Global Journal of Information Technology: Emerging Technologies

Volume 9, Issue 2, (2019) 033-040

www.gjit.eu

Developing apps for people with sensory disabilities, and implications for technology acceptance models

Paraskevi Theodorou*, Department of Digital Systems, University of Piraeus, 80 Karaoli & Dimitriou str., Piraeus, 18534, Greece

Apostolos Meliones , Department of Digital Systems, University of Piraeus, 80 Karaoli & Dimitriou str., Piraeus, 18534, Greece

Suggested Citation:

Theodorou, P. & Meliones, A. (2019). Developing apps for people with sensory disabilities, and implications for technology acceptance models. *Global Journal of Information Technology: Emerging Technologies*. *9*(2), 033–040. https://doi.org/10.18844/gjit.v9i2.4431

Received from January 15, 2019; revised from March 15, 2019; accepted from October 15, 2019.

Selection and peer review under responsibility of Prof. Dr. Dogan Ibrahim, Near East University, Cyprus.

Abstract

The significance of digital assistive technology in everyday life of people with disabilities has been continuously increasing during the last decade. An important example is that of the development of mobile apps which are suitably adapted for use by sensory-deprived people. We are involved in developing two such initiatives. The first offers interactive indoor navigation for blind and visually impaired persons, while the second offers deaf people a user-friendly environment for text depiction of the verbal speech, even when the articulation is defective, which is usually the case when the speaker is deaf. Despite the possible benefits of these apps, this does not necessarily signify automatic acceptance. This study aims to examine factors that may inhibit take up, in order to obviate these as much as possible. Factors contributing to the acceptance of technology may be complex, such as ‘perceived usefulness’, ‘self-efficacy’ and ‘social influence’. An exploratory study of this issue will accrue qualitative evidence from the potential users. The paper concludes by presenting recommendations for the development of a tentative modified Technology Acceptance Model that considers the special circumstances around technology use by disability cohorts, to be tested as the research continues.

Keywords: Technology acceptance model, blind and visually impaired, deaf, mobile apps, qualitative analysis.

* ADDRESS FOR CORRESPONDENCE: **Paraskevi Theodorou,** Department of Digital Systems, University of Piraeus, 80 Karaoli & Dimitriou str., Piraeus, 18534, Greece. *E-mail address*: van4.theodorou@gmail.com / Tel.: +030-210-970-0269

1. Introduction

The advance of 'smart' devices has been one of the defining characteristics of the 21st century, along with equally smart 'apps' that help people to carry out a wide variety of tasks. It is surprising, therefore, that little or no research appears to have been undertaken on the particular circumstances inherent in the take up of technology by people with disabilities. These include usability problems, where the devices or apps are not designed or have not been adapted for people who have particular needs, the extent and type of support offered (possibly of greater relevance to people with learning disabilities), and their differing needs.

This paper focuses on the design and user acceptance of apps for people with significant hearing or visual impairments. On the basis of international statistics, blind people around the world amount to 36 million (Bourne et al., 2017). The largest proportion lives in poor and developing countries. Most of the blind population are young and in productive age. It follows that there is a demand for technological solutions aimed at improving the accessibility, self-service and autonomous living of the blind, contributing catalytically to social inclusion, promoting the educational and cultural level, independence in social and professional life, and in upgrading the quality of life of the blind. In this context, large populations of blind are looking for autonomous navigation systems and therefore it is estimated that the proposed innovative application of autonomous safe outdoor blind navigation with excellent guidance accuracy will be readily adopted by blind people.

Turning to deaf and hearing-impaired people, it is estimated that around 466 million people worldwide have disabling hearing loss (WHO, 2019). The largest proportion of them lives in poor and developing countries. Hearing is one of the five senses and is considered as the second most important of the senses as it not only plays a dominant role in the communication of humans or animals but also helps one perceive external space, thus completing and complementing the function of sight. Therefore, the spoken word, which is the most important means of communication between people, depends directly on hearing. The loss or inadequacy of this sense creates a serious impact on our relations with our fellow human beings. People with deafness or hearing loss also face other serious difficulties in their everyday life involving the handling of simple actions such as using the phone, watching TV, listening to the alarm or the horn of a car. Many times, they give the impression that they are slow in perception and understanding, with the result that they are subject to derogatory comments. Moreover, it has been claimed that deafness is the loneliest handicap of all.

