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User-centred design as an important component of technological development

Improving stroke rehabilitation systems with user acceptance and satisfaction surveys

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Abstract: New technologies can be implemented in clinical rehabilitation processes or to close the gap in health care provision by transferring them to the patients' home. Successful use can only be achieved under the assumption that the technology is accepted by its users. The involvement of users in iterative development processes is to be shown to increase the quality of health care systems and to prevent refusal. In this review potentials of user acceptance and satisfaction surveys in the development of stroke rehabilitation systems are discussed. The surveys are conducted as a method for improving the ongoing design process of innovative technical systems developed in the BMBF funded project "BeMobil".

Keywords: acceptance; ICT; satisfaction; stroke rehabilitation; user involvement.

1 User-centred design approaches

The lack of a proper understanding of the needs and expectations of users is considered a main aspect of the failure of innovation [1]. Human-centred design approaches focus on a product development tailored to the needs and expectations of potential users. In order to achieve the goal of developing a useful and usable product, which is not just acceptable but also satisfying, potential users are involved

in the development process [2]. Since changes in the development of a system get more difficult and expensive the later they occur, user participation is recommended already in early stages [3]. To which degree users should participate in design processes mainly depends on the system and its complexity [4].

Involving users in iterative technology design processes became more and more important and recommended over recent years. This led to an increased focus on consulting users in the evaluation and design of new technologies not only in consumer products, but also in health care systems [2, 3]. Observing users interacting with prototypes and thereby collecting information in interviews or questionnaires can help developers and designers to understand the users' insights and to optimize a system or create new solutions [2]. 'Users' in the context of rehabilitation system might refer to patients and health professionals as well. Only by addressing the interests of both user groups new technologies can be successfully integrated in the rehabilitation process.

Due to the high safety requirements we have to place emphasis on the necessity of approvals from the responsible ethics committee for the clinical testing of medical devices (cf. section 20 (1), Medical Devices Law).

1.1 User acceptance and satisfaction surveys

Evaluation of technology acceptance and patient satisfaction helps in the design and implementation of health care concepts. Usually, user acceptance and satisfaction surveys are carried out using standardized questionnaires or semi-structured interviews [3, 5, 6]. Although acceptance and satisfaction surveys are – albeit rarely – used in the development and evaluation of health care systems, it often lacks a theoretical distinction of both concepts. Acceptance and satisfaction questionnaires in the context of health care systems seem to arise quite often without building

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upon a theoretical background, but more upon a common understanding [3, 5]. However, this may lead to limitations in aspects of validity. Furthermore both concepts are mostly evaluated once at the end of the development process, when the health care system is already finished or near-final prototypes have been developed. Due to the difficulties of changes in late development stages, only restricted action can be taken on user feedback [3]. Therefore user acceptance and satisfaction surveys should be conducted already in earlier stages of the development process and for valid results based on a profound theoretical background.

Technology acceptance is an often investigated phenomenon in the evaluation of innovative products [7]. It is assumed that the actual use of a technology can be predicted by the attitude toward using or the behavioural intention to use it. In this context, the Technology Acceptance Model (TAM; [8]), is one of the most widely used acceptance models. It is based on the theory of reasoned action by Fishbein and Ajzen [9]. According to Davis [1989], the acceptance and actual use of a technology can be explained in the terms of internal beliefs, attitudes and intentions of the user, which are decisively influenced by the perceived usefulness and perceived ease of use of the technology. Moreover, patient satisfaction is an accepted indicator of the quality of a health-care service. It is particularly examined in relation to the predictive power of treatment results [10], depending on the expectations of the health service and the valuation of the service actually provided [11].

Based on widely accepted models in acceptance and satisfaction literature the following questions are addressed:

- Are these systems accepted or rather rejected by the users? What are the underlying reasons? Are these reasons more related to the technology or to the individual living conditions of the users?
- To what extent and wherefore do the users use information and communication technologies (personal attitudes, expectations and attitudes towards technology and use)?

2 Methods

In the BMBF funded project “BeMobil - Regain Mobility and Motivity” innovative technical systems and technologies for motor rehabilitation after stroke will be developed. Intelligent technologies are the key to regain an independent ability to move. One focus is to support the therapy treatment of upper limbs in clinical rehabilitation or the

following rehabilitation process at home. In this article two systems developed in BeMobil will be discussed as examples for successful implementation of users-centred design in technological development. The mentioned examples were conducted at a very early stage of the project, results will be presented at the TAR conference in March 2017. First, a hand neuroprosthesis which is going to enable patients with a hand paresis to manipulate objects of the daily life. A small mobile electrical stimulator is combined with custom-made electrode arrays, which consist of multiple small stimulation electrodes, selectable via control algorithms. This feedback controlled stimulation system is used to support functional hand and finger movements [12]. This system is developed by the Control Systems Group of the TU Berlin (Figure 1). Second, a tele-rehabilitation system for home use developed by the Rehabilitation Robotics group, Chair of Industrial Automation Technology (IAT) of the TU Berlin (Figure 2). This system allows the continuation of intensive movement therapy of the upper limbs after discharge from the rehabilitation clinic in the home environment of the patient [13].

