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Preprint Version

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Abstract

The continuation of training at home after a stay in a rehabilitation clinic requires motivation and personal responsibility. However, patients do often not achieve the required training frequency. In this work, we propose a method to visualize the training status based on light, which can be integrated into the rehabilitation process. Integrated into the personal environment, feedback is generated if training is necessary or not. Based on a first prototype, we evaluated the impact on a patient in a qualitative experimental pilot study over four weeks and the expected overall effect on patients by an expert interview. The results show an animating and rewarding impact on the patient, as well as an orientation for scheduled training days and supporting effect for regular training. This work provides a basis for further research to improve the integration of home training into the everyday life of patients and the use of feedback.

1 Introduction and Related Work

A rehabilitation clinic enables effective progress in cognitive and / or motor rehabilitation in a short period of time (Yoo et al. 2015: 2487, Hatem et al. 2016: 442). However, training often has to be continued at home to support long-term effects. At home, the patients are responsible for their own motivation and for carrying out the training. In home training, less than half of all patients train sufficiently (Knop 2014). One problem may also be an excessively high training frequency. The feedback given to patients usually refers to performance or physical movements. (Kearney et al. 2018:1, Ginis et al. 2016:28). However, feedback between training sessions in everyday life has been neglected. To address it, we suggest to visualize whether a training session is currently to be performed, or whether no training is currently required according to the training plan. Our research questions were:

a) How can the training status be visualized outside of training in patient's personal environment?
b) How does a physical permanent visualization affect patients?
c) Are patients guided by the frequency of feedback?
d) Is the visualization of the training status perceived as support to conduct training?

We suggest light as a feedback to provide patients with information about their training status. This is based on easy comprehensibility and a positive influence on the mood by constantly illuminated elements (Wardono et al. 2015: 342). Light is used as safety feedback on machines according to DIN EN 60204-1 or to visualize current biological data (Snyder et al. 2015). However, this is limited to the time of use. By changing the light, a nudge effect may be created. The view of vegetation or garden-like elements has a pleasant promoting effect and reducing sadness (Ulrich 2002). We propose to integrate this. The contributions are the prototypical development of a method to visualize feedback on training status in the patients' environment and the evaluation of the effect on patients for further HCI research to support patients in rehabilitation.

2 Design Considerations and Prototype

A set of user-centered requirements and restrictions was identified by literature research and expert review to inform the development of a prototype (research question a). This was done with a focus on the medical aspects of rehabilitation and the emotional needs on the patient. The requirements and restrictions were developed in cooperation with interaction designers, psychologists and patients and are presented in Table 1.

Requirements	Restrictions
- transfer of feedback to a physical object - visually harmonious integration into the patient's personal environment - technical elements shall not be in the foreground - indirect interaction (visualization based on patient's interaction with training) - creating a connection between training and everyday life - can be combined with various rehabilitation trainings (software / physical) - giving feedback on when training is needed to motivate and minimize one's own cognitive memory requirements - giving feedback when no training is necessary to give the patient a sense of security regarding the training plan and to avoid too high training frequency - promoting a sense of self-efficacy - positive reinforcement in the assumption of personal responsibility - easy to clean / disinfect and easy to grab (also for patients with motor limitations)	- a supplement to training / therapeutic feedback, not a substitution - no visual effect like a medical object to prevent stigmatization - not integrated into a smartphone, as feedback would require conscious interaction - no or little interaction by the therapist required - non-valued visualization of training performance to avoid negative feedback

Table 1. Requirements and separated restrictions for the visualization of feedback external to training sessions

This resulted in the prototypical combination of a light, initially in the form of a light-emitting diodes (LED), with a plant placed in a glass corpus in a closed physical system. Based on Arduino, HTML and Javascript, an ESP12e Wifi module is used as web server to control the light status (on / off) (Fig. 2 (1)). The Wifi module is powered by a rechargeable battery. The technology is hidden in the prototype (Fig. 2 (2)).

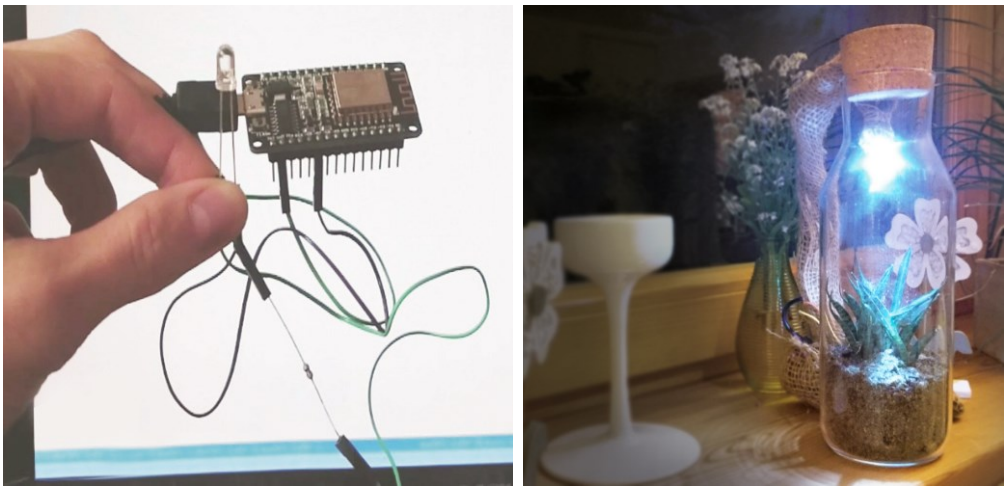

Fig. 2. (1) Left: Technical base of the prototype, (2) Right: Prototype during use by the patient

3 Evaluation

The first use of the system by a patient and an expert evaluation allows to consider subjectively perceived effects and therapeutic aspects for use in rehabilitation. The study was conducted in Germany.

