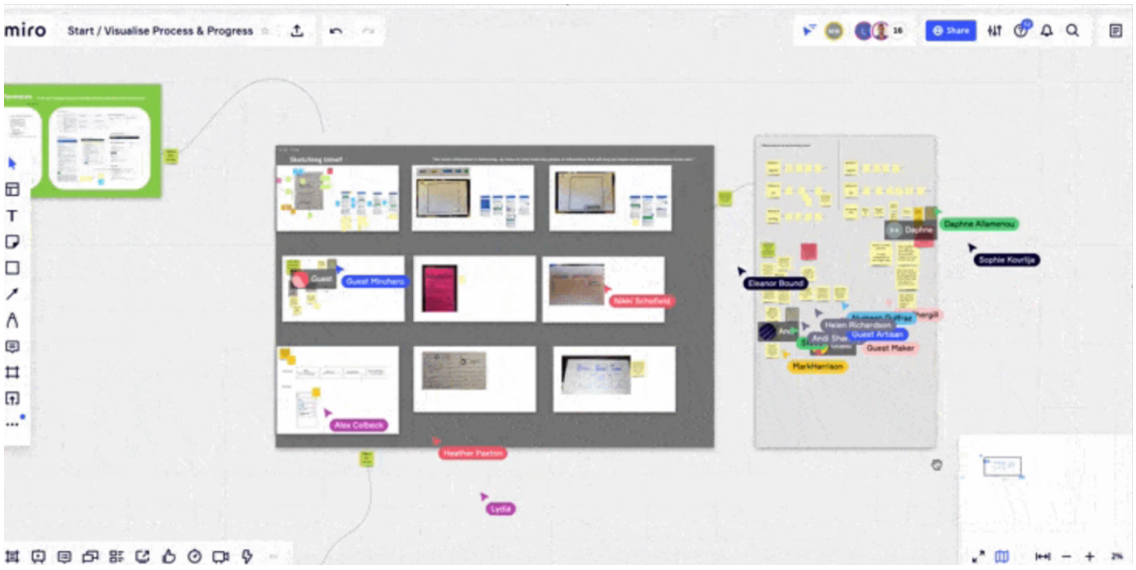
Going through the NHS login signup and identity verification process seemed very exhausting to participants. With no explicit expectation setting at the beginning of the journey, participants were unsure how long the process would take. And with no progress indicator throughout the signup process, participants didn't have context as to how far along they were. A theme of frustration regarding the amount of time and effort needed for the identity verification process emerged. Over half of all participants in both conditions made comments about the length of the signup process. Participant #7 in the moderated condition stated "this is a really long process, I wasn't expecting it to take this long!". Participant #10 in the moderated condition mentioned "this is a long haul! I wasn't expecting it to take this long!" Participant #7 in the unmoderated condition stated "this is taking a really long time! It's just page after page. How much longer will this take?"

Absents of audio feedback:

Absents of audio feedback, particularly for registered blind users, was a common area of feedback. 5 people in total across both conditions made statements regarding the absents of audio cues and how it would have been useful for them in completing the photo taking portion of the process. Participant #11 in the unmoderated condition mentioned "with no audio, I'm not sure what is happening!". During the photo taking portion of the signup process, participant #13 in the unmoderated condition stated "some sort of audio guidance would be useful here, I'm struggling to know if I'm doing this how they want it". In the moderated condition participant #3 mentioned "I'm going to try to take this picture, and I'm going to try my hardest, I'm going to hold my

passport in front of my iPad and take a picture. Hopefully it will be a success but without any audio feedback I can't check it to see if it is ok because I can't see it."

After the moderated and unmoderated sessions were completed the session recordings were analysed internally by the NHS login development team. Being that we were working remotely at the time, we worked collaboratively within Miro, a popular cloud-based project management and design platform. We translated participant quotes and key insights from these research sessions into a thematic analysis of usability issues, common areas of confusion, as well as interaction design and content design elements that performed poorly. The themes of absents of photo framing, lack of instructional clarity around passport photo taking, the length of the signup process, as well as lack of audio guidance were the dominate themes on our thematic analysis. The results of this thematic analysis were used to inform future design and content iterations for NHS login.



4.3.1 Comparison of the two evaluation conditions: moderated vs unmoderated conditions

In comparing the remote moderated and unmoderated conditions with blind and partially sighted people, I found there were advantages and disadvantages in using both methods. This section will discuss the advantages and disadvantages of using moderated and unmoderated remote evaluation methods, as well as the advantages and disadvantages of using remote methods in general, with blind and partially sighted people. This section will finish with recommendations for researchers wishing to utilise remote methods with blind and partially sighted users in the future.

4.3.1 Advantages of remote moderated condition

In utilising a remote moderated method, there were several notable advantages. One of the main advantages was the ability of being on the same session live with the participant, in which I was able to ask questions and observe their interaction with the system in real time. Moderating sessions in real time with a research participant allowed me to ask probing questions when users encountered a usability issue, as well ask in-depth questions related to their session during the post-session interview of the study.

Another advantage of the remote moderated condition was that my development team at NHS Digital were able to easily view user sessions in real time as I facilitated each session. By simply sending a Microsoft Teams link to my team members, they

were able to discreetly observe sessions without disturbing the participant. Of course, permission was obtained from each participant for this. Not only did this give designers, developers, and managers on my team critical exposure to primary user research in real time, it also helped in the team contributing to questions asked during the live sessions. During several sessions, members of the development team would relay questions directly to me in the private Microsoft Teams chat box, for me to then ask the participant. This contributed to a sense of team comradery in research efforts, as well as gaining insights into questions that I, as a user researcher, may not thought of in the moment live with users.

Gaining informed consent, via email, prior to each session proved to be an unexpected problem. Many blind and partially sighted research participants struggled with filling in and returning the informed consent form that was sent to them prior their research session. This was a standard NHS Digital informed consent PDF file that is send to research participants via email attachment. I was able to mitigate this issue at the start of each moderated session, by capturing informed consent audibly. For any participant who had difficulty with the email consent form, I would start their session by reading the consent form aloud to them and capture their informed consent over the Microsoft Teams recording. This proved to be far easier for participants as opposed to filling in and emailing a digital consent form. Another added benefit was the fact the participant was able to ask me any questions directly as I read the consent form to follow up with any further clarification.

In terms of any technical issues that may have hindered smooth recording and facilitation of a session, being on the same Microsoft Teams session in real time with participants proved to be invaluable in terms of quickly troubleshooting any issues a participant had in relation to screen recording, sharing their screen, as well as any audio issues related to having their microphone muted or obstructed. Being able to quickly sort out any technical issues someone had during their session proved to be incredibly valuable.

