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Marine Guffroy[1(✉)], Yohan Guerrier[2(✉)], Christophe Kolski[2(✉)], Nadine Vigouroux[3(✉)], Frédéric Vella[3(✉)], and Philippe Teutsch[1(✉)]

[1] Le Mans Université, CREN, EA 2661, Le Mans, France
{marine.guffroy,philippe.tetutsch}@univ-lemans.fr
[2] Univ. Valenciennes, LAMIH, CNRS UMR 8201, 59313 Valenciennes, France
{Yohan.Guerrier,Christophe.Kolski}@univ-valenciennes.fr
[3] IRIT, UMR CNRS 5505, Univ. Paul Sabatier, Toulouse, France
{vigourou,Frederic.Vella}@irit.fr

Abstract. The goal of this paper is to report how the adaptation of user centered (UCD) design approaches meet the specificities of impaired persons and their ecosystem for the design of interactive systems. Adapted UCD methods are illus-trated through three case studies involving different impairments. The discussion reports the success of the different design processes.

Keywords: User-centered design · Disabled person · Assistive system

1 Introduction

The literature is rich concerning user-centered design (UCD) approaches [1, 2]. They promote the involvement of users in each stage of the methodological approach. In case of assistive systems design, the use of generic UCD approaches is not applicable for being used for people with certain kinds of impairments. Several studies have shown the high abandonment rate of assistive technologies [3]. The reasons are various: insufficient representation from potential users, environmental barriers dependent of the disability, difficulties to express the needs, including the needs of ecosystem (informal and familial caregivers, teachers and so on) [4].

2 State of the Art

UCD involves focusing on the user's needs, carrying out a task analysis and designing iteratively. However, UCD methods are not completely appropriate to involve the disabled people in the participatory design. Indeed [5] have evaluated a set of methods and techniques according to two criteria: the disability and the age. For instance, how to adapt a questionnaire to make it accessible to a person with cognitive disorders? What solutions can be put in place to allow disabled people to participate in the design stages despite their difficulties [6]? This paper will consider different types of disabled persons. These are sometimes at the crossroads of both criteria. For example, children with ASD

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are both children and users with communication difficulties; person who suffers stroke can be older, have communication disorders and visual impairment. This paper will report how some methods of the UCD have been adapted to overcome limitations of participation in the design through three illustrations for people with cognitive/communication problems.

3 Case Studies Involving Different Types of Disabilities

Three case studies present illustrations of adaptations of UCD approaches dedicated for disabled users. For each, we explain the profile of the target users, the needs of adaptation of the UCD approach, the UCD approach used, the main results obtained.

3.1 Adaptation of Evaluation Stage for Chidren with Autism Disorders

The aim of çATED project [7] is to provide a digital organizer on tablet to children with autism spectrum disorders (ASD), see Fig. 1(a), and to help the public gradually appropriate the tool in a user instrumentation process. Despite the communication difficulties of the target audience, the project has shown that the public, as well as its human ecosystem, could participate during the prototype evaluation phase.

Fig. 1. (a) Work and observation session on the application between a child with ASD and the engineer, (b) user-centered design and test of the ComMob system dedicated to users with cerebral palsy in real environment with members of the ecosystem, (c) adapted UCD

Children with ASD have difficulty communicating and working with others. Design and evaluation methods based on communication, such as brainstorming or focus groups, are not recommended [8]. In addition, the work sessions to design or evaluate the tools dedicated to these children can be long and tiring for them. As proof, school activities usually do not exceed twenty minutes. However, in order to evolve in their living environment, children with ASD are accompanied by their ecosystem (family, medical and educational teams).

The goal is to enable children with ASD to contribute to the evaluation of the tool dedicated to them. Study proposes to extend the classic user-centered evaluation model to a shared evaluation model between the central user and his or her human ecosystem. The extended ecosystem evaluation method was implemented during 18 months in a specialized

classroom for 6 children with ASD. The ecosystem included the teacher, two school assistants and an embedded engineer. Finally, the children are involved in the return of use on the user interface. The data collected via each of the actors complement each other.

3.2 Adaptation of UCD for the Design of CECI System

The CECI (Environment Control and Integrated Communication) system [9] is an assistive technology which allows people with motor impairment and/or language disorders to communicate with their ecosystem (occupational therapists and family caregivers) and to control their digital environment.

Persons who suffer cerebral palsy, traumatic brain injury, and stroke are the target users. They communicate with their ecosystem using facial expression, sign language (eyes, head, thumb, etc.) and/or disorders language. Sometimes visual or cognitive impairment can be also identified.

Without adaptation of the UCD, their participation in the design process can be limited or impossible. The proposition is that the ecosystem may be involved in the UCD (Fig. 1c) process to report the needs, to understand the behaviour in the customizing or in the trials made by the disabled end user. Firstly, the patient needs form is written by the ecosystem. For that, the caregivers ask questions to patient. These needs are then translated into functionalities, features, pictograms or audio messages. Then, the Hi-Fi prototypes are given to the end user to assess the current prototype and to identify potential new needs. This implementation of UCD consisted in a co-design between the end users and their ecosystem during the trial of the assistive technology in all phases. As illustration, the design of the CECI system for a person suffering locked-in syndrome took 18 sessions with occupational therapists for each iterative prototype. This co-design took 9 months. This method is implemented for two patients with Locked-In Syndrome and one with traumatic brain injury.

3.3 Adaptation of UCD for the Design of ComMob for Users with CP

A communication support, named ComMob (communication and Mobility) was carried out according to an adapted UCD approach, Fig. 1(b). It allows the user to prepare and formulate a set of sentences using pictograms.

Our focus is on users with athetoid Cerebral Palsy (CP). This type of disability is characterized by involuntary which greatly reduce the precision in the gestures. In addition, these people have speech problems. When the speech problems of the target users are important, the approach used should facilitate the search for solutions to improve the communication with the actors of their ecosystem, as well as with systems. The process must be adapted in this sense, giving a large part to the technical and user-centered tests throughout the project.

An adapted UCD approach, in which the designer has the target profile, has been performed; he was representative of the end users. His role was central in each stage, particularly during the needs analysis, the modeling and the prototyping, and throughout the project during technical and user-centered tests. Tests on the field were made in a public place and involved requests for help from him, using the ComMob system, from

281 people [10]. From the test results, it has been possible to progressively improve ComMob. The project lasted about two years. The direct involvement of the designer having the targeted profile in all stages has allowed successive evolutions taking into account in a detailed way the needs.

4 Discussion and Research Perspective

The three examples of interactive system show that adaptations of UCD are efficient. Indeed these systems have been designed and are used in real context. These three cases demonstrate that the design process needs to involve the end disabled users but also their ecosystem. The participation of the caregivers, the specialized teachers but also the family is essential to avoid abandonment. The methods "Questionnaires", "User trials", "Prototyping and participatory design" have been co-realized by the end user and the ecosystem for the case studies 1 and 2. In the case study 3, the designer is an end user. This suggests extending the work of [3] by proposing UCD approaches dedicated to one or several types of disabilities.

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