3.1. User Test

We conducted a qualitative explorative pilot study over 4 weeks. The participant was female, 52 years old, undergoing medical treatment and has an acquired long-term physical impairment. In consultation with her doctor, light physical training several times a week to improve strength and endurance promotes her health. The selection of the age based on the increasing frequency of illnesses and rehabilitation in older patients.

Method and Material:
The participant was informed about the prototype and instructed to place it visible at home as preferred. The training days chosen by the participant were Tuesday, Thursday and Sunday. There was no direct control by the participant, but by her husband who works from home and acted as our test assistant by observing her training routine. He changed the status of the LED (on/off) via web server (Wizard of Oz): On training days the LED was switched off and switched on after training. It remained switched on until the next training day began. The test assistant moved a training day once to another day and observed the participant's training behavior. Finally, the participant answered open questions on her subjectively experienced impressions during the use of the prototype and the meCue questionnaire to record user-centered evaluations in the experience of interactive technical products (Minge et al: 2013:89). Statements were evaluated on a 7-point Likert scale between strongly object (1) and agreeing completely (7). Thus a minimum of 3 and a maximum of 21 could be achieved per category. Overall rating was between bad (-5) and good (5).

Results:
The participant perceived the switching on of the light as training success (b) and described the subjectively experienced emotions 'proud' and 'satisfied'. With the light switched off, her emotional response was reported as 'spurred on' and 'prompted'. The meCue questionnaire scored the following ratings: Usefulness (20), Usability (18), Visual Aesthetics (21), Status (16), Binding (17), Use Intention (16) and Product Loyalty (18). Furthermore, for positive emotions AP (18) and DP (16) and for negative AN (3) and DN (3). The overall rating was 4. The participant did not indicate that she arranged her training behavior according to the day of the week, but rather according to the light status (c). The test assistant also reported that after changing the training day, the participant trained on the day indicated by the light rather than her schedule training day. The participant stated that the light had a supportive effect on conducting the training (d). By positioning the light in the personal living space, it was often perceived when walking past. The technique of the system was not consciously perceived during use.

3.2. Expert Interview

The expert interview was conducted with the head psychologist of an outpatient clinic.

Method and material:
The prototype was demonstrated to the expert and explained to him with a video recording. An oral, semi-structured expert interview was conducted afterwards.

Results:
The expert rated the method as a good, coherent and functioning system (a). The interviewee stated that the system transfers responsibility to patients and thereby inspires confidence (b). He indicated that it may have a life-affirming effect and, in combination with the plant, conveys a lively atmosphere. This is important for diseases that may be fatal despite rehabilitation. The interviewee also stated that the system communicates, in a positive way, that the patient is being involved in therapy and achieved something. The feedback is presented in an easily understandable way. The expert assumed that the system supports and motivates patients to conduct training (d). He concluded that it can be used in this way for patients.

4 Discussion

The visualization of the training status is feasible by means of light (a) and can be used in the presented form. Due to individual preferences and personalization, different elements may be used in combination with light. It should be noted that there is no guarantee for the survival of the plant, which may have a negative effect on the motivation of patients. To counteract this, a drought tolerant semi-arid plant can be used. The encouraging and rewarding effect beyond training (b) shows that the desired effect has been achieved. This is also shown by the participant following the light with her training times (c). This is particularly relevant when no training is necessary, as this enables a confirmation of the training behavior for patients in the rehabilitation process. A risk factor, however, is whether the patient positions the object at a visible place. The pilot study shows that feedback outside the training shows the potential to support the regular conduction of the training (d). A long-term effect over several months or years should be further tested. The presented system can be connected with devices for motor training or software for cognitive training via wifi, but it requires the existence of wifi. However, a stand-alone version would probably require a direct interaction.

5 Conclusion and Future Work

The visualization of the personal training status by means of light is perceived as animating and rewarding. It is easy to understand and is perceived as support to conduct the training regularly. The feedback on the training status is used as an orientation for when a training session has to be conducted. The advantage of the presented method is that it can be used for different types of rehabilitation after the clinical stay.
The pilot study shows not only the impression of a single use, it shows the results after four weeks and thereby a tendency towards long-term use of the system. Due to the small sample size, however, this cannot be generalized. In this work we show a first approach to supporting patients in rehabilitation in home training beyond of clinical training, which is geared towards improving the health and thus also the emotional situation of patients in the long term. In the next step, the method and prototype will be further developed and evaluated with a larger sample size without requiring a test assistant. The development of a concept to strengthen the emotional connection of patients to the training and thus to oneself is currently in progress.

Acknowledgements

This work was funded by the European Social Fund (ESF) of Saxony-Anhalt (under the operation number CCI 2014DE05SFOP013) as part of the initiative “Sachsen-Anhalt WISSENSCHAFT Chancengleichheit” with the program title "FEM-Power". This work was also funded by the European Regional Development Fund under the operation numbers ZS/2016/04/78123 and ZS/2017/01/83843 as part of the initiative ”Sachsen-Anhalt WISSENSCHAFT Schwerpunkte”.

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