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# The Future of Mobile Usability, Workflow and Safety Testing

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**Abstract**

*In this paper, the authors outline a vision for the future of mobile usability, workflow and safety testing. The authors argue for the use of glasses that can audio and video record usability, workflow and safety data. Here, citizens, patients and health professionals would become collectors of study data as they use mobile devices and software to support healthcare in the real world. This has become quite feasible with the introduction of low-cost glasses and software applications that allow for the uploading of data for additional analysis by researchers and evaluators of mobile technologies.*

***Keywords:***
Patient Safety; Health Information Systems; Medical Errors

## Introduction

Mobile healthcare is on the rise. Citizens and health professionals are using mobile phones to support their healthcare anytime and anywhere (i.e. in the hospital, home and community) [1]. Yet, the usability, safety and workflow implications of these devices and their associated software applications has not been fully researched [2-4]. In this vision paper we consider the use of glasses that audio and video record in terms of: (1) usability, workflow and safety testing, (2) citizens as collectors of audio and video data for research, (3) the potential of video and audio recording devices, (4) the methdological issues associated with using glasses that audio and video record, and (5) future research directions.

## Background Literature Review

### Why is Usability, Workflow and Safety Testing of Mobile Devices and their Software Important?

Around the world, citizens (e.g. patients, caregivers and health professionals) are using mobile devices such as tablets, mobile phones and smart watches to support their health and wellness, as well as to engage in activities related to healthcare (e.g. looking up health research online, recording physiologic data, using mobile software applications) [1]; for example, using mobile healthcare software applications (e.g. exercise, diet and mood monitoring applications) to self-manage their wellness and chronic diseases [1]. This is consistent with Fox and Duggan's research findings that identify 38% of American adults use exercise, fitness, pedometer or heart rate monitoring health applications; 31% use diet, food or calorie counter software applications; and 12% use mobile weight monitoring software applications [5].

In additon to this, citizens are repurposing existing mobile technologies (e.g. text messaging, mobile calling, photo applications), and using social media software applications that are not traditionally thought of as healthcare applications (e.g. Twitter®, Facebook®, YouTube®) to obtain and communicate health and healthcare information and to manage their health (e.g. take a picture of a rash) and during health crises (i.e. to communicate information about a family member who is critically ill) [1,5].

Internationally, there has arisen a recognition that mobile phones and their software applications hold significant promise for improving the health of individuals, patient health outcomes and the health of populations [1]. The potential power of mobile technologies when applied to healthcare is signficant when considering statistics that reveal close to a 100% adoption of these technologies in the developed and developing world [5,6]. Attention to the mobile health revolution is needed. Researchers need to understand how mobile technologies and their software are used (i.e. through usability testing) and integrated into everyday and worklife (i.e. healthcare related activities and workflows). There is also a need to assess the safety of these technologies with the introduction of technology that causes medical errors. These conditions need to be satisfied to ensure citizen safety and improve patient and population health outcomes [1-4, 7].

To illustrate, in a recent publication by Li et al. the researchers found that usability testing led to the refinement of the software user interface design and improved clinician workflows. This in turn lead to higher rates of adoption of the technology among clinicians [8]. In a study on mobile prescribing systems safety, researchers were able to identify user interface features and functions that led to prescribing errors (i.e. technology-induced errors). In identifying these user interface features and functions and refining the sofware, potential medical errors were reduced and the costs associated with treating patients who are harmed or injured were also reduced or eliminated [2, 8].

These issues are not limited to software designed for healthcare use. Mobile hardware and software repurposed by citizens and health professionals for health activities can also introduce errors; for example, the autocorrect function on mobile phones may lead to the wrong name of a medication being recorded (if the auto correct changes the name of the medication) while being written into a note taking app on a mobile phone [2,9]. It is for these reasons that usability, workflow and safety of mobile devices and software need to be tested.

