German Medical Data Sciences: Visions and Bridges
R. Röhrig et al. (Eds.)

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doi:10.3233/978-1-61499-808-2-13

User Experience Evaluations in Rehabilitation Video Games for Children: A Systematic Mapping of the Literature

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Abstract. Background: In recent years, the interest in user experience (UX) evaluation methods for assessing technology solutions, especially in health systems for children with special needs like cognitive disabilities, has increased. Objective: Conduct a systematic mapping study to provide an overview in the field of UX evaluations in rehabilitation video games for children. Methods: The definition of research questions, the search for primary studies and the extraction of those studies by inclusion and exclusion criteria lead to the mapping of primary papers according to a classification scheme. Results: Main findings from this study include the detection of the target population of the selected studies, the recognition of two different ways of evaluating UX: (i) user evaluation and (ii) system evaluation, and UX measurements and devices used. Conclusions: This systematic mapping specifies the research gaps identified for future research works in the area.

Keywords. Systematic mapping study; user experience evaluation; children; cognitive disabilities.

1. Introduction

User Experience (UX) can be defined as "a person's perception and responses that result from the use or anticipated use of a product, system or service" [1]. UX evaluation is particularly important for solutions in the health context, since users/patients need to maintain the motivation to keep using the technology. There are several UX evaluation methods [2], and they are classified depending on the data collected, the measures taken, and the way the data are collected [3]. Classification is also depending on the properties of UX that can be reliably and repeatedly measured and those that cannot, like the psychophysiological measures of an individual [4]. In recent years, the interest in the topic has increased [5]. Notwithstanding this growth, we have not found a comprehensive overview about the UX evaluation methods, particularly methods for evaluating health technologies for children with special needs.

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We conducted a Systematic Mapping Study (SMS) to aggregate and categorize primary studies, creating an overview of the research area/topic in question [6]. The results from this SMS include the identification of several important factors, and the devices and measurements used to evaluate the user state explicitly or implicitly. We discuss the implications from the type of studies found and finally, we draw some conclusions regarding the study and the challenges it presented for the future work. Part of the motivation for doing this SMS came from the current scenario from the HapHop-Physio project [7]. It supports the rehabilitation of children with intellectual and cognitive disabilities, focusing on memory and concentration therapies. While developing the game, it was challenging to measure satisfaction in children: whether they would be able to play with the game, have fun while using it and undergo the therapies. However, we could not identify enough adapted tools to evaluate the whole experience that children can have while using this game.

2. Methods

A SMS was conducted to provide an information structure about the topic at hand. SMS is a five-step process, starting with the definition of the research questions, followed by a search for primary studies, thereafter screening the found papers for including them in or excluding them from the study. As a fourth step, key-wording of the abstracts is completed to finally perform data extraction and mapping of the selected papers [6]. There are two core components of a SMS: the research questions and the systematic map. For analyzing the scope of research provided by publications on the topic to see trends over time, the following research questions (RQs) were raised:

RQ1: Are there video games, exer-learning games, serious games and/or games for health supporting cognitive therapies for children with cognitive disabilities?

RQ2: Which video games supporting cognitive therapies have been designed and/or evaluated by UX?

RQ3: Has UX evaluation of video games (exer-learning, serious, for health) been performed in an implicit or explicit way?

Conducting the search for primary studies and screening papers for inclusion is a technical aspect and is not detailed here. After the selection of the papers meeting the criteria established for the purpose of this study, the next step was to look for key-words and concepts for building a set of categories to classify the selected papers. As a result, the following categories were defined to classify the studies by their type, according to an existing classification of research approaches [8]:

1. Guidelines papers: Studies that sketch new methods and frameworks proposed to structure the implementation of video games according to their final purpose.

2. Design proposals: In this category, all studies that propose the design of an interactive system to fulfill requirements for certain disability and population are included, following pre-stablish or validated models of their own.

3. Solution proposals: This category includes studies that describe the construction of a specific solution for the treatment, rehabilitation or improvement in health or social interactions of a population with a disability.

4. Validation papers: These studies use several resources to measure the user experience of video games, through design and development stages.

Besides identifying the type of research that was carried out and reported in the selected studies, it is also important to characterize the research objectives of these primary studies. Therefore, the second classification comprises:

A. Evaluating games: These studies verify through different evaluation methods, how the users perceived the designed/developed game.

B. Verifying benefits: The authors from these studies measure how the game impacts the health of the user.

C. Rehabilitation: These studies present the games as the mean to rehabilitate people with cognitive disabilities.

D. Improving skills: The studies present games for developing the cognitive skills of healthy people.

E. Building good games: These studies propose some guidelines to make good games fulfilling its rehabilitation purpose.

F. Creating methods: The authors of these studies propose new evaluation methods for evaluating as well as possible a rehabilitation game.

G. Improving games: These studies show how a previous game was changed due to performed evaluations.

3. Results

We extracted and analyzed data from the abstract and key-words in 49 papers. The first outcome of the systematic mapping study is an overview from literature about video games used for supporting rehabilitation therapies, especially for children with cognitive impairments.

Regarding RQ1, we found seven types of games (Figure 1), but nothing on exer-learning games. Different type of games found in the studies and classified as interactive games, web platforms, technology solution systems, robots, Brain-Computer Interface systems, and haptic systems, were set as Human-Computer Interaction (HCI) systems.

