

Games for the Rehabilitation Of Disabled People

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ABSTRACT

In this paper, we consider the use of games in the rehabilitation of disabled people, with particular attention to blind and partially sighted people. Serious games are currently very widely used in a variety of applications including education, training, culture, therapy and rehabilitation. However, this raises the issues of whether they are suitable for disabled people and the extent to which disabled people have been involved in the design. We will be reporting the results of a survey to investigate the extent to which existing and proposed games are accessible to disabled and older people, particularly blind and partially sighted people.

CCS Concepts

- Human-centered computing~Accessible design and evaluation methods
- Human-centered computing~User interface design
- Software and its engineering~Interactive games

Keywords

Serious games; accessible games; disabled people; visually impaired people, ageing

1. INTRODUCTION

Serious games are widely used in many different applications, including education, culture, training and practicing (new) skills. Their use has also been proposed for use in rehabilitation. Games can be very helpful to disabled and older people in practicing skills and activities and learning fundamental concepts. Rehabilitation frequently involves repeating a basic movement or other exercises multiple times, for instance to improve physical condition after a stroke [1]. Serious (computer) games are likely to engage the person's attention and provide challenge through increasing difficulty levels, therefore reducing the potential boredom associated with repetitive activities. They may even be able to distract attention from pain [15]. Examples of serious games for rehabilitation reported in [15] include games for balance improvement, hand and arm exercises post-stroke and therapeutic support for eating problems, gambling and other behavioural issues. Other applications include healthcare and illness prevention [17], as well as encouraging increased physical activity and exercising, balance and sensory-motor training and improving muscle strength, endurance and coordination for older people [17]. It has been suggested that serious games have the potential for new multi-facet approaches to rehabilitation and should not be limited to a 'serious purpose + motivation' [17]. However, research on serious games for disabled and older people

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has been limited, despite their potential and the popularity of digital games with players over 50, who range from 14% of the total in Germany to 29% in USA [17]. For instance, a relatively recent survey of game accessibility [19] considered entertainment rather than serious games. Most of the games surveyed were aimed at disabled people with a particular impairment and only a few games took a design for all approach. [19] also identify the strategies used to make games accessible to particular groups of disabled players.

All games need to be well designed and take into account both the likely interests and particular requirements of the intended users. In the case of serious games, such as those used in rehabilitation, equal attention needs to be given to game enjoyment and the serious game function, such as (re)training. This function should preferably be embedded in the game, so that players can learn and develop skills as they play and are motivated to do this by the fun aspects of the game. Unfortunately, serious games which effectively fulfil their learning or other serious role are not always successful as games. In the case of disabled and older people, in particular, specific attention is required to game accessibility and usability [8]. An important aspect of this is a user interface which is fully accessible and easy to use by the intended end-users, so they can focus on playing and enjoying the game rather than struggling with the user interface. In many games visual feedback is used to convey information to the user, for instance that they have carried out an activity, and visual effects are an important feature of the game and enjoyment in playing it. Visual information and features are not accessible to many blind and partially sighted people. Therefore, other means are required to convey information so that these players can concentrate on the game rather than having to spend time struggling to work out what they are supposed to be doing. In addition, alternatives to the visual effects, for instance audio effects, will be required to ensure the game has sufficient stimulation and interest for blind and partially sighted players. On the other hand some autistic people are disturbed and in some cases very highly stressed by excessive visual and/or audio stimulation, giving a need for personalisation options [8]. Thus the design of enjoyable, accessible and usable games for blind and partially sighted, as well as other groups of disabled and older people, raises a number of important issues. However, there do not seem to be any studies of the use of serious games in the rehabilitation of blind and partially sighted people.

2. ACCESSIBILITY AND USABILITY

Information and communications technologies (ICT) have changed over the last few years from new to well established technologies which are widely used in many different fields, including education, training, entertainment, the legal system and the civil service. Using ICT has become the default in many areas. This makes it essential both that all ICT applications are

fully accessible and easily usable by everyone, including disabled people, and that there are other options for people who do not use ICT for whatever reason, including lack of access. Otherwise, the digital divide will increase and disabled and other people without access to some or all ICT features will experience increasing marginalisation and social exclusion [2].

Three concepts are important here: design for all (universal design), accessibility and usability.

Design for all [3] and [11] involves design which takes into account factors such as disability, age, size and gender, so that the result can be used by as wide as possible a group of the population. However, it can be difficult to ensure that the design does indeed meet the needs of all users, particularly in the case of products or applications which are complex or for which different users have contradictory requirements. A number of factors need to be taken into account to achieve an appropriate design and an effective product. These include users' requirements, specific goals and activities and the technologies used. This may be particularly important in contexts such as education and rehabilitation. Thus, despite its advantages, it may not always be possible to use a design for all approach. In some cases the design of products targeted at particular groups of end-users will be more appropriate. This will require an appropriate interface design with a choice of input and output modalities that take account of user characteristics and, for instance, the available sensory modalities. However, accessibility and usability principles need to be considered in both the cases of design for all and design for a specific group of users.