**What is the Current State of Mobile Device and Software Usability, Workflow and Safety Testing?**

Less attention has been paid by researchers and industry to developing new methods for mobile device and software testing for usability, workflow and safety testing [10]. There has also been less attention focused on understanding how mobile technologies' usability, workflow and safety influence citizen and health professional users in the research literature [11]. There are a number of reasons for this. Perhaps one of the biggest barriers is the mobile nature of devices and the limited development of methods that can be used to test mobile devices for usability, workflow and safety in an effective manner [2,9]. There is a need to develop research methods that allow for recording of audio and video data for analysis of the impact of these technologies in the areas of usability, workflow and safety. Once mobile devices have been refined, we will be better able to understand their impacts upon citizen health, patient outcomes and health professional work processes [9].

***In-situ Usability Testing***

As mentioned earlier, there has emerged an increasing need to evaluate the effects of mobile device hardware and software from a usability and workflow perspective. Such work is critical to fully understand how the technologies are used to support the health of individuals and populations. "In situ" usability testing, which refers to the collection of usability and workflow data in real-world settings, has become important to understanding how: (a) mobile phone software applications, (b) non-healthcare, mobile phone software applications downloaded by citizens and (c) "true" mobile healthcare software applications are used together by citizens in differing contexts to support health and healthcare [10]. Early work done in this area by Kushniruk and colleagues [10], has often involved conducting usability testing in real-world work settings (i.e. at a computer in a hospital or in a physician's office). Here, electronic health records and hardware devices used in a hospital or physician's office are used during usability and workflow testing to ensure the participant feels they are in a real-world environment [10]. Such testing, although effective, is limited by the type of hardware used (i.e. desktop computer or laptop) and is specific to a particular fixed setting by the hardware (i.e. using a desktop computer in a hospital) [11].

With the introduction of mobile phones and software (including healthcare software applications), there has emerged a need to consider and extend existing approaches to usability, workflow and safety testing to account for the ability of citizens and health professionals to move from one setting to another as they perform activities that influence their health (e.g. dietary choices, the choice to exercise) [9]; for example, "in-situ" testing should take place anywhere a citizen may go and use technology to support their health activities [10]. To illustrate, a citizen might use a mobile device and software to support health-related activities in the home, in the car on the way to work, at work, in a restaurant at lunch, at the gym and/or in the physician's office [5]. This represents a signficant challenge for researchers: to collect a fullsome dataset that can be used to improve the overall user experience in engaging in healthcare activities and managing their health, while at the same time collecting information about mobile device hardware and software in these real-world settings [2,10,9,12].

***Citizens as Collectors of the Data***

Around the world, citizens (e.g. patients, caregivers and health professionals) can now post and view pictures and video online, increasing the potential for consuming and exchanging differing types of health information [13,14]. We have seen rapid growth in the use and miniturization of cameras and audio recorders, and the trend towards supporting citizens, patients and health professionals in recording their own video and audio data (e.g. mobile phones have cameras, video and audio recorders, smart watches have audio recording capabilities, and glasses can be used to record audio and video) for social, recreational, work and educational purposes. [13-18]. Citizens are posting health information online, and this information may include textual, picture, video and audio data [13, 14]. Some of these postings take the form of information posts, such as links to health information and posts about self help strategies. Some posts include video and audio data uploaded to social media such as YouTube® and Snapchat® [13,15].

The potential to involve citizens and health professionals in the collection of video and audio usability data using these technologies, due to their miniturized form and integration with other technologies (e.g. glasses, mobile phones, smart watches and social media), is signficant [15,16]. Yet, there are few papers that describe the potentials and pitfalls of citizens and health professionals using these ubiquitous tools to collect data in usability, workflow and safety testing (i.e. testing for usability, technology-induced errors and health information technology safety). To date, the focus on such testing has been on mobile devices and software in a traditional laboratory setting [2, 9, 11].

## The Challenge of Collecting Mobile Video and Audio Data

Audio and video recordings are essential components of usability testing. Audio data allow one to document verbalizations. If an individual is participating in a usability test, then audio recordings allow for collection of "think aloud" verbalizations or the thoughts of the user as they arise while using a technology, such as a mobile healthcare application [2,11]. Video data in usability testing should include collection of computer screen or mobile device screen recordings [2,9,12]. This is important as it is necessary to be able to view how the user is interacting with the user interface of the technology as they verbalize their thoughts [2,12].