4.3.2 Disadvantages of remote moderated condition

Although I found many advantages in in the moderated condition, it was not without its disadvantages. One of the most problematic issues with the moderated condition was audio quality. Participants' devices, in particular their microphones, were of varying quality. For any participant using a screenreader, this issue was exacerbated, as I had to try and understand both what the participant was saying and the screenreader speech, often at the same time. It was sometimes necessary during sessions to ask the participant to pause their screenreader while they articulated their thoughts, so I could hear what was being said. In situations in which participants would speak over their screenreader to give feedback, it was necessary for me to retroactively listen to recordings to decipher what was being said. This made analysis of data more time consuming.

Quality of the internet connection was also an issue for the moderated condition. For any participant with a weak internet connection, slight delays in conversation would make for a moderated interaction that felt unnatural and drew attention to the

remote technology being used. Connection impediments related to lags and breaks in internet connectivity made for a more difficult interaction process for both me and the participant. Audio and video connectivity issues also made for a difficult note-taking process for observers. Most of the time, a participant was not aware of these issues happening in real time. This meant that I had to often ask any participant with a poor internet connection to repeat actions as well as their think aloud information. This was less than optimal, as the goal was to have the participant concentrate on the evaluation, tasks, and questions during the session and to minimise the attention of the remote situation as much as possible.

The moderated condition may have led to drawing attention to an expert observer being present during session and negatively impacted natural use of the system from participants.

4.3.3 Advantages of remote unmoderated condition

One of the biggest advantages of the unmoderated condition was the fact the participant was using *NHS login* independently and needed to problem solve on their own, just as they would in a real-world context. This method had greater ecological validity, as participants were by themselves at home, working through the authentication system, rather than being observed and potentially assisted by a researcher.

I also found that the unmoderated condition to be less strenuous from a time standpoint as a researcher. The fact that I could deploy a study at scale with multiple

participants and later receive video files from to be analysed, was far less time intensive than moderating each individual session myself. When compared to the time spent facilitating the moderated condition, speed and efficiency were one of the main advantages of the unmoderated condition.

4.3.4 Disadvantages of remote unmoderated condition

The unmoderated remote condition was not without its disadvantages. One of the most obvious disadvantages was the inability to ask questions of a participant in order to gain more depth and context when they encountered usability issues. Although they were asked to verbalize their feedback while using *NHS login,* the richness of feedback paled in comparison with the moderated condition. The post-session survey data also lacked richness and depth when compared to the post-session debrief interviews from the moderated condition. For the unmoderated post-session survey, most of the data was not actionable and lacking in quality. Many participants only filled in a sentence or two for each question, with many participants abandoning the survey entirely. The ability to converse with participants after their session and have them reflect on their experience in real time during the moderated condition proved to be incredibly valuable as it relates to gaining deeper insights. Members from the development team who were observing were also able contribute to post-session questions for the participant during the moderated condition, which lead to useful feedback. This was not possible in the unmoderated condition. Survey abandonment issues were frequent in the unmoderated condition, even though the instructions given to participants in the explicitly outlined that the post-session survey was

mandatory. This led to poor data that lacked in substance and was unactionable in terms of any future accessibility enchantments for *NHS login*.

In utilising the unmoderated condition, one of the biggest disadvantages was related to technical issues and disruptions that impeded many sessions. As a moderator, I was unable to troubleshoot any technical issue in real time with participants. This led to some sessions being delayed until participants were able to figure out technical issues related to Microsoft Teams recording software by themselves or were able to contact me for help. Two participants that contacted me directly had a digital literacy self-rating of 6 and struggled to troubleshoot technical impediments on their own. Technical issues related to recording remote sessions seemed to be amplified with the unmoderated condition.

4.3.5 Advantages of remote research methods in general

Given the circumstances of the unfolding COVID-19 pandemic, one of the most obvious advantages of using a remote research method was ensuring the safety and wellbeing of research participants. Remote conditions ensured that the evaluation environment was not susceptible to Coronavirus transmission, as opposed to a face-to-face research lab where participants would be put at risk of transmission.

I found remote methods in general came with many advantages. One of the most evident advantages was related to participant recruitment. Remote evaluations allowed for a recruitment process across a broader geographic area, rather than needing to recruit participants from a fixed proximity. This was particularly useful in

recruiting blind and partially sighted participants who may find it difficult to travel to an evaluation site due to their disability and run the risk of exclusion in research. This factor was especially true for participants in rural areas as well as elderly participants. The ability to recruit and run a study with 22 registered blind and partially sighted people in two weeks impressed me, as compared to previous recruitment processes with the same participant demographic during my time as a user researcher at NHS Digital. Finding replacement participants for people who dropped out of the study also proved to be a quick and efficient process, given the wider recruitment panel of people across the United Kingdom.

The ability to easily involve members of the development team at *NHS login* also proved to be a major advantage. During my time as a user researcher at NHS Digital, involving the wider development team in research activities proved to be time consuming and burdensome for team members who want to observe live user research. In-person research activates such as face-to-face usability labs, workshops, and popup research came with the added commitment of having to travel to the evaluation site and the time burden of setting up research materials. In utilising remote methods, involving development team members proved to be fast and relatively simple, in comparison to in-person studies. By sharing research timetables and a Microsoft Teams link with development team members they were able to observe, and even contribute to, evaluation sessions in the moderated condition from the comfort of their home in a time efficient manner they could fit in alongside their other work tasks. With the unmoderated condition, I was able to simply send them a link of the video file (after obscuring any personally identifiable information) for

viewing. The lack of travel and preparation time with any physical materials and tools meant that I was able to conduct research with a higher volume of participants each day.

An unexpected advantage of both remote conditions was that fact it gave participants more control over sharing and recording their identity documents. During their entry of personal information into *NHS login*, some users were not comfortable with having their identity document recorded and broadcast over Microsoft Teams. During this portion of the study, some participants felt more comfortable pausing the screen recording so they were confident that no personal information was being inappropriately recorded, as they were in control of what was and was not being broadcasted.

4.3.6 Disadvantages of remote methods in general

By far the biggest disadvantage of remote methods with blind and partially sighted people were the technical difficulties that came with using remote screensharing and recording technology. Many sessions in both the moderated and unmoderated conditions suffered from technical difficulties related to screensharing, audio quality, internet connectivity issues, and participant difficulty with initial setup. Many of these technical difficulties either delayed sessions, impeded on the quality of data and natural flow of the study, or obstructed participant natural use of *NHS login*. This was less than optimal, as in the session the goal is to have the participant concentrate on the evaluation, the tasks, and questions to be undertaken, rather than the remote situation and recording software being used. As the moderator, one of my goals was

to avoid drawing attention to the technicalities of the remote situation as much as possible, but in many cases some technical difficulties were unavoidable.