Without adequate accessibility measures (signing for deaf people, or audio description for those with visual impairments) people with disabilities must overcome barriers such as:

(a) reduced exposure to new information, such as from TV news/radio broadcasts,
(b) reduced ability to participate in social networks, and
(c) difficulties using technology.

On the other hand, when it is suitably designed and configured, technology can be powerful, significantly improve access to information via various channels and provide access to culture and independence in social and professional life. In fact, it has the power to greatly facilitate social inclusion and the quality of life generally.

In this article, we provide recommendations for the appropriate adaptation of the Technology Acceptance Model (TAM) to the case where the user is sensory deprived. These recommendations are derived, in part, by a qualitative analysis of interviews which have been held with blind and visually impaired people.

2. The technology acceptance model

The TAM is a model that aims to explain why and how people would choose to use a particular technology. TAM was based on the Theory of Justification and was introduced by Fred Davis (1989). It is specifically designed to model the acceptance of systems and technologies by users. Davis's goal was to explain and predict the determinants of acceptance of these technologies that lead to an understanding of user behaviour across a wide range of computer technologies.

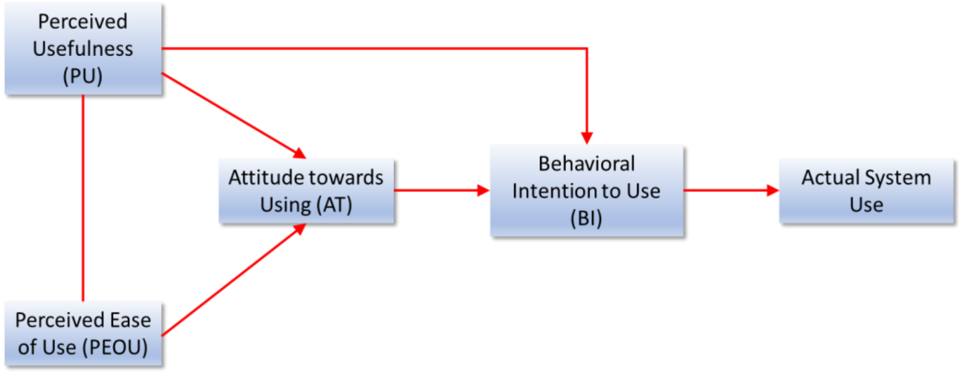

Figure 1. Perceived usefulness and ease of use as determinants of actual system use: the first TAM (Davis, 1989)

The basic TAM included and tested two constructs, Perceived Ease of Use and Perceived Usefulness. Perceived Ease of Use is defined as the degree to which a person believes that using a particular system will require no effort, while Perceived Usefulness is the degree to which a person believes that using a particular system will increase her performance at work (Davis, 1989). Research to date has demonstrated the validity of this model, which is now widely accepted (Legris, Ingham & Collerette, 2003). However, the first TAM did not include any social factors that play an important role in a person's attitude. For this reason, Venkatesh and Davis (2000) proposed the second Technology Acceptance Model (TAM2), a modified model to offset the previous defect.

During the last decade, various models of technology adoption have also emphasised features that have an impact on the adoption of technology by people with disabilities. However, the negative social and psychological characteristics that impede the adoption of such technologies have not been studied in depth by academic research.

2.1. TAM for people with disabilities

TAM explores technology acceptance factors but doesn't address the consequences of disabilities, such as those of visually impaired, blind or deaf people. For example, in the original (Figure 1) and updated (Figure 2) TAMs there is little regard paid to the influence of those who may act as 'gatekeepers' to the technology. Only in the updated model (Venkatesh, Morris, Davis & Davis, 2003) is the influence of outsiders considered, but not in this regard (only a general 'social influence').