The freedom of movement (i.e. physical and contextual) associated with using a mobile device is significant and poses a number of challenges for conducting research. Mobile device users of healthcare applications seldom stay in a fixed context or position when using the technology. The portability of the device allows the citizen or health professional to move from one location to another and to interact with the device while moving in differing locations throughout the day. This must be accounted for in testing studies. Workflows embedded in the software and workflows associated with using the mobile device and software applicaton need to be captured, and this can be challenging in the real world (i.e. in-situ) [2, 3,10,12].

**Existing Approaches Toward Mobile Device and Software Testing**

Many methods have been used to collect usability data using mobile approaches. Research methods and factors that influence the quality of mobile usability testing data are important to consider when designing studies. There are a number of challenges associated with conducting usability tests using mobile phones and healthcare applications [2,12]. One such challenge arises from the recording equipment and the mobile device. The quality of the data collected during mobile usability, workflow and safety tests can be influenced by the type of mobile device and recording equipment/software used. This influences the interpretability of the research results. To illustrate, if the mobile phone is used to record mobile phone screens as the user moves through a software application, hand motions and screen touches will not be recorded. This in turn will make it difficult to determine what the user was touching on the screen at what point in time and if the user interface is confusing [9,12].

In such cases an external audio and video recording device is needed to fully understand what the user is touching on the mobile phone user interface. External devices may require that the mobile phone be fixed to a specific location and position so that all user interactions are captured. This may limit the user's movement, as well as the researcher's ability to record the impact of the device and software upon work tasks and activities [2,12].

Some researchers have documented their experiences in conducting usability and workflow testing involving mobile phone hardware and software. In this work the researchers identified a number of issues that need to be considered when conducting such testing, including: data quality issues, the Hawthorne effect and the inability of participants to engage in typical activities and contexts due to the limitations of the audio and video recording equipment employed in mobile phone and software testing. There is a need to attend to the type of audio and video recording equipment used, as this may affect data quality; for example, recording audio and video data directly to the mobile phone of the user does not provide the researcher with insights into what the user is touching on the mobile device screen or what other artifacts and events in the user's environment are being considered or are influencing mobile phone and software use [2,9,12].

Alternatively, if a user is participating in a test in a usability lab, then data can be captured regarding the user's interactions with the mobile device using an external camera, but the user's interaction with their environment is limited to that of the usability lab, rather than the real world (i.e. a citizens home, work or community environment) [10,12] The user cannot engage in actitivites that are typical of those undertaken when using a mobile phone in the real world, in-situ setting (e.g. sitting in a restaurant and recording information about one's meal) [12].

## The Future: Using Glasses that Audio and Video Record Data

### What is the Potential for Glasses as Video and Audio Recording Devices?

The development of glasses as a video and audio recording tool had its origins in the surveillance [19] and sports industries [20]. In the surveillance industry, glasses that can record video and audio data are used by law enforcement officials to collect data in real time from the perspective of the user for the purpose of conducting surveillance of criminal activities [19]. In the commerical sports industry there emerged a demand for a lightweight, unobtrusive method to collect video and audio data for the purpose of providing the user's view of sports activities, such as snow boarding, skiing, mountain biking and skateboarding [20]. Users have posted videos for family and friends to share their experiences (with those who were unable to participate) [15,20]. Initially, many of these glasses recorded only video data. Today, they record both audio and video data that can be easily downloaded for review from the glasses [14, 15, 19, 20].

The use of wearable audio and video recording devices has increased in popularity with a wider consumer interest in the technology developing since 2013 [14,15,18]. Approaches have emerged that can be used to effectively collect mobile video and audio recordings for the purpose of assessing the usability, workflow and safety of mobile devices. The idea of collecting audio and video data using glasses has only recently been considered as a viable means of collecting usability, safety and workflow data [21]. In 2013, early work in this area was fostered by Google® with the development of Google® glasses that could be used to present the user with information gleaned from the world wide web, while at the same time providing the capacity to audio and video record data [18]. Wider citizen interest in glasses that record audio and video data increased in 2016 when Snapchat® began marketing glasses that record video and audio data from the user's point of view. Snapchat® glass users, after recording videos or taking pictures using the glasses, can post digital images and video online via an online social media tool [14-16].

