In Search of a Multimodal Interfaces Impact Evaluation Model for People Who Are Blind

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ABSTRACT
Visual disability has a significant impact on the quality of life of people with visual disabilities. To ameliorate this issue, many technologies exist to help people who are blind, such as mobile applications and serious games. However, these applications must prove their effectiveness and impact. Thus, the objective of this work is to propose a multimodal interfaces impact and effectiveness evaluation model for cognitive, psychomotor and emotional development and enhancement in people who are blind. This work presents the proposal of a master thesis research (in progress), centering on the initial corresponding systematic literature review. We divided the methodology into three steps: *State of the art Study* (current step), *Theoretical Review* and *Model Proposal*.

Author Keywords
Effectiveness Evaluation; Impact Evaluation; Multimodal Interfaces; People Who Are Blind.

ACM Classification Keywords
H.5.2 Information interfaces and presentation (e.g., HCI): User Interfaces: Evaluation/methodology; H.5.m Miscellaneous.

INTRODUCTION
According to the "Disability Overview" of the World Bank [19], one billion people, or 15% of the world's population, experience some form of disability. The last report of the "World Health Organization" [18], in 2014, informs that 285 million people are estimated to have visual disabilities worldwide, of which 39 million are blind.

Visual disability has a significant impact on quality of life of people with visual disabilities, including their ability to work and to develop personal relationships [1]. In this respect, technologies, such as serious games [15] and assistive technology [4,17], have been designed to help people who are blind to supports daily life activities. These technologies work as aids to facilitate the independence, autonomy and safety, and thus improving the quality of life of these people. These technology aids could stimulate and develop several skills, such as cognitive [5], psychomotor [7] and emotional [14], the three-domain skills subject of study in this work.

In general, technologies for people with visual disabilities combine different sources of perceptual inputs and outputs. The modes combined, typically audio and haptics [5], provide multimodal interfaces and enable multimodes or channels for the combination of different user senses [15]. Although multimodal interfaces could help to improve the learning skills of people with visual disabilities, most of these technologies have been not completely validated; they remain in prototype phase without being integrated into people´s everyday life [8].

One method to validate assistive technologies and to assure the achievement of a desired cognitive development and enhancement purpose is to apply a standardized clinical trial to measure the real impact and effectiveness. Therefore, impact evaluation involves the application of rigorous, systematic, and objective evidence procedures to assure the quality of assistive technology for cognitive and enhancement purposes [6].

As shown in Darin et al.'s (2015) mapping study [5], there are many serious games and virtual environments designed for stimulating cognitive improvement.

In this study, we analyze computer applications according to a four-dimensional classification (Interface, Interaction, Cognition, and Evaluation). The cognition dimension comprises six skills defined: mental models, mental maps, spatial structures, orientation and mobility (O&M), problem solving, and social collaboration. Such an approach addresses the main cognitive skills developed and enhanced for impact evaluation purposes.

Besides cognition, visual disabilities could affect psychomotor, social, and emotional development. Burmedi et al. (2003) [2] defines emotional adjustments for people who are blind as a decline in mental health or as severe manifestations of emotional disturbance, such as lower well-being.

Regarding psychomotor development, visual disability can cause low physical work capacity, posture problems, orientation difficulties, depression, and problems with balance [1]. Psychomotor skills are fundamental for learning O&M, including the independent movement concept [16]. O&M is a remarkable ability to be developed for people who are blind because the visual channel is the main vehicle for cognitive mapping of spaces [11].

Finocchietti et al. (2015) offer a practical example of skills application. They aim to improve spatial cognition, psychomotor and emotional abilities of people who are blind through the use of another sensory modality: hearing. For this end, they present the ABBI, an Audio Bracelet for Blind Interaction [7]. In the same line, the AudioMetro application focuses on the improvement of cognitive, sensory, and psychomotor skills development for orientation and mobility learning in a Metro scenario [16].

In relation to the quality of applications, the No Child Left Behind (NCLB) Act defines that research in inclusive education must (a) utilize the scientific method, (b) be replicated in more than one set by more than one investigator, and (c) result in findings that converge to a clear conclusion [6]. Thus, some studies in this area utilize Evidence-Based Practice, which meets prescribed criteria related to the research design, quality, quantity, and effect size of supporting research [4,17]. In doing this, the method provides the impact and the expected effect achieved by using the technology used.