Our research focuses on the understanding of how blind or deaf people will accept and absorb the technological knowledge in order to take advantage of the very substantial potential benefits that may accrue in terms of independent living (self-navigation) and inclusivity (e.g., being able to better communicate with people who are not deaf). In particular, we aim to examine possible negative social and psychological features that may prevent technology adoption by these groups of people. Within this framework, we consider the influence and importance of adequate training of people with disabilities.

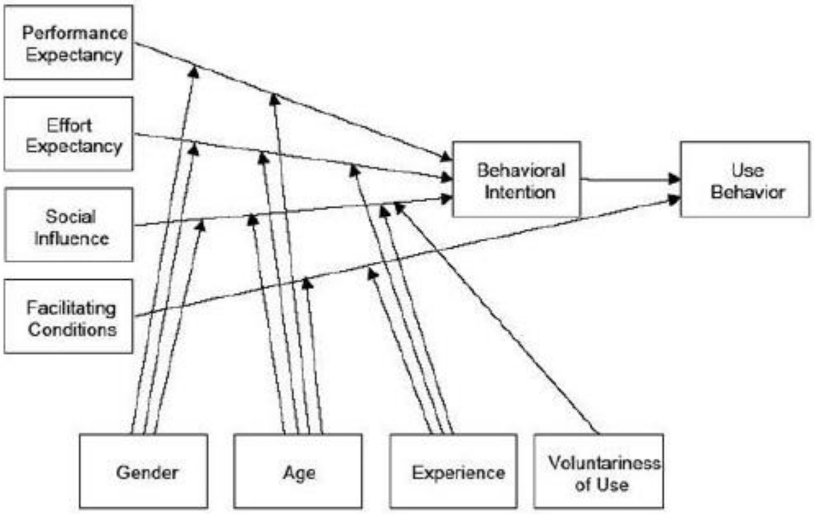

Figure 2. Unified theory of acceptance and use of technology (Venkatesh et al., 2003)

3. Type of support facilitating usage

As later TAMs suggest (e.g., Venkatesh et al., 2003), acceptance of a technology by the target users themselves may be influenced by the social environment. In a major study, Eckhardt, Laumer and Weitzel (2009) found that the adoption of Information Technology in the workplace was significantly influenced by 'referents' such as colleagues and line managers. However, TAM has not, to date, considered the influence of close family members, friends, or even teachers and trainers, who may facilitate access to technology by the individual. Although people with physical impairments may not be disabled in terms of their critical thinking or intelligence, nevertheless, their impairment may mean that the role of these 'significant others' assumes a greater importance than might otherwise be the case. A blind person, for example, may require a greater degree of training in order to be able to use an 'app' (which itself may need to be reconfigured).

The research reported here can be also viewed as the first part of an exploratory study of this issue, because it accrues qualitative evidence from the potential users, to explore the factors which influence TAM-elicited issues such as 'perceived usefulness', 'self-efficacy' and, of course, the role of 'social influence' in general. Opinions are sought to elicit the reactions of the target users in order to (a) help identify the unique circumstances and situations of the target population and (b) help tailor training methods designed to obviate usability problems, enhance potential users' views, both on the usefulness of the apps and on their own self-efficacy (the latter referring to the abilities they perceive themselves as having in order to use the technology).

4. The apps

A series of assistive apps for people with disabilities is being developed by our research team. Two examples are described in this paper; one app aims to help blind and visually impaired people to travel safely, and the other to help deaf and hearing-impaired people communicate.

Blind RouteVision is being designed to facilitate the pedestrian navigation of blind people outdoors. It will have GPS functionality and utilise the Google Maps service for navigating, but with additional voice prompts and an ultrasound sensor for real-time recognition and avoidance of obstructions along its path. It will also contain

(a) (a) a simple keyboard for the interaction of blind people, to enable them to select routes and other available functions,
(b) (b) application synchronisation with traffic lights and weather information, and
(c) (c) the utilisation of information telematics of the Athens Organisation of Civil Transport (OASA) for routes and urban transport stops.