### Viability of Glasses as Video and Audio Recording Devices

The viability of glasses as an audio and video recording tool needs to be considered in the context of citizens and health professionals as collectors of video and audio data for usability, workflow and safety testing. Glasses can be used to record audio and video data to capture user interactions with mobile device hardware, software and the real world. When considering the technology for mobile usability, workflow and safety testing one must consider that the technology is used independently from the mobile phone with the user wearing the device. Here, glasses are used to not only collect data about devices and software, but also about how these technologies are used in the context of the user's surrounding environment [1].

Earlier, the authors of this paper identified there are several types of glasses that perform this activity on the consumer market. Some have been specifically developed for research purposes or for work use (e.g. Tobii®, Google® glasses) . Other glasses have been developed for consumer use (to be used by citizens to record events or sport activities, e.g. Snapchat® glasses). Regardless of the type of glasses used to audio and video record data, there are a number of methodological issues that need to be considered, which we will discuss in the next section of this paper [14-20].

### Field of View

One critical issue that needs to be considered when using glasses for audio and video recoding data is the field of view. The field of view refers to the extent to which the observable world is seen by the user. Humans have a forward facing horizontal diameter of almost 180-degrees in their field of view [15,18]. In selecting glasses for video and audio recording of interactions with a mobile device and the surrounding environment, it is important to select a device that provides a field of view that is representative of what the user would typically see. The more consistent the field of view is with the users, the more representative the data will be. Some glasses reduce the field of view, thereby limiting the amount of video data that is collected. Some glass manufacturers have attempted to address this issue by providing glasses with a field of view that is more consistent with the typical user's field of view; for example, Snapchat's® glasses have a 115-degree field of view [15]. As the field of view is not consistent across glass types, pilot testing needs to take place to ensure full video data collection.

**User Control of Activation/De-activation**

One of the key issues in using glasses in video and audio recording data is the activation of the recording function. Different glasses have different approaches to user control of the recording function. This is imporant if users are asked to wear the device and record interactions. The ability to activate and de-activate the recording function is important from a methodological perspective. Some glasses do this through voice command, others in response to head motions and still others through a touch pad on the glasses themselves [15-20].

In terms of analysis and use of mobile devices for health purposes, the user could activate and de-activate the recording functions of the glasses, recording only when using the mobile device for health-related activities. The advantage of this approach is that the researcher does not have to review hours of video and audio data, and collected data is focused on the activity of interest. To ensure recording device and application use for health-related activities becomes the focus of the study, glass users may need to be trained to record the activities the researcher is interested in studying.

**Privacy, Confidentiality and Ethics**

From an ethical perspective, the ability to activate or de-activate the recordings at key points in time is critical from a user's perspective. Here, the user could ask others for permission to record an encounter involving the mobile device, a health app and a health professional or caregiver. Similarly, if the user is unable to obtain the consent of others, the recording could be deactivated by the user. Also, there is the ability to deactivate the recording when the user does not want specific video or audio recorded. To illustrate, Google® glasses can be activated/deactivated through the use of voice commands or head movement at key points in time to enable recording of health related activities [17,18]. Snapchat® glasses offer another approach to the issue of recording. Snapchat® glasses can also be activated/deactivated through a mobile Snapchat® app [15,16]. Snapchat® affords the user some additional features that may be of value from an ethical perspective. Snapchat® glasses indicate when the video and audio camera is recording to those in the field of view (i.e. a light on the glasses indicates when the recording is on). This may be of value to those being video recorded as they can see when the recording function is enabled and disabled [15,16].