Accessibility requires the system input and output to have appropriate characteristics to enable particular (groups of) users to access and use all facilities. Usability allows particular (groups of) users to carry out intended function(s) or achieve specified goals effectively, efficiently and with satisfaction [4]. The concepts of accessibility and usability are relevant to all technologies, low tech as well as high tech, though the focus here is ICT. Despite the existence of several sets of web site accessibility guidelines, with those produced by the Worldwide Web Consortium [18] the best known, web accessibility remains a problem. Mobile devices can raise particularly issues for game accessibility and usability, due to their small size [8] and [9].

A study reported in [5] has proposed a proactive design for developing games which are accessible to people with a wide range of diverse requirements, including disabled people. They propose the use of user profiles and the ability to customise the user interface in line with the profiles, including to support diverse interaction methods, as well as a participative design approach. The approach has been applied to four case studies, but not to rehabilitation games.

End-users of ICT are very diverse and cover the whole population, though they are currently less well represented amongst older people. The availability of software is highly dependent on language, with the greatest availability in English and speakers of minority languages likely to experience difficulties in finding software in their language. The types of application and information requirements are very varied, with some users using ICT in many different contexts, including social,

educational and the workplace. Users' technical abilities are also very varied, with more able and experienced users often having greater expectations and using ICT in a wider range of context. In addition, most technology is designed for non-disabled users and disabled people may experience barriers in using particular technologies or require to use additional assistive software or hardware to access it.

In this perspective end users can be characterized in terms of:

- Goals and activities: a categorisation could be developed. Examples of activities for the goal of obtaining a new improved laptop include obtaining information, making a choice of laptop and where to buy it, and purchasing the laptop.
- User characteristics: they affect user behaviour in a range of activities, as well as their accessibility and usability requirements. Characteristics include culture, language, education, experience of using ICT, age, gender and disability;
- Access technologies: end users use a variety of technologies to interact with a given ICT that are not necessarily under the control of the designer of the user interface. This includes browsers, keyboards, screens, text input and output and assistive devices and, in some cases, the operating system and platform.

As indicated above, accessibility guidelines have not been very effective in ensuring web site and application accessibility. There are several usability standards, such as ISO9241, though again attention to usability is more limited than it should be. There has sometimes been a tendency to consider accessibility and usability separately, rather than as equally important and complimentary. In addition, they and design for all are often seen as add-on extras rather than as an essential and standard component of good design practice. Until this happens and accessibility and usability become an integral part of all engineering, computing science and design courses, they will remain a frequently ignored add-on. In addition, accessibility and usability are often user specific and therefore require understanding of the particular end-users and their needs and an ability to involve them in the design process. [10] and [16] provide examples that accessibility on its own without usability is insufficient. Thus, specific accessibility and usability guidelines should be provided in order to improve the interaction according to the user features as well as the application goal.

Unfortunately game design has frequently not taken into account the need for accessibility. Applying accessibility solutions to existing games is not necessarily easy [2] and may not result in satisfying games. For instance, blind and partially sighted players may play the game using screen reading software. However, this may require additional time, consequently slowing the game down and making it less satisfying.

3. Serious Games for Blind and Partially Sighted People

Several studies have found that serious games are widely used in education and rehabilitation, including for people with cognitive and physical impairments [14] and [19]. However, work is still required on serious games for visually impaired people and older people with multiple, possibly age-related, impairments.

A number of games developed specifically for visually impaired players are discussed in [2]. The authors report that a number of games have been developed specifically for visually impaired users. These are mostly audio games but there are also a few tactile games and games using haptic feedback [6]. However, no surveys have been carried out on the use of haptic feedback in games, despite proposals to do this.

The need for alternatives to visual feedback for both instructions and responses for games for blind people is considered one of the main issues in developing games for blind people [5], [12], [13]. However, the need for alternatives to visual affects to ensure game interest (as well as the ability to switch them off) is equally important. The two main technical approaches taken to computer game accessibility are: (1) the use of third-party assistive technologies, such as screen readers and mouse emulators. The results have generally been poor, with limited accessibility and poor interaction quality and usability. (2) accessible design from the start, but targeted at people with a specific impairment, such as audio games for blind people or single-switch games for physically disabled people. Both approaches have disadvantages. The usual approach to developing games for visually impaired people is replacing visual elements by auditory and haptic ones, for instance [12], [13]. However, the authors are not aware of serious games for rehabilitation for visually impaired people.