Another disadvantage in utilising remote methods when evaluating *NHS login,* was the technical limitations of Microsoft Teams. When participants needed to record a short video of themselves saying the authentication code, or to complete a facial scan, they were not able to complete this step while simultaneously broadcasting their device screen over Microsoft Teams, as video-on-video broadcasting was not technically feasible. This was a critical part of the evaluation, to assess whether visually disabled users would be able to negotiate the visual aspects of the video or facial scan authentication process. Because of this technical limitation, participants had to pause MS Teams while they completed this step. Although I was able to retroactively ask participants about their experience with the video or facial scan procedure, it was a major disadvantage not to be able to observe their interaction with this step of the registration and identity authentication process. Being in a physical environment, in-person, with participants, and as a moderator would have been advantageous in terms of observing the process participants took in taking an authentication video or face scan.

4.4 Suggestions for conducting remote evaluations with blind and partially sighted participants

For researchers seeking to utilise remote conditions with blind and partially sighted participants, I would make the following suggestions based on my experience:

Prior to running remote evaluations with participants, schedule in a mandatory pre-session check-in meeting, in which ensures screen recording technology, internet connection, and device are suitable for the evaluation session. Ensuring a mandatory check-in such as this will minimise risks of the study encountering impediments related to audio quality, connectivity issues and/or software recording interruptions. Therefore, it is important to thoroughly test the software to be used to conduct remote evaluations with any assistive technologies participants will be using and software (including all versions) that participants have on their devices, to ensure that they will be able to access the tools and all the functions needed during the study. Navigating accessibility, representation, and quality of data, was a struggle but is something to consider in future research. After reflecting on the research protocol I constructed, I would have made this arrangement mandatory instead of being an optional or a self-administered process by participants.

Given the rather poor post-session questionnaire data stemming from the unmoderated condition, making full completion of post-session surveys mandatory before compensation is given would be recommended. Although I reminded participants to complete the post-session survey in its entirety, many participants either ignored completing the survey or left it partially completed, leaving me with poor, unactionable data. If recruitment is done through a recruitment agency handling monetary compensation for participants, having in place an explicit agreement with participants and the recruitment agency that compensation be deployed only after post-session surveys are completed in their entirety would be my suggestion upon reflection of the unmoderated condition.

4.5 Conclusions

After analysis of the research data from this study, it was clear that evaluation with audio feedback cues was the next logical step. An interactive system that requires people who cannot see to take a clear photo of their identity document and position their head isn't accessible. Given the evident accessibility issues of *NHS login* and participants voicing negative feedback regarding the absents of audio guidance, it was well-reasoned to construct a study which investigated the use of audio guidance during the photo taking and biometric identity verification process.

Chapter 5: In-Person Evaluation of Verbal and Audio Cues for Identity Authentication by Blind and Partially Sighted People

5.1 Introduction

Two aspects of *NHS login* which the programme of research had identified as critical accessibility problems were the need to take a photo of a identity document (which has a photo of the person) and to take a scan of one's face to be matched to the photo in the identity document to thus prove one's identity. Users are first required to take a clear photo of a government issued identification document which includes a photo of themselves, such as a driving license or passport. They are then asked to take a scan of their face, so that the face images i can be matched. Both these segments of the account creation process proved to be major points of difficulty for partially sighted people and impossible for blind people, as they cannot see where their identity document is aligned in the first task. In the second task, users are required to have their face correctly aligned in the scan frame on the screen, which also proved to be difficult for partially signed users and impossible for blind users who cannot see the visual frame. After observing the difficulty users had with this these two tasks in the *NHS login* in the previous study, reported in Chapter 4, I came up with two possible solutions of providing different audio guidance to direct users to replace the problem of inaccessibility of the visual guidance. The two solutions were evaluated in this study. The first solution was to provide verbal cues to the participants. The second solution was to provide audio cues in the form of beeps, in which beeps would be faster and higher pitched when the participant's ID document or their face is in

frame, and slower and lower pitched when the participant's ID document or face is out of frame.

Therefore, this study set out to address three research questions:

RQ1: Do verbal cues enable blind and partially sighted users to effectively use the ID document input and face video parts of *NHS login*?

RQ2: Do audio cues enable blind and partially sighted users to effectively use the ID document and face video parts of *NHS login*?

RQ3: Do blind and partially sighted users prefer verbal or audio cues for the ID document and face video parts of *NHS login*?

5.2 Method

5.2.1 Design

A repeated measures design was used. Blind and partially sighted participants completed the account registration and identity authentication process for *NHS login*, in three different conditions: control (the current live version with visual cues only), verbal cues and audio cues. Participants all started with the control condition and then the order of the two experimental conditions was counterbalanced between participants. Participants undertook a concurrent think aloud protocol while undertaking two tasks in each of these conditions, taking a photo of the ID document and taking a face scan. Dependent variables were ability to complete the task in each condition, and participants' subjective reactions and preferences for each condition.

5.2.1 Participants

A commercial agency was used to recruit participants for the study. Inclusion criteria were that participants be aged 18 years or older, registered blind or visually impaired, use a computer or smartphone and not have registered an *NHS login* account. During the screening process for recruitment, prospective participants were informed they would be setting up a real *NHS login* account when taking part in the study.

14 participants were recruited in this study. However, two participants were not able to access *NHS login* and undertake the evaluation due to technical issues. One participant was not able to access *NHS login* using their laptop and one participant was not able to load *NHS login* on their phone. A further participant's data could not be analysed, as insufficient information was provided about the nature of his visual impairment. This left 11 participants in the study.

Demographic information for the participants is presented in Table 5.1. Participants included 4 male and 7 female. Their ages ranged from 28 to 55 years, with a mean age of 37.8 years. Five participants stated they were registered blind. Eight participants stated they were visual impaired. Participants were offered £80 for their participation in the study. The study took place in Leeds, United Kingdom with all participants recruited from the West Yorkshire area.

Table 5.1: Demographic details of participants

Participant No.	Gender	Age	Impairment	Device used

2	Female	38	Registered Blind	Samsung A5
3	Male	30	Registered Blind	iPhone 7
4	Male	55	Registered Blind	Samsung A5
5	Female	37	Visually impaired	iPhone 8 Plus
6	Male	30	Severely visually impaired	Sony Xperia XZ1
7	Female	28	Registered Blind	iPhone 8
8	Female	29	Registered Blind	iPhone 8
9	Female	49	Visually impaired (Punctate Inner Choroidopathy)	Samsung Galaxy S8
10	Male	46	Visually impaired (Retinitis Pigmentosa)	Samsung s10
11	Female	31	Visually impaired (Leber Congenital Amaurosi)	iPhone 7
14	Female	43	Visually impaired (Keratoconus)	Samsung Galaxy S8

5.2.2 Equipment and materials

This study took place in a research laboratory in Leeds, UK (see Figure 5.4). During the study, all participants used their preferred personal digital device (see Table 5.1). Sessions were recorded on a MacBook Pro (15 inch, 2018) with a portable IPEVO V4K Ultra High-Definition portable camera. IPEVO capture software on the MacBook was used to record participant interaction during the ID document photo and face scan tasks. The research laboratory came equipped with recording and broadcast equipment of a fixed IPEVO V4K camera to capture user interaction with their mobile device, as well as a fixed Logitech C920s HD webcam for recording participants' faces. The research laboratory also had overhead AV broadcast equipment, which was used

to steam sessions live to observers in the NHS login team via a private, password protected streaming link.