Effective impact evaluation, which has been used as evidence-based in other areas for users with and without disabilities, should, therefore, be able to assess precisely the mechanisms by which people with visual disabilities are developing or enhancing any skills, e.g. cognitive skills [5]. Figure 1 shows an estimated impact example applied for an economic program [7]. Effectiveness studies provide evidence from interventions that take place in normal circumstances, using regular implementation channels, and aim to produce findings that can be generalized. The effectiveness assessment is considered a kind of impact assessment, as well as efficacy evaluation.

In this work our focus is on the impact evaluation of multimodal technologies for skills development in people who are blind.

According to Darin et al. (2015) [5], there is a gap of study instruments and methods for evaluating the cognitive impact in the context of multimodal video games for blind learners' cognition enhancement.

Until now, we did not encounter any study in the related literature that compiles the impact or effectiveness evaluation methods of multimodal interfaces for people who are blind. There exist some related studies that we introduce here. The study "An integrative literature review of the effectiveness of nurse-led clinics in ophthalmology" [3], researches the best approach to ensure effectiveness by using a literature review, determining the best available evidence related to the effectiveness of nurse-led clinics in ophthalmology.

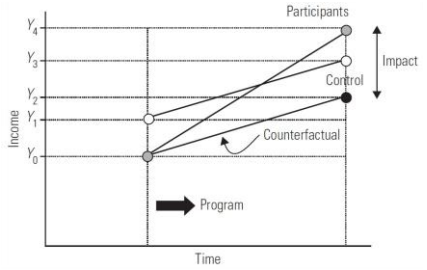

Figure 1. Impact Example [7]

Darin et al. [5] proposes and discuss a four-dimensional classification to analyze the design of multimodal video games for the cognition of people who are blind: Interface, Interaction, Cognition, and Evaluation. This work divides the Evaluation dimension into Usability and Cognitive Impact.

Finally, Lahav and Mioduser [11] discuss the need for an evaluation framework specifically for (ICT-based) learning technologies used by disabled learners. One phase of the framework includes an impact evaluation of various measures on the effective implementation and use of ICT learning technologies for learners with disabilities.

In general, literature-related works do not meet a model to support cognitive, psychomotor, and emotional impact evaluation of multimodal interfaces for people who are blind. They tend to present specific focused studies about impact evaluation in different research areas.

The main goal of this study is to propose a multimodal interfaces impact and effectiveness evaluation model for cognitive, psychomotor and emotional development and enhancement in people who are blind. Thus, application designers and practitioners will be able to use this model to design, develop, evaluate and improve their applications. For this study, we consider video games and virtual environments to be multimodal interfaces.

METHODOLOGY

The methodology consists of three steps: (i) state-of-the-art research, (ii) theoretical review and (iii) model proposal. All of them are represented in Figure 2 and described in the next subsections.

State-of-the-art: aims to review the existing evidence concerning the impact evaluation of multimodal interfaces, and also seeks to summarize the empirical evidence concerning the strengths and limitations of a specific evaluation method [10]. We also expect to create a bibliographic review based on the steps proposed in the systematic review approach. In contrast to an ad hoc literature review, the systematic review is a methodologically rigorous analysis and study of research results.

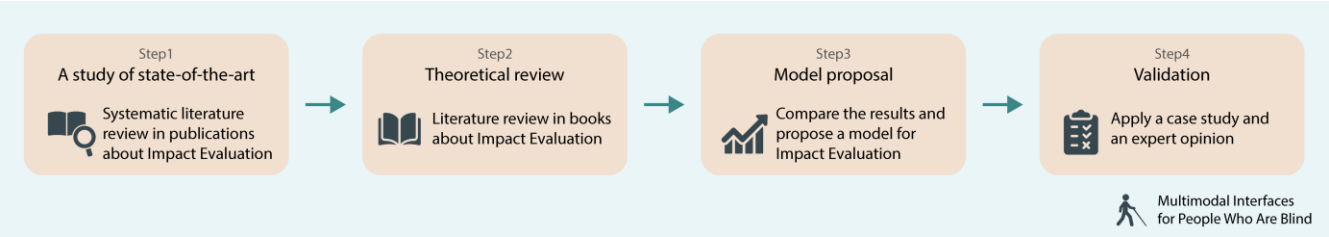

Figure 2. Methodology of the Study

Besides, we intend to identify study opportunities related to a multimodal interfaces impact and effectiveness evaluation model for cognitive, psychomotor, and emotional development and enhancement in people who are blind. To achieve this goal, the research question for this first part of the proposal was: how is the cognitive impact evaluated on multimodal interfaces for people who are blind? For a better understanding, as a second goal question, we aim to learn the challenges regarding impact evaluation on this scenario.

