

Developing a system for robot-assisted stroke rehabilitation through user centered design methods

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1 Background

The SCRIPT (Supervised Care and Rehabilitation Involving Personal Tele-robotics) project aims to create a rehabilitation device to be used by stroke patients in their homes for training wrist and hand movements. The goal of the project is to make training more motivating and therefore more effective/efficient. For this purpose, gesture controlled games are used for training, including an orthosis to support and measure the movements.

The SCRIPT system consists of a user interface (UI) on a touch screen, a set of games for training and an orthosis which supports the patient's movements. The patient's system is remotely connected to a therapist application for supervision. Defined user groups of the SCRIPT system are chronic stroke patients with affected hand or arm movements, as well as treating therapists.

The SCRIPT project follows a User Centered Design (UCD) process as described in ISO 9241-210. According to the process the needs of the user are in focus throughout the project, as well as the whole context in which the product will be used. To gather reliable information, users are involved in the development process. The UCD process consists of iterations of four phases: (1) analyzing the context of use, (2) defining the requirements, (3) concept and creation and (4) evaluation.

Within the SCRIPT project several studies have been conducted to define requirements and to evaluate the system. In the first phase a first prototype of the system (SCRIPT1) was created and evaluated. The feedback was used to improve the second prototype (SCRIPT2) which will be evaluated in a second round.

This paper will mainly focus on the evaluation feedback regarding the UI and the gesture controlled games and will discuss the main conclusions drawn from the results.

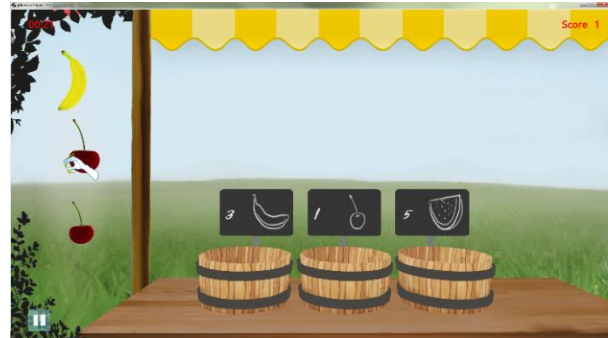


Figure 1. The game "Fruit picker" (SCRIPT2)



Figure 2. Start screen of the patient UI where the patient chooses what game to play (SCRIPT2)

2 Methods

The user involvement in the SCRIPT project consists of two parts: formative evaluation phases aimed to gather feedback for improvement of the system during development and summative evaluation phases aimed to assess the feasibility of the system, to analyse validity and usefulness of the system.

For the formative evaluations, participatory methods as cognitive walkthrough and cooperative evaluation [1] was used and the evaluations were carried out across three clinical sites. Members of the steering group committee including patients, careers and stroke professionals provided feedback and, in addition, six home-visits were conducted where tasks were carried out in the system by patients and their cares. Additionally, two usability tests have been carried out during the project, focused on the UI for patients and therapists, to find and correct usability issues. The first usability test (for SCRIPT1) was carried out in three countries with three patients and three therapists. The second usability test (SCRIPT2) was carried out in one country with three patients and three therapists.

For the summative evaluations, currently one out of two planned evaluations has been carried out (SCRIPT1). Twenty-one subjects were included in a clinical study, where they used the system for independent training at home for six weeks, with remote supervision by a healthcare professional. Feasibility was evaluated in terms of actual use (training duration in minutes), usability was measured by the System Usability Scale (SUS) [2] and user acceptance of the total SCRIPT1 system was assessed by a semi-structured interview.

3 Results

Through formative and summative evaluations, insights regarding the user experience of the system (SCRIPT1) was gathered and fed into the development of the next version of the system (SCRIPT2). A set of learnings regarding the system were drawn from the formative evaluation results, the following being the main conclusions:

Games

- The scoring element is crucial for motivation. Most patients liked to improve their previous earned scores, which motivated them to practice more and more. The variation in difficulty, like the automatic speed correction of the obstacles, also acts motivating.
- Understanding and remembering what gestures to perform is difficult for patients in some situations. Visual gesture hints within the games are important, as well as clear instructions presented to the user before starting the game.
- Clear feedback in the games is a must, e.g. visual or acoustical hints to indicate when an object is selectable, or was successfully handled. This is also a matter of motivation.
- The orientation of grasps must relate to the orientation of the corresponding objects, e.g. if a banana is shown horizontally the grasp has to be performed horizontally.
- The ability of the game to correctly react on the patients' movements influences the user experience. Any technical issues resulting in poor control of the movements of the games demotivates the patients.

Patient UI

- The appearance of the gestures images, explaining the gesture to be used in a particular game, must be elaborated to clearly show what gesture and what movement is meant to be carried out. Extra care must be given to clearly and unambiguously visualize the direction of the gesture, e.g. forward/backward or left/right.
- The calibration process is experienced as too long and clear visual instructions are needed to have the patient performing the correct gesture at a certain point in time.

Therapist UI

- The overview page showing a table of current patients plays an important role and the navigation from the table to the rest of the application must be quick and easily understandable. Visual keys were used to improve the navigation from table cells to each section of the tool.

The summative evaluation results showed an average amount of use of 105 (\pm 66) minutes per week, which is about 15 minutes of self-administered practice at home per day. The individual training duration per subject varied however considerably, ranging from 13 up to 284 minutes per week. The group average SUS score was 69%, indicating that usability of the SCRIPT1 system is promising with a good chance of acceptance in the field. Three subjects scored 'usability difficulties in the field' (SUS <50%), whereas ten subjects scored the SCRIPT1 system as promising or high acceptability (SUS >70%) [3].



Figure 3. Game information screen showing what gestures to be used in the game (SCRIPT2)

4 Interpretation

A system targeted for stroke patients to practice hand exercising at home with the aid of gesture controlled games has been developed and evaluated within the SCRIPT project. Training duration and SUS scores were promising and further work will aim to improve these aspects further. Based on the results on the evaluations, improvements have been carried out for the new version of the system (SCRIPT2) regarding the UI and the games. The system will again be tested by patients at home in a second summative evaluation.

References

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