The audio cue beep simulation was carried out from my MacBook Pro (15 inch, 2018), utilising an online soundboard. As a moderator, I would observe participant use NHS login and manually play the appropriate audio cue that was appropriate for their interaction in real time. When users had their ID document of face out of frame, I would simulate a negative low pitched beeping sound. When users had their ID document in frame or face in the appropriate location for a face scan, I would simulate a higher toned positive beep.

For verbal cues, I voiced these cues myself. I would observe participants' use of *NHS login* and give real time verbal instructional cues that aligned with their real time interactions. If a participant did not have their identity document or face in frame I would provide appropriate cues. Cues for the ID document task are listed in Table 5.2 and for the face scan task in Table 5.3.

TABLE 5.2

Cue if photo taken is unclear	**Cue if ID photo is out of frame**	**Cue if ID photo is too close or far away**	**Cue if photo ID is clear & acceptable**
"Photo not acceptable" "Photo unclear"	"The photo you have taken is out of frame"	"Document too close, please move back" "Document too far, please move forward"	"Photo is clear, please take a picture"

TABLE 5.3

Cue if face is out of frame	Cue if face if too close or too faar away	Cue if camera is facing the wrong way	Cue if face is in frame
“Face is out of frame, please move [left, right, up,down]	“Face too close, please move back” Face too far, please move forward”	“Switch camera to front facing”	“Face in frame, please record video”

An informed consent form was provided for participants (Appendix 3.4).

Figure 5.4. Photographs of usability lab

5.2.3 Evaluation Tasks

The evaluation tasks used the NHS App, which uses *NHS login* as the identity authentication and account creation process. A current real-world build of the app was used for the control condition and was augmented with the vebal and audio cues for the two experimental conditions.

The instruction for the evaluation, as given to the participants, were:

1. Enter your email address.

2. Create a password. (Must have 8 characters or more, 1 capital letter or more)

3. Open email inbox.

4. Open email inbox and confirm email the automated authentication email sent from NHS sent to email address entered.

5. Enter your mobile phone number into NHS login.

6. Enter the 6-digit code sent to the phone number entered in Step 5.

7. Take a photo of your ID document (passport, driving license, European ID card). [ID Document task]

8. Confirm photo of ID meets requirements

9. Upload photo of ID to NHS login.

10. Take scan of your face. [Face scan task]

11. Submit face scan.

12. Enter address postcode.

5.2.4 Procedure

When each participant arrived at the usability lab, I introduced myself and had them sign an informed consent form after describing what we would be doing during the research session. After introductions and signing of the consent form, we would situate ourselves in the usability lab, with the participant holding their device under the recording equipment and me sitting directly to their right-hand side to observe and moderate.

All participants started with the control condition and then the order of undertaking the two experimental conditions was counterbalanced to avoid practice and fatigue effects.

Participants were asked to perform a concurrent think aloud protocol while undertaking the three conditions (Dumas & Redish, 1999). If necessary, I prompted the participant to explain what was happening if they fell silent for more than 20 seconds Prompts consisted of me asking the participant; *"What are you thinking about now?" "What are your thoughts?" "Can you give feedback on what's happening?".* The only situation in which I stepped in to help a participant was if a technical issue happened with their device running *NHS login*, or if they stated that they would not be able to proceed because they were unsure of what to do on a particular page.

In the control condition, participants were asked to verify their identity by taking a photo of their identity document as well as complete a face scan or authentication video when prompted. Participants were asked to think aloud while they carried out these tasks. During this task I observed participants' performance on the two experimental tasks, noting any accessibility issues.

Participants were then asked to start the authentication process over again, in which there would be one of two types of auditory cue to help them with the ID task and the face scan task as they proceeded. Participants were not told about the specificities of this verbal or audio information to starting. As in the control condition, I observed participants' performance on the two experimental tasks as well as providing the appropriate verbal or audio cues

Following the three conditions, I then held a debrief session with each participant. This session focused on their preference of the two auditory solutions and which solution they found most useful and why. I also prompted users to share their thoughts on the shortcomings of the solution they did not prefer and the rationale behind why they didn't find it as useful.

5.3 Results

Table 5.2 summarizes the results of the first of the two experimental tasks, taking a clear photo of an identity document. This shows that in the control condition, only 5 of the 11 participants (45.5%) were able to take a clear photo of the identity document. None of the 5 blind participants were able to achieve this part of the task, with 5 producing unclear photos, and one failing to take a photo at all. Of the 5 partially sighted participants, 4 (80.0%) were able to take a clear photo. Many people found the audio condition to be too ambiguous and not helpful While the verbal condition performed much better.

Table 5.2: Results of identity document photo task

Participant No.	Sight status	Control condition	Audio condition	Verbal condition
2	Blind	Unclear	Unclear	Clear
3	Blind	Unclear	Clear	Clear
4	Blind	Failed to Take Photo	Clear	Clear
5	PS	Clear	Clear	Clear
6	PS	Clear	Unclear	Clear
7	Blind	Unclear	Clear	Clear
8	Blind	Unclear	Clear	Clear
9	PS	Clear	Clear	Clear
10	PS	Unclear	Unclear	Clear
11	PS	Clear	Clear	Clear
14	PS	Clear	Clear	Clear

Table 5.3 summarizes the results of the second experimental task asked to create a photo or video of their face in the verbal and audio cue conditions.

Table 5.3: Results of face scan task

Participant No.	Face scan video
2	Verbal cue: Video with voice instructional feedback was clear and useful Audio cue: Audio cue was not useful, and video was unclear
3	Verbal cue: Unable to complete with verbal cue Audio cue: unable to complete with audio cue
4	N/A
5	N/A
6	Verbal cue: Video with verbal instructional feedback was clear

	and useful Audio cue: Audio cue was not useful, and video was unclear
7	Verbal cue: Useful and video clear Audio cue: Confusing and video unclear
8	N/A
9	Verbal cue: Useful and video clear Audio cue: Not useful and video unclear
10	N/A
11	Verbal cue: Useful and video clear Audio cue: Useful and video unclear
12	Verbal cue: Useful and video clear Audio cue: Ambiguous but video clear
13	N/A
14	Verbal cue: Useful and video clear Audio cue: Ambiguous but video clear

Using qualitative insights from this moderated study, the NHS login development team followed the same process of post-session thematic analysis as we did for the first remote study, in which we took an inductive approach to thematic analysis allowing the data to determine the themes. Using Miro, we collaborated as a team remotely and analysed video files and notes that were taken from this study. As we worked together on this thematic analysis three dominate areas emerged. The dominate themes were non-verbal auditory cues (audio condition) performing poorly, human audio guidance (verbal condition) overwhelmingly preferred and performed well in terms of helping participants take a clear picture of their ID document and annoyance around the length of the signup and authentication process. Observational notes of

participant interactions as well as participant quotes from sessions were used in this thematic analysis this thematic analysis.