Interactive games can provide an easy and enjoyable way to learn the fundamentals of a subject and sometimes more advanced concepts. For instance, interactive games could be used to support the training of blind toddlers and preschool children in spatial concepts, spatial exploration, movement and cane use. These are complex skills, particularly for blind people and there is some evidence that training from a very early age is likely to lead to more effective mobility throughout life. In addition, it can facilitate acceptance of the cane and avoidance of embarrassment and concerns about what other people might think leading to non-use [7]. However, while serious games have an important role in education, training and rehabilitation, they are not suitable for everyone, and should be used alongside rather than instead of other approaches.

Although ICT has been used in rehabilitation, applications for disabled and older people are still limited. Several leisure games for blind people have been developed, but there is still a lack of serious games for use in rehabilitation and other applications for them. When designing serious games, for instance for use in (re)training and rehabilitation, it is important to pay attention to both the serious aim and the fun aspects of the game. In addition, game design, including the fun element, should take account of user characteristics. In particular, games for both children and adults need to be culturally, as well as age appropriate to the particular age group. Unfortunately, only a minority of blind people are literate in Braille due to a combination of factors, including the lack of teachers and the availability of screen reading software and increasingly natural synthetic voices. Games for learning Braille could contribute to overcoming perceptions that Braille is too difficult and motivate practice in the absence of a teacher, though for the overwhelming majority of learners some teacher input will be required. The tactile nature of Braille means that games based on low tech technologies which

allow, for instance, metal pins representing the Braille 'dots' to be felt directly may be more effective than ICT with a haptic interface. In addition, different approaches may be required for older people and those with reduced manual dexterity or tactile sensitivity and/or cognitive impairments. While expectations of the likely achievement of these groups should be realistic, appropriately motivating approaches, including serious games, can have good results.

A wide range of tasks and activities could be included in rehabilitation and training programmes for blind adults and children. A team approach, involving developers, blind people and therapists, is recommended to enable the games to be designed to meet rehabilitation goals in a way that takes into account the realities of the experience of blind people. There are also benefits in being able to tailor the rehabilitation goals to the specific individual and smoothly change the game parameters, for instance the level of difficulty as the player progresses. Tracking and recording the player's movements could allow assessment and feedback to improve performance. However, this raises data privacy and security issues. Users should have control over who can access their data and privacy management systems will be required. ICT can be used to enable blind and other people play rehabilitation games without assistance, for instance at home [14].

4. SOME DESIGN SUGGESTIONS

Designing an accessible game is a challenge and presents several issues and critical aspects. Designing serious games for blind and partially sighted people can be very difficult, as it requires the provision of communication and information channels which are not based on vision, while retaining the fun elements, excitement and learning, rehabilitation or other goal.

In summary, when designing a serious game, including for use in rehabilitation, including of disabled or older people, attention should be paid to the following:

End-users, goals, activities and tasks

1. Clarity about which groups of end-users are being targeted and involving them throughout the design and development process from the very start.
2. A clear definition of the rehabilitation or other serious aims of the game, as well as its fun elements, both of which should be appropriately targeted at the main end-user group(s).
3. A structured approach to goal achievement. This will generally involve a series of activities (possibly with alternatives), with each activity broken down into several tasks.

Technology and platform

4. Game design for technology and platform independence, where feasible, i.e. to be compatible with use on a wide range of different technologies and platforms. However, this is not always feasible, for instance due to inadequate memory or too small controls on some mobile platforms. In this case, choices will need to be made to take account of both game and end-user requirements, for instance for compatibility with assistive technology.

5. Technology as an enabler rather than a barrier, so that players can focus on enjoying the game and its rehabilitation (or other serious) outcomes.

Accessibility and usability

6. The game should be designed to take account of accessibility and usability. This should include end-user involvement and feedback and meeting usability standards and accessibility guidelines.
7. Customisation or personalisation options to enable users to choose game features to best meet their needs.
8. Multimodal and natural interaction with the interface. Multimodal options can improve accessibility. In addition, interaction should be designed to be as easy and natural as possible, including through appropriate uses of technology.
9. Compatibility with a wide range of assistive technologies. This will enable users to access the game in the most appropriate way.
10. Multimodal feedback, including through voice, sounds, haptics, text and graphics, as well as options to turn off all feedback. This will give all players feedback in the form they require and avoid irritation.
11. Alternatives to visual and sound effects for game features, as well as options to turn them off.

5. Conclusions

This paper has discussed the potential for the use of serious games in rehabilitation, with a particular focus on skills and (re)training for blind and partially sighted people. It has also demonstrated the importance of accessibility and usability in the design of games for disabled and older people and the value of a design for all approach. A few studies have investigated the use of rehabilitation games for particular groups of disabled people, but there seems to be a lack of rehabilitation and other serious games for visually impaired people. Further work will include a survey on the use of serious games by blind and partially sighted people, with a particular focus on their use in rehabilitation.

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