**Sufficient Length of Recording Time**

Length of recording time refers to the amount of time that is dedicated to recording audio and video data. The recording time needs to be of sufficient length to be able to fully record a health-related activity involving a mobile device. There is a range in the length of recording times for differing types of glasses. Short recording times may lead to disruptions in user activity [9]. This may lead to segmented disruptions in user data or place a burden periodically on the user of downloading recordings to a software application, leading to missing data if the user forgets to download data periodically.

**Cost**

Cost is a consideration when conducting studies involving the use of glasses. The cost of purchasing glasses that can record video and audio data for usability testing can range from $120 to several thousands of dollars [15, 17, 18, 20]. Glasses used to collect data for usability testing at the upper end of this cost range not only record data, but include analysis software (i.e.Tobii®) [20]. However, involving multiple participants may be costly or cumbersome to coordinate if sharing the glasses between users is difficult. Snapchat® has developed low cost glasses that can be used to live stream and record audio and video data for upload. Snapchat® glasses are priced at $129/pair, and this includes glasses and a charger. Snapchat® ofters prescription glass users the opportunity to purchase a pair of glasses with their own prescription [15,16]. Other glasses used for sports and surveillance purposes that can record audio and video data have also entered the consumer market, allowing for audio and video recording for prices as low as $50, making real-world studies inexpensive and feasible to conduct with large sample sizes [20].

**Asthetics**

A key issue associated with the use of glasses for recording of audio and video is asthetics. Some users of glasses that audio and video record do not want to wear glasses that differ from other types of glasses that citizens currently wear (e.g. sunglasses, prescription glasses) during the study [15,16,20]. This may decrease participation, as Google® glass users are reluctant to continue using the technology due to privacy concerns for others in their field of view.

## Future Research Directions and a Future Vision

Glasses that audio and video record data offer significant advantages over traditional recording techniques used to collect usability, workflow and safety data. Such glasses allow one to record the user's interactions with the mobile device hardware and software (i.e. health app and mobile phone app software). In addition to this, the glasses can record user interactions with their envionment, in context and how the mobile technology is used within that context, as recorded in the field of view of the glasses.

Historically, glasses that audio and video record were costly (i.e. $30,000) [18]. The cost of the technology has been signficantly reduced in the past few years (i.e. $50-100) [20]. The technology is now available at low cost, and there has arisen signficant consumer demand for video and audio recording glasses for personal use as a result. Citizens are uploading video to social media (e.g. YouTube®, Snapchat®) to share their experiences and perspectives of the world (i.e. their field of view) [14,15]. Citizens are now capable of collecting usability, workflow and safety data about the mobile hardware and software they use for health activities. There is a signficant opportunity to employ consumers in the process of collecting research data. As the cost of the technology has decreased, there are opportunities to increase the sample size of usability, safety and workflow studies and for these studies to take place in real-world contexts.

There remain a number of challenges in conducting such research. Researchers need to understand the audio and video recording glasses they plan to use for such research, as they vary along a number of dimensions. For example, the field of view is different depending on the type of glasses used and glasses may have differing lengths of time that the technology records video and audio data. Privacy, confidentiality and ethical issues are also present, as some users may not be comfortable with recording health-related activities and others in their immediate context or environment. This is linked to the visiblity of such glasses as recording devices; for example, Google® glasses [20] were observed by others in an individual's context as recording devices, whereas Snapchat® glasses are similar to spectacles or sunglasses [15]. Additionally, advances in analysis of video data will be needed as recording using glasses could potentially lead to large data sets.

There are many challenges associated with using glasses that can audio and video record, but they do represent a significant advance in the area of mobile usability, workflow and safety testing as they allow the researcher to see how technology is used in real-world settings, capturing information about user gestures, activities and interactions with the mobile technology and their environment. As this represents a signficant leap in recording devices, future research will need to focus on how to analyze user interactions between mobile devices, software and others in the healthcare setting. Such information will be critical to refining existing mobile hardware and software used by consumers for health-related activities. The work will lead to technology designs that have greater and more seamless intergration and support for healthcare activities within the context of the users's worklife and their lifestyle.

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