Non-verbal auditory cues performing poorly:

Almost every participant in this study mentioned that the audio condition was not useful and too ambiguous to be of help in terms of taking a photo that would be acceptable. During the post-session debrief conversation, when asked what the auditory cues meant when taking an ID document photo, participant #11 stated “I think it was a countdown of when to take the photo, but I’m really not sure”, he went on to say “it was a bit too ambiguous, it wasn’t direct enough for me to know what it meant or what I should do.” User #7 stated “honestly I would lay the phone down on the document and just feel where it is and try my best to take a photo. The deeper tones might have meant it was far away but it wasn’t very useful in guiding me on what to do.” When asked what she thought of the audio condition, participant #6 stated “that doesn’t mean anything to me, I would not know what those noises meant (…) to me they are just beeps, I have no idea what that meant so it was of no help to be honest.”

Human audio guidance (verbal condition) overwhelmingly preferred by participants:

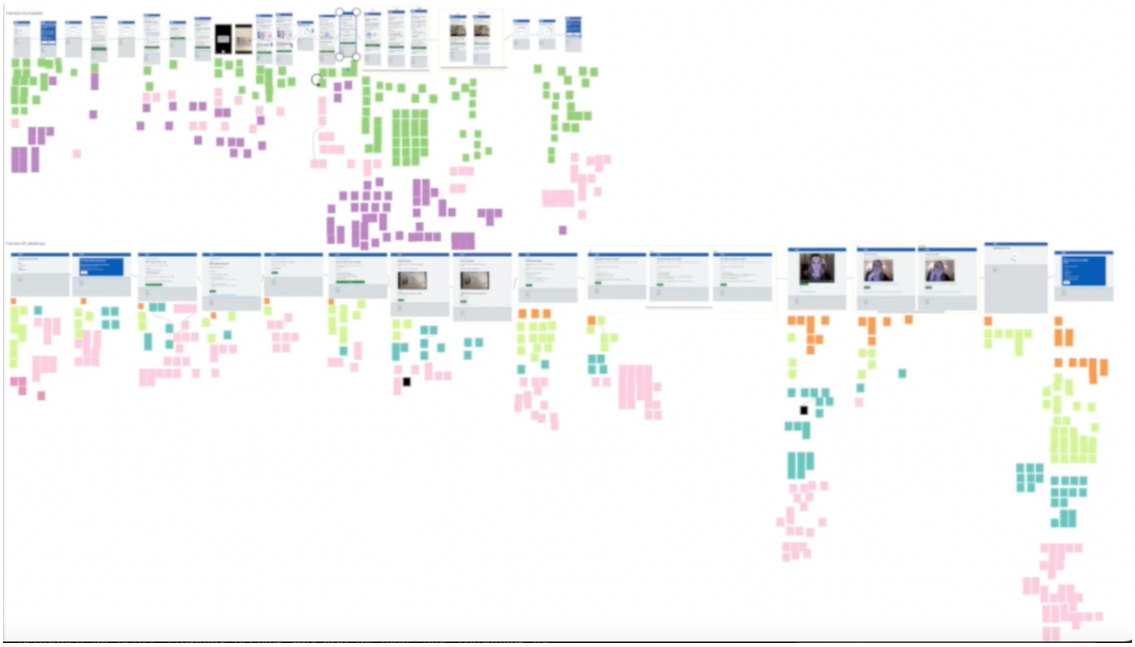
The verbal condition performed very well, with all participants taking a clear photo of the ID document and responding with positive feedback. Every participant from this study gave positive feedback towards the verbal condition. Participant #7 mentioned

“this is far more helpful than anything else. There isn’t any ambiguity, it is very direct in terms of where I need to be placing the passport. I like this a lot” participant #12 stated “I much prefer that over the beep noises, the beeping was not helpful and confusing, having a voice give instructions is much better. Participant #2 stated “Ok that is much better, without clear instructions like this I’d be lost in terms of what I should be doing. That was great!” Participant #6 stated “there is no guess work with feedback in that form. I know what I need to do unlike with the beeping which was not helpful at all.”

Negativity towards the length of the signup and authentication process:

Similar to the first study, participants expressed negative sentiment towards the length of the signup and authentication process. With no expectations set at the start of the process in terms of how long the authentication procedure will take, users expressed annoyance at how long it took. Participant #6 mentioned “this is a really long app to get through, is it like this for everyone?” During the post-session debrief portion of the study participant #9 stated “I really didn’t like how long that took to get through. For getting set up and authenticated for my bank it didn’t take nearly as long.” Participant #14 mentioned “this is a very long app to get through! I didn’t think it would be this much of a time commitment. If this was real life I probably would have quit to be honest!”

After socialising the results of this study internally in the from a qualitative thematic analysis,documented this evidence to use for future product roadmap prioritization of new features.



5.3.1 Discussion

When assessing the effectiveness of each condition, I reviewed both the qualitative feedback from users during the post-session debrief phase of the study as well as task results of each auditory feedback condition. When comparing the effectiveness of the auditory condition to that of the human voice instructional auditory condition as it relates to successful completion of tasks, the human voice instructional condition performed far better. Proximity beeping was also far more time consuming for participants when compared to voice auditory feedback, with many participants finding beeping cues to be ambiguous and unclear.

During the post session debrief, 11 out of the 12 research participants preferred the voice instructional auditory option rather than proximity beeping or using *NHS login* with no auditory feedback when taking a photo of their ID document. Participants found the proximity beeping condition to be too vague, ambiguous, and requiring too much interpretation and thought as to what the beeping means. Two participants stated that they found the auditory beeping to be unhelpful and confusing when taking a picture of their identity document. Participants found the human voice condition to be explicit and requiring no interpretation.

When completing the biometric face authentication portion of *NHS login,* all users that made it to that portion of the service preferred having human voice instructional feedback in guiding them on where to place their face. Users found proximity beeping to require too much interpretation and found it challenging when placing their face in the appropriate place.