Regarding the age of target users, we found not only children (47%), but also elderly people (13%). 40% of the studies did not report the target audience. When talking about the children being the target users, not all the studies were designed/developed for children with cognitive impairments. 41% of the studies were looking for improving cognitive skills for children in their developmental stage. Among the disabilities found (59%), there are Down syndrome, obsessive-compulsive disorder, Attention Deficit Hyperactivity Disorder, and delays in speech.

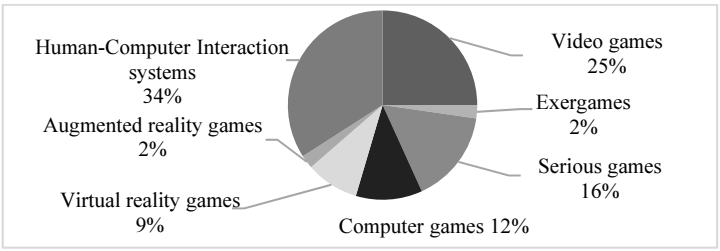

Figure 1. Video games types

RQ2 has two parts for answering it: Regarding the studies belonging to the design proposal category from the classification scheme, only 10% of the studies were designed from UX, and the remainder 90% used other methods. Regarding the UX evaluation from

the HCI field, it is important to recognize two perspectives of this evaluation: (i) the evaluation of a system for improving it (user's opinion on the system) or, (ii) the evaluation of the user to improve the system (system's impact to the user). Just 17 of the studies use UX evaluation methods (5 for user evaluation and 12 for system evaluation) to assess the designed/developed system, while the 21 deploys their own evaluation methods (14 for user evaluation and 7 for system evaluation). The evaluations of the user we identified in the studies were, among others, controlled trials, taking neuropsychological measures, obtaining psychophysiological data, and recording audios and videos. In the other hand, the system evaluations included case studies, comparative studies, and feasibility studies. Regarding RQ3, 82% of the UX evaluation studies used explicit evaluation methods, while 18% deployed implicit ones. Regarding No UX evaluations, this ratio is 52% to 48%. Those studies performing the implicit evaluations, independently if they were UX or No-UX evaluations, used multiple devices for obtaining physiological measures in order to get objective data. Some of the devices/wearables used were electroencephalography neuroheadsets, Kinect from Xbox One, 3-axis accelerometers, 3D sensors, Microsoft Band 2, MYO sensors. Several of the physiological measures mentioned in the studies include EEG brainwaves, electrodermal activity, stress levels, contraction of facial muscles, movement and postural attitudes, galvanic skin response, skin temperature, heart rate, interbeat interval, heart rate variability, and respiratory rate. There has been a recently growing research interest on developing games for health environments in a personalized way, taking into account user centered methods such as the UX for the improvement of the system, and at the same time, the improvement of user's health.

The final result of the SMS is a systematic map characterizing the type of research that was carried out and the research objectives of these primary studies, as defined in the methods section. For representing this, we generate a bubble plot over the classification schemes with the studies (Figure 2) bearing in mind that the size of the bubbles is determined by the amount of studies that have been classified in the pair of defined categories. This x-y plot is the map of our research on video games for rehabilitation of cognitive disabilities in children. The categories with most studies were solution proposals for evaluating the therapeutic video games (8 papers) and validation papers for creating new evaluation methods for these kind of video games (8 papers). The research objectives categories for evaluating games and creating methods had several studies in it, with 13 and 11 studies respectively.

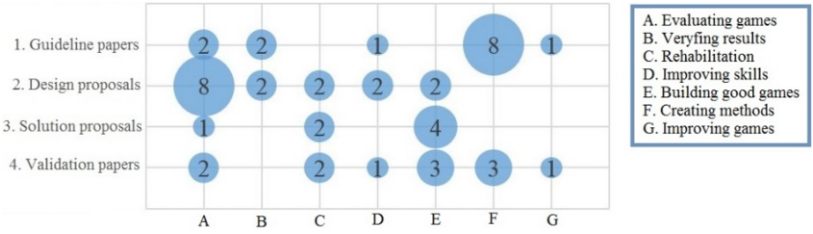

Figure 2. Distribution of the research by research objectives (x-axis) and study type (y-axis)

4. Discussion and Conclusions

Performing a SMS, we could create an overview about the topic video games to support cognitive therapies for children and how to evaluate them using UX methods. There is

no clear methodology regarding parameters to be assessed both for user and for system evaluation. We followed the SMS process by defining three research questions to be answered with the findings of the study. One of the contributions of this study was the categories classification according to the research objectives; these categories gave us implications about the types of research conducted in the area, mostly evaluation of the rehabilitation systems (not their improvement) and the creation of new evaluation methods for the therapeutic systems (not standardized ones). With the map of the study built from the classification scheme, we could identify the way the video games have been developed and evaluated for the rehabilitation therapies contexts, thereby determining research gaps and future research opportunities. An unbiased selection process is difficult to ensure. However, some precautions were taken, e.g., the RQs and the inclusion and exclusion criteria were established before conducting the SMS. Another threat to the validity of the study consists of whether we selected all relevant studies in the area or not; we minimize this threat by taking into account several important scientific databases, both from the health and computer disciplines, and also considering the synonyms of the searched key-words. The final threat could be the classification scheme; nevertheless, the proper way to categorize the resulting studies relies on the perspective of the researcher in the consulted topic. As future work, we will investigate the gaps identified in this study regarding the UX evaluation concerns, to have a conceptual and developmental standard framework for estimating the implicit UX in rehabilitation video games for children.

Acknowledgments

This work was founded by the General System of Royalties (SGR) in Colombia under the “InnovAccion” Program and project HapHop-Fisio (VRI ID 4441)

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