2.1 Study design and sampling

In an accompanying preliminary study during the first observation of the technologies in clinic, face-to-face user surveys were conducted. The survey “satisfaction and technology acceptance of the system in stroke care” based on a semi-structured questionnaire. The aim is to explore and evaluate experience, acceptance, satisfaction, attitudes towards the system and their intended actions by using it. The focus is to identify the willingness and the resulting requirements for the hand neuroprosthesis (study 1) and the tele-rehabilitation system (study 2) from user

Figure 1: Hand neuroprosthesis.

Figure 2: Tele-rehabilitation System for home use.

perspectives. The specific reasons for the (dis-)satisfaction with certain aspects of the system are collected focusing on functionality, interface design or usability features of the system.

A sample of stroke patients and therapists were recruited by the clinic (study 1: $n = 5$ patients, $n = 3$ therapists; study 2: $n = 9$ patients, $n = 9$ therapists). No one had previously trained with this technology. The inclusion criteria were: female/male stroke patients, hemiparesis of the upper extremity, minimal function in the upper extremity. Exclusion criterion was severe communication limitations for practical reasons.

The successful use of such technical support systems depends not only on the effectiveness of the treatment, but also on the willingness to use a technology, the technology acceptance and user satisfaction (patients and therapists). Modern information and communication technologies (ICT) comprise a great opportunity to be used properly in rehabilitation processes [14].

2.2 Questionnaire and data analysis

It is an ongoing study. The surveys started in November 2016. The data are currently collected and analysed. So far, one interview has been transcribed and initial analysis steps have been started. The questionnaire uses structured, standardized as well as open questions. The questionnaire contains 40 questions. In order to answer the research

question, the survey was also carried out on a qualitative level in order to identify aspects which implied patient satisfaction. Both quantitative and qualitative research methods were used. These complementary research strategies are suitable to compensate for the strengths and weaknesses of the respective methods. The specific reasons for (dis-)satisfaction with certain aspects of the devices are collected to detect potential deficits. The items were divided into five areas:

1. Sociodemographic data; only for patients: health parameters with one question from SF-36 [15]; quality of life [16, 17]; Barthel-Index [18].
2. Attitude to technology with TBS [19]; Experience with technology [20]; only for patients: questions about current technical equipment.
3. Usage experience with the system (e.g. problems, understanding, motivation, safety, pain in dealing with the system, etc.)
4. Experience with interfaces (e.g. problems, understanding, motivation, assistance and feedbacks).
5. The TAM-Questionnaire [21] was used to record the technology acceptance for the technologies. The predictors of perceived benefits, perceived ease of use and social norm were considered.

Quantitative data will be analysed with the statistic software “SPSS Statistics Version22” (IBM) using methods of descriptive and nonparametric inferential statistics. Qualitative data analysis employed qualitative content analyses.

The aim is to analyse the statements systematically with the software “MAXQDA Version 12”(VERBI GmbH). The material is passed step by step and a category system is created on the material to interpret meanings associated with experiences [22].

3 Outlook

The results of the upcoming analyses are supposed to answer our research questions and subsequently provide the required input for the development teams. The fundamental outcome for developers is that user problems and difficulties are perceived, structured and systematized at an early stage. A catalogue of measures based on user requirements will be given to developers to inform about further development steps. The catalogue includes the following areas:

- Adaptation and improvement of system characteristics,
- Selection of various system characteristics (e.g., comparison of two methods),
- Implementation of additional system features

However, new challenges may arise in the implementation of the results. According to specific factors, user, system characteristics or personal circumstances, the adaptation of the systems differs. If the system lacks of functionality or usability, concrete recommendations for the optimization of specific characteristics can be offered. But if interface problems are caused by the user per se or their personal circumstances a deeper analysis is needed in order to decide what an adequate solution would be.

Implementations of graphical illustrations or audio/video demonstrations in intros or tutorials can be sufficient to compensate deficits of users with low technical experiences and/or abilities. However, in this context alternative approaches which go beyond optimizing the system features and more in the direction of adapting the user to the system (e.g. user training) should be considered as well. If it appears that all possible solutions may not be sufficient for the user, redefining of the user group can also be an option. Furthermore a key question can be how to deal with differing views of patients and health professionals? Previous research had already shown that the two user groups differ in their view on what is most important in the quality of care. For example, as part of the evaluation of the hand neuroprosthesis in one of the underlying studies, two procedures are tested and evaluated by patients and therapists. If the

patients' and therapists' opinion follow different directions, compromises satisfying both user groups must be closer explored.

The transferability of the results to other studies is not possible. User acceptance and satisfaction surveys in system evaluations always have to be adapted to the specific system. Conversely, the small samples are not seen as a limitation but as an advantage in the early development process. Several small evaluations provide better results than only one big evaluation at the end. A small group of users is already able to find the first biggest system failures at early developmental stages. In a following evaluation phase after improving the system, another small group of users can then concentrate on subtleties, which were earlier masked by bigger problems. Several small evaluations will reveal problems at a time when they are easier to fix and a non-use is avoided.

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