All users stated they found auditory cues useful when asked to give their thoughts on both conditions, as compared to *NHS login* with no auditory cues. For both the ID document picture and face biometric tasks, all but one participant stated that preferred human voice cues. The one research participant (participant #11) preferred proximity beeping cues during the ID photo taking stage but stated the human voice auditory cues were more useful during the facial biometric portion of *NHS login.*

5.4 Conclusions

This chapter discussed a study of two ways for blind and partially sighted users to take a photo of their ID document and biometric authentication video as part of the *NHS login* process. The purpose of the study was to evaluate if verbal cues enable blind and partially sighted users to effectively use *NHS login,* if audio cues enable blind and partially sighted users to effectively use *NHS login,* and do blind and partially sighted users prefer verbal or audio cues

Chapter 6: Overall Discussion and Conclusions

This study reflected the poor performance of *NHS login* with blind and visually impaired users and the various accessibility issues encountered. Blind and visually impaired users encountered a high volume of accessibility and usability problems with *NHS login*. The problems that these research participants encountered, and the tasks success rates proved that *NHS login* required more consideration of the accessibility of the app for blind and visually impaired people from the inception of the project. Upon reflection of this academic work and my time as a User Researcher with the *NHS login* programme, there are a few insights to conclude with and that development teams working within digital identity authentication should be made aware of in order to make their application accessible.

The lack of focus on accessibility from the beginning of *NHS login* as a programme lead to exclusionary practices for people with access needs. Software development teams need to think about accessibility while they are still in the planning stages of a project in order to avoid setbacks later and technical problems that could arise. The lack of focus and planning as it relates to accessibility for blind and visually impaired users, ultimately led to an inaccessible public facing application, as well as costly time-intensive future development work for accessibility enhancements. The failure to make software accessible is a common problem when developing a new application. With a stringent focus on accessibly from the initiation of *NHS login,* the programme could have built an accessible digital service with a lower cost scope related to future work, rather than having to retroactively fix issues related to accessibility because it was not a focus from the inception of the project.

Experimentation and implementation of auditory cues for guidance, from the beginning of *NHS login* as a programme would have been made a positive difference for blind and visually impaired users. Although it would have posed an interesting challenge for the software development team, implementation of auditory guidance from the beginning of development work would not have been as difficult to include compared to retroactively carrying out development work to incorporate auditory cues. Auditory guidance from the beginning would have also served as a usability enhancement for users with situational disabilities, such as having a damaged device screen or poor screen visibility due to lightening in their environment while attempting to authenticate their identity.

Software applications often fail because teams lack understanding of user needs. Before someone investigates a problem with software that they're developing, there is a high likelihood that no one has directly observed the people who need to use the product or service. This was the case with the software development teams within *NHS login.* It was only when the wider team of developers, project managers, and designers observed primary user research with blind and visually impaired users, that accessibility issues were taken into consideration as a priority. Having the wider programme observe primary user research with blind and visually impaired users struggle to use *NHS login* was a powerful strategy in terms of the wider team gaining a shared understanding of the severity of accessibility issues. Having development team members in the same research context observing users in real time proved to be more useful than presenting secondary reports related to accessibility issues, in terms of

action being taken within the programme related to accessibility improvements for *NHS login.*

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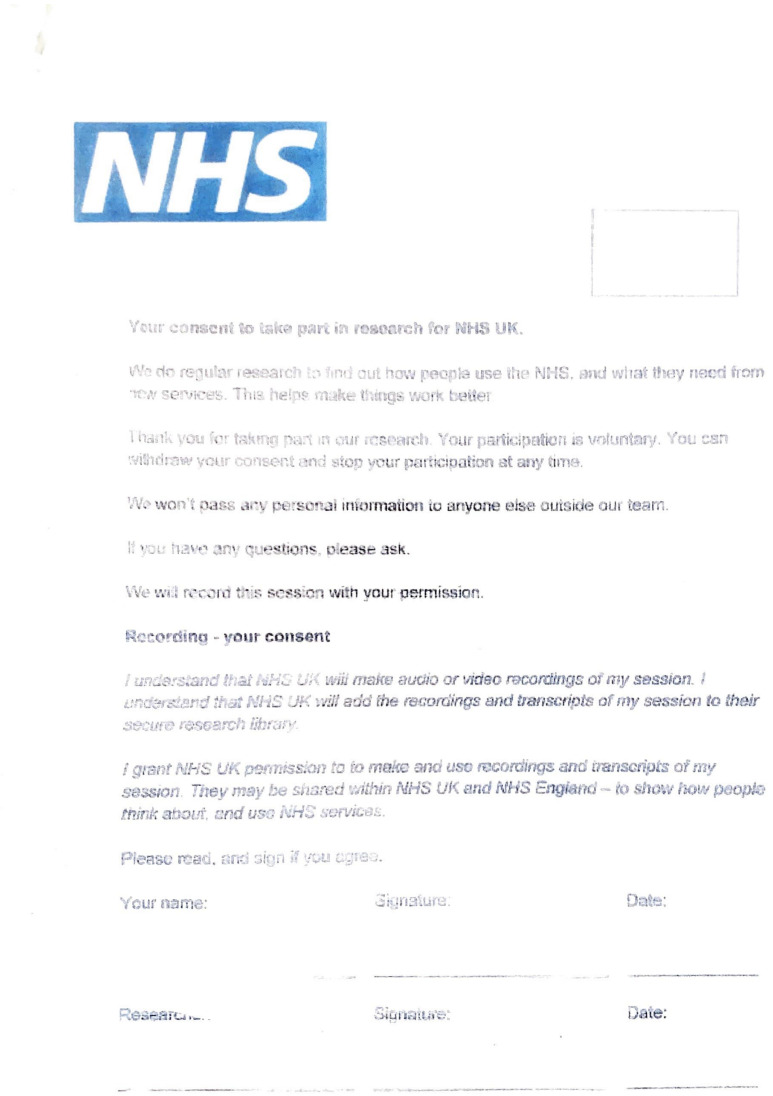
Appendices

DAC Audits uploaded seperatly

Appendix 3.4



Your consent to take part in research for NHS UK.

We do regular research to find out how people use the NHS, and what they need from new services. This helps make things work better.

Thank you for taking part in our research. Your participation is voluntary. You can withdraw your consent and stop your participation at any time.

We won't pass any personal information to anyone else outside our team.

If you have any questions, please ask.

We will record this session with your permission.

Recording - your consent

I understand that NHS UK will make audio or video recordings of my session. I understand that NHS UK will add the recordings and transcripts of my session to their secure research library.

I grant NHS UK permission to to make and use recordings and transcripts of my session. They may be shared within NHS UK and NHS England – to show how people think about, and use NHS services.

Please read, and sign if you agree.

Your name:	Signature:	Date:
Researc...	Signature:	Date:

Appendix 3.5

February 5th 2018
https://nhs-cid.herokuapp.com/start/v6/nhs-app-start

0.Introduction

Intros
- Introduce each other, chat a bit.
- Ask if brought own devices and if OK to try an app on their device

Purpose
I work for the NHS with a team of people who make websites and apps. Today we're inviting you to try a new app to help us understand how we can make it better.