The second app offers deaf people a user-friendly environment for automated text depiction of the user's verbal speech. Speech recognition is a mature technology which specifically refers to translating spoken language into text. All modern OS platforms include speech to text tools. However, these do not necessarily work for the hearing impaired. Indeed, they are not designed to do so. Special requirements have to be considered when offering a specialised real-time speech to text transcription device addressing the hearing impaired. This is because the articulation of deaf people is often idiosyncratic, with a wide variation of pronunciation styles and unusual intonation. The SeeSpeech application is designed to take these into account when processing the speech and rendering it to text, to still give an accurate translation of the speech (see Meliones and Duta, 2019, for a first and simple implementation).

SeeSpeech will also implement an interface for a simple dialogue with a deaf or hearing-impaired person in different languages, doing so by integrating two Application Program Interfaces for transforming speech to text. Another key feature of the application is the ability to register sound from an external Bluetooth microphone. This makes SeeSpeech a very competitive application in the arena of similar scope applications.

5. Method: elicitation of user requirements

During the development of the apps, qualitative research is being carried out in the form of a user needs and requirements analysis. In this paper, for reasons of economy, we focus on how we have been undertaking this analysis with respect to the requirements of the blind and visually impaired people. For the precise identification of the problems and preferences, as well as the specific characteristics of this particular cohort, the requirement analysis was conducted based on interviews with members of this community. Next, we present a synopsis of preliminary interviews.

5.1. Interviews with blind and visually impaired people

The interviews were undertaken with a small but highly knowledgeable and articulate sample of three experts: These were (a) the Head of the famous Greek institute 'Lighthouse of the blind' (male) who is blind, (b) a teacher (male), also blind, of the Braille system for reading and writing who also teaches blind people how to use new technologies such as smartphones and (c) a visually impaired museum guide (female) for blind people.

Questions concerned both those which placed the Blind RouteVision app into the context of people's general use of digital technology and those related more specifically to the future functionality of the app. Later interviews will be undertaken after the trial of the app, seeking feedback from users and their views on how the following iteration of it. The interviews outlined below were undertaken before interviewees were shown a prototype of the app itself. This was so they would not be influenced by its functionality or appearance. As the interviewees were experts in the field and had considerable experience in being and working with others in the same situation, the questions did not only relate to them as individuals but to their knowledge of other people's experiences. Later, when a large number of users will be involved, the focus will be more on themselves.

Contextual questions concerned:

- Familiarity with pre-existing apps and software (e.g. Google maps for navigation with voice prompts) and whether they are easy to use.
- Use of particular hardware/devices.
- Use of headsets, and experiences of how ambient sounds are rendered, and about the type of the headset (a preference for Bluetooth or cable).
- Questions relating to the development of the app included:
- How a keyboard should be configured.
- How sounds should be used to signify obstacles (e.g., continuous sound increasing frequency and interrupted sound).
- Optimum navigational menu options.
- Preferences regarding the synchronisation of the app with traffic lights (the developers recommend that it be centralised through the traffic management system, so it does not require each traffic light to be equipped with an audio signal).

6. Results from the analysis of the interviews

Each interview was recorded, and the answers were compared, classified into categories and analysed. The results of the analysis identified the following main issues with respect to apps ease of use and usability by blind and visually impaired people, classified into the following requirements:

(a) application requirements (detection of obstacles, navigation, adaptability and change possibilities, notification of a person of confidence about the position of the BVI),
(b) functionality requirements of applications and devices (maintain external stimuli separate, complete and seamless voice and sound interaction between the BVI and the app, enhanced positioning accuracy),
(c) usability requirements (user-friendly device and application features, simple handling and voice function),
(d) requirements concerning the learning process (these are many and varied, and include the physical environments – places where all aspects of the apps may be tested, and safely – and also methods and materials with regard to teaching and promoting the app) and
(e) compatibility requirements and parallel operation of project applications with other applications and screen readers.