In this step, we consider more types of technologies beyond multimodal video games and virtual environments, with the purpose of obtaining more data and not excluding methods that could also be related to multimodal video games and virtual environments.

The process initiated with a manual string research in five scientific bases: Scopus, Springer Link, PubMed, PubMed Central, and Web of Science. We chose the primary research bases for scientific articles in the research area or the bases that index them [9]. Other bases were not included because they are indexed by the bases considered.

The bibliographic review was developed in four phases. In the first one, we identified which papers are in and out the scope of the study by reading their titles and abstracts, and considering the inclusion and exclusion criteria. Next, we evaluated each retrieved paper in its entirety according to inclusion and exclusion criteria. From these articles, we selected any papers that present a mobile application; computer software; an IoT system; a virtual environment; or a video game with multimodal interfaces for people who are blind including cognitive, psychomotor or emotional impact evaluation. We also included studies about methods, methodologies, frameworks or approaches to evaluate the cognitive, psychomotor or emotional impact and effectiveness of using multimodal interfaces for people who are blind.

Finally, we plan to read the full text of the remaining studies to extract the following data about impact evaluation methods: type of technology evaluated and the type of multimodal interfaces and feedback [5], impact evaluation method used, skills evaluated and typical activities, and evaluation instruments used for impact assessment. All these data must cover the three domains: cognitive, psychomotor or emotional.

Theoretical Review: we plan to carry out a literature review of books and surveys about impact or effectiveness. The main goal of this step is to understand the methods described in theory. For convenience, the review will focus on cognitive, psychomotor and emotional domains. The theoretical literature review helps to establish what theories already exist, the relationships between them, to what degree the existing theories have been investigated, and to develop new hypotheses to be tested [12]. The expected results of this step are the theories that apply an impact evaluation and their processes.

Model Proposal: the impact and effectiveness evaluation methods declared in the papers found in the literature review study will be contrasted with impact evaluation methods grounded in the most established literature concerning the theoretical review step. As a result, we aim to compare, condense and propose features to design a model for evaluating the impact of multimodal interfaces for people who are blind.

Validation: we plan to realize a case study to apply the model in a real application. After compiling the information acquired, the results should undergo an expert review for the second validation of the model proposed. This solution aims to reduce the bias and to improve the model proposed.

PROPOSAL

As the work is ongoing, the model for evaluating the impact and effectiveness of multimodal interfaces for people who are blind is not yet well defined; it will depend on the previous steps. Next, we describe the preliminary results obtained and the expected contributions.

Preliminary results

Up to now, we have performed two first filters of the bibliographic review, the first step of the proposal. The initial research brought us 5237 papers and documents. The first filter excluded 757 of them, among them duplicate papers (110), books, conference documents, short papers, and posters. We divided the second filter into two parts: the first one excluded 4327 papers.

A large amount of papers is excluded because the scientific base PubMed Central (PMC) brings a lot of medical papers focused on disease effectiveness and specific medical statements. Even though the area of this study is computer science, we decided to insert the PMC in the bases' list due to the nature of the subject. To help the exclusion process,

we highlighted some key words not desired in the titles, like "malaria" or "Alzheimer," which facilitates the exclusion. To create a protection mechanism, we reduced the exclusion bias by using cross-validation [10]. Some specialists in the area will exclude a set of 10 papers to compare and to get the cost estimation accuracy. The second part of the second filter excludes 115, resulting in 38 remaining papers. The next filter will apply the inclusion and exclusion criteria by reading the full text.

EXPECTED CONTRIBUTIONS

In the context of the many applications and technologies developed for people who are blind, the main contribution of this work will be to provide a multimodal interfaces impact and effectiveness evaluation model for cognitive, psychomotor, and emotional development and enhancement in people who are blind.

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