Before we start
- We are looking for honest opinions and thoughts, don't worry about offending anybody, you won't.
- I didn't make the app, so you won't offend me, or any of us, if you tell us what you don't like about it
- You're feedback will help us make improvements and make things more accessible.
- As we go through the interview please say your thoughts out loud, tell me what you are thinking
- If that's Ok with you, we'll be recording the interview, so we can check our notes
- Everything you say is completely confidential and will not be shared outside of our direct team at NHS Digital
- You can stop and leave at any time
- Consent form

1. Digital habits

- Do you have or use a computer, tablet or smartphone?
- What sort of things do you use them for?
- What websites and apps do you use?
- Have you ever needed help to use a website or an app?
    - If so how often and for what?
    - How did you get help?
    - Do you ever use websites or apps with another person by your side or helping you?
    - Are there any websites or apps you gave up using because they were too difficult, or too clunky, to use?
    - Have you ever used any apps or websites related to health? Government?
    - Is there anything in general you'd like us to know about?

2. Scenario

I am going to ask you to try out an app

KVIN (Feb 5th 2019)

IMAGINE you went to your GP surgery and the receptionist tells you about a new NHS App. It's an app where you can do a number of things to do with your health such as booking appointments, getting repeat prescriptions.

It asks you to sign up and proceed

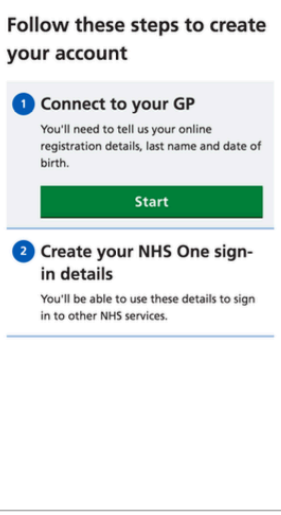
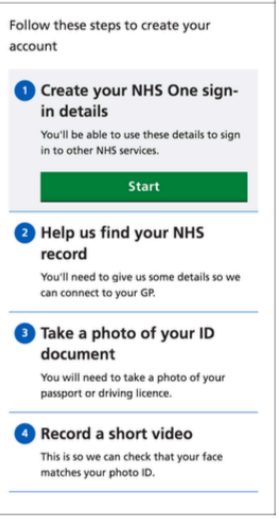
Pretend we're not here and you are doing it on your own.

Please try to think aloud while you use it

screen / step / theme	observe / probe in review
Do you have an NHS Account?	- Understanding of what an 'NHS Account is? - Confused? - Click 'What is an NHS Account?'
Set up your NHS login	- Issues with accessibility - Ability to progress and enter details - Ability to handle errors?
Check you email	- Ability to check email and progress? - Switching from web app to email and back - Accessibility issues?
Log in	- Accessibility issues? - Ability to log back in
Check your phone (security code)	- Ability to enter code from phone? - Switching from web app to phone and back? - Any issues?
Has your GP Surgery given you details that let you book appointments online?	- Pull down accordion issues? - Have they been given details in real life? - Issues with entering options?

Steps screens

Do they understand what steps they will need to take to complete the journey

A. Steps screen for POL	B. Steps screen for PYI
	

Help us find your NHS record

screen / step / theme	observe / probe in review
Do you know your NHS number	- accordion dropdown issue? - issue entering options?
Last name + DOB	Any issues?
Postal code	Any issues?

Take photo of you ID

* Let user know that this is a work in progress *

screen / step / theme	observe / probe in review
What type of photo ID do you have?	user confidence at this point?
Uploading photo	Any issues? Ability to take picture of ID?
Check your photo	Any issues?

Record a short video

screen / step / theme	observe / probe in review
Take a selfie	Accessibility issues? User confidence at this point? Ability to open camera and proceed confidently? Errors?
Open Camera and say numbers	Accessible with a screen reader? Able to view video? Can user confidently say number and record themselves?
Check your video	User able to check video and proceed with confidence and with no errors or issues?
Please Submit your information	Ability to proceed? Understanding of journey? What happens now?

iProov

Intro: We are working on integrating a step in our service that takes away the need to take a selfie video with an authentication code.

This service will simply scan your face and match it to the form of ID would upload. How does that sound?

Demo: https://demo.iproov.com/

screen / step / theme	observe / probe in review
iProove	- Ability to use with no assistance - Is iProov accessible? - * assist in terms of telling them to move forward or backwards depending on user ability/ confidence * -

Review / Co-Design

General reactions to their experience

What did you think of what you've just gone through?

Thoughts on iProove vs taking selfie + code

Do you have any suggestions regarding things that could be improved?

Probe in terms of real world context use. —> how would they find this service?

Do you have any suggestions regarding things that could be improved? Any general thoughts?

Lets pretend you could build your own version of some sort of sign up and log in process, what might that be like, talk us through it.

Go back to any relevant screens and probe for more insight

Appendix 3.7

No	Page	Description	Heuristics	R1	R2	R3	Median Rating
1	1	no explanation of why I need to prove who I am at this point	9, 10, 11	2	4	4	4
2	1	why have this page, it doesn't move the user forward		3	4	3	3
3	2	user not informed of an overview of about how the process will work (I need one of these IDs, a camera/computer with a camera)		2	4	4	4
4	2	user not told this is a one off process		2	3	5	3
5	3	passport - what countries		1	3	3	3
6	3	European - EU or Europe		1	3	3	3
7	3	What if I don't have any of these IDs - only covers if I have an ID but don't want to upload (statement unclear)		1	2	3	2
8	3	make "what happen to my data" easier to access		0	4	3	3
9	3 / Interuption cards	inconsistent button colour (white vs green)		1	1	1	1
10	3	"Choose the ID you want to use" - no options given, not clear	10, 17	3	2	3	3
11	3	no forewarning people of what they will need	9	2	3	3	3
12	3	Step 1 of 3, meaning not clear (is "Sending a photo of your ID" step 1 of a bigger process or is this Step 1 of the process of sending a photo		2	3	3	3
13	3	info about the two photos should be earlier or later	6, 14	2	2	2	2
14	3	We are still in step 1, but on a different screen, not clear	8, 10,N&M4	1	4	2	2
15	4	No "back" on the breadcrumb trail		1	1	1	1
16	5.5	Message about visual impairment comes far too late		3	5	5	5
17	5	Better "Are all corners of the driving licence visible"		1	2	1	1
18	several screens	radio buttons + continue button add to number of clicks required		0	3	2	2
19		Better? Have you covered up any part of your driving licence e.g. with your fingers?		1	3	1	1
20		"Match your face to your photo ID" better "Compare ..."		1	2	3	2
21		Provide a more logical order of the explanation of the "matching"		2	2	3	2
22	Interuption card scree	continue should not be underlined		1	1	1	1
23		Instruction could be clearer e.g. "To scan your face .."		1	2	3	2
24		Add "Warning: Photosensitivity" to the Warning		1	1	3	1
25		Warning for dual screens when the scan flashes		2	2	2	2
26		Title needs to be more informative e.g. We need to match your ID with your NHS records"		2	2	4	2
27		need to indicate that you will be logged out if you don't do something, give them the option of extending their time		3	5	4	4
28		lack of contextual feedback on multiple pages		4	5	4	4
29		Add - If you don't receive an email in 2 hours first check spam, and what to do if no email (e.g. contact number, website)		3	5	3	3

Appendix 4.1

Hello, my name is Mitchell Wakefield. I am a user researcher here at NHS Digital. Thank you for your participation in this unmoderated study. In our session, you'll be looking at an identity authentication application called NHS login.