7. Discussion

The acceptance of mobile services is a gradual process (Osman, Maguire & Tarkiainen, 2003) which involves understanding of the benefits offered by these services before their acceptance and systematic use by the majority within a target group. In general, the development of smart apps does not take into account the particular requirements of people with special needs, and especially of the BVI (Ghidini, Almeida, Manssour & Silveira, 2016). Even in the case that an app is especially designed for sensory deprived people, there is no such extension of the TAM, which is adapted to their needs and requirements with respect to assistive mobile apps.

In this study, a first step is made towards filling this gap in the literature. The main interest, however, in the results of this study is not theoretical. By means of our qualitative analysis, we showed that people with sensory disabilities are more demanding with respect to the design of the assistive apps. Moreover, the classification of user needs and requirements, presented in Section 6, forms a framework for the appropriate adaptation of the TAM so that it can meet the specific needs of the sensory-deprived people. The next section provides recommendations with respect to the design of a TAM which will be adapted to people with sensory disabilities.

8. Recommendations

The findings reported in the previous sections highlight the importance of understanding the special needs and requirements of people with sensory disabilities. Specifically, it was identified that factors such as the interaction of the app with the environment and the location where the app will be used may increase the difficulty of acceptance of the corresponding technology by its potential users. It was also identified that details concerning specific features of user interfaces are much more important to sensory disabled people. These features must be designed considering the elicited requirements of the app target group.

A TAM which aims to be applied to people with sensory disabilities must be adapted to the following two factors:

(a) (a) the increased sensitivity of these groups of people to particular needs related to their disability and
(b) (b) the corresponding psychological patterns which stem from the insecurity caused by the disability.

The interviews with the blind and visually impaired people provided support for the significance of these two factors. A good example for the first factor is the requirement of the BVI that sounds of the surrounding environment must not be covered by the sounds generated by the app. As far as the second factor is concerned, it is interesting that the BVI felt reluctant to try learning the assistive navigation app for the first time in an environment not familiar to them, although a big part of the functionalities of the app concerns unknown environments.

Furthermore, the interviews revealed that people with sensory disabilities probably feel much more attached and dependent to assistive apps that they are already using. This fact was highlighted by the emphasis all the interviewees gave on how the assistive app will be compatible with other services or apps they are often using (such as screen readers). This remark implies that the TAM for people with sensory disabilities must consider the assistive apps and services which are already used by the target groups.

9. Conclusion

In this article, we described the results of user requirements analysis concerning assistive apps for people with sensory disabilities. Specifically, it was described how the process of development of two innovative apps for people with visual and hearing impairments involves the identification of these groups' particularities with respect to technology acceptance, and consequently, the corresponding adaptation of educational and training methods. Therefore, the implementation of these apps will be undertaken with a view to enhancing their acceptance, according to an enhanced TAM that takes into account the specific circumstances of people with disabilities. This approach focuses on the social value of the tools, achieved by adopting empathy and real interest for the users and those who support them. In this way, one can see the apps through users' own criteria for usability, usefulness and understanding of how attitudes towards technology are shaped.

It is hoped that the further development of the apps described above, considering user needs and wishes, will enhance technology acceptance of the 'end users' (the people with disabilities). Their contributions – and indeed their attitudes and whole approach to using the apps specifically, and digital technology generally – will inform in more detail how the TAM should be applied to the particular group in order to formulate a best practice for the acceptance of the relevant technologies. The research in this area has yet to be undertaken – full-scale tests of usability and practicability are to be carried out, and appropriate feedback accrued to inform the extent to which the technology is being accepted. In addition, no previous research has been carried out to investigate the acceptance of 'Assistive Technology' by supporters, such as, for example, teachers in schools or more generally in other support structures for visually impaired or hearing-impaired people. This will be captured in a modified TAM which should inform anyone attempting to improve the lives of people with disabilities, by the use of technology.

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