We will be conducting our research session on Microsoft Teams, so please **ensure you have the MS Teams app downloaded on your device and ready to go**.

Also, after you complete the session on MS Teams, you will be asked to complete a post-session survey. It is important that you give as much detail as possible for each answer. 1 or 2 paragraphs for each text field would be sufficient. **Failure to do so may lead to you not receiving your full monetary incentive.**

Attached is a consent form. If you are comfortable taking part in this research, I'd like to ask you to sign the form and send it back to me prior to our session.

- ***Prior to the study here are some things that you should be aware of:***
    - Your participation is completely voluntary, you can end this study at any time if you wish.
    - There are no right or wrong answers. We are not testing you or your aptitude. We are only researching to see if the service that has been created is easy to use.
    - Please have your identity document on hand
    - Please give honest feedback on the website.
    - I did not design or create the website you will see today. I'm just the researcher. Your feedback cannot offend me.
    - This study is unmoderated, which means you'll be completing tasks independently.
    - The data from this session will not be shared with anyone other than the internal team at NHS login & the University of York for research and development purposes.
    - As mentioned in the screener, you will be interacting with a real world app, that means that you will actually be creating an NHS login account.
-
- ***If you have any questions or concerns prior to the study you can email me at: mitchell.wakefield@nhs.net***
- [Survey Link]

- ***Please be sure you have downloaded MS Teams and have an account setup for our session beforehand.***
- ***Please, text or email me a time that suits your convenance before our scheduled sessions for a brief tech check. This is to ensure you are able to share your screen remotely so our session runs smoothly.***

Appendix 4.2

Hello, my name is Mitchell Wakefield. I am a user researcher here at NHS Digital. Thank you for your participation in this moderated study. In our session, you'll be looking at an identity authentication application called NHS login.

We will be conducting our research session on Microsoft Teams, so please **ensure you have the MS Teams app downloaded on your device and ready to go**.

Also, after you complete the session on MS Teams, you will be given a link to a post-session survey in the chat box. It is important that you give as much detail as possible for each answer. 1 or 2 paragraphs for each text field would be sufficient. **Failure to do so may lead to you not receiving your full monetary incentive.**

Attached is a consent form. If you are comfortable taking part in this research, I'd like to ask you to sign the form and send it back to me prior to our session.

- ***Prior to the study here are some things that you should be aware of:***
    - Your participation is completely voluntary, you can end this study at any time if you wish.
    - There are no right or wrong answers. We are not testing you or your aptitude. We are only researching to see if the service that has been created is easy to use.
    - Please give honest feedback on the website.
    - Please have your identity document on hand
    - I did not design or create the website you will see today. I'm just the researcher. Your feedback cannot offend me.
    - This study is moderated, which means I will be facilitating our session with you live in real time. I may ask you questions and you may ask me questions.
    - The data from this session will not be shared with anyone other than the internal team at NHS login & the University of York for research and development purposes.
    - As mentioned in the screener, you will be interacting with a real world app, that means that you will actually be creating an NHS login account.

Appendix 5.2

Participant Number		Registered blind or visually impaired	Photo ID without audiofeedback	ID with beeping audio feedback	ID with voice instructional feedback	Facescan/video selfie	Preference
Participant #1		Registered Blind	• First attempt hand was coving details • Second attempt was clear	N/A	N/A	N/A	
Participant #2		Registered Blind	• Photo was **unclear** and the picture was unusable	• Took unclear photo	• Took clear photo	• Selfie video with beep audio feedback was not useful. Video unclear • Selfie video with voice instructional feedback was clear and useful	Voice instructions
Participant #3		Registered Blind	• Fail. Photo unclear	• Photo clear	• Photo clear	• Fail • Unable to complete without audio guidance	Voice instructions
Participant #4		Registered Blind	• Fails	• Photo clear	• Photo clear	N/A	Voice instructions
Participant #5		Visually impaired	• Photo clear	• Photo clear	• Photo clear	N/A	Voice instructions
Participant #6		Visually impaired - Severely sight impaired	• Photo clear	• Photo unclear (found it confusing)	• Photo clear	• Facescan with beeps not useful and confusing, video unclear. • Facescan with voice, clear	Voice instructions
Participant #7		Visually impaired - Severely sight impaired/ Registered Blind	• Photo unclear (apple audio feedback)	• Photo clear	• Photo clear	• Facescan with beeping audio feedback was confusing and process was unclear • Facescan with (apple) audio feedback was much more useful and facescan was clear	Voice instructions
Participant #8		Visually impaired - Severely sight impaired/ Registered blind	• Photo unclear	• Photo clear	• Photo clear	• Selfie video fail (tech issues)	Voice instructions
Participant #9		Visual impairment - Punctate Inner Choroidopathy	• Photo clear	• Photo clear	• Photo clear •	• Face scan clear but feels auditory feedback is necessary • "I don't mind it because if I've done it wrong it reminds me	Voice instructions for both scan and ID photo
Participant #10		Visual impairment - retinitis pigmentosa (RP)	• Photo unclear	• photo unclear. Did not find beeping audio feedback to be useful • "the beeps don't mean anything to me."	• photo clear but far away (apple voice)		Voice instructions
Participant #11		Visual impairment - Leber Congenital Amaurosi - Severely sight impaired	• Photo clear (with accessibility voice feedback)	• Photo clear	• Photo clear	• Selfie video unclear without audio feedback • Did not find beeping audio cues useful. Beeping is too ambiguous. ("The beep was annoying and very frustrating") • Found voice audio cues helpful and necessary	Beeping audio cues (similar to seeing AI)
Participant #12		Color blind	• Photo clear	• Photo clear	• Photo clear	• Selfie video with voice feedback preferred	Voice instructions
Participant #13		Visual impairment- Charles Bonnet syndrom	• failed process				
Participant #14		Visual impairment - Keratoconus	• Photo clear	• Photo clear • "On days when I'm struggling it might be useful"	• Photo clear • "This is a lot more intuitive, it's giving a direct instruction. It requires less interpretation that the series of sounds (beeps) • I like the direct instruction and	• Prefers voice feedback for facescan • Voice instructions: "The clear instructions would be better" • There is no requirement of thought or interpretation	Voice instructions