Us’em
Motivating stroke patients to use their impaired arm-hand in daily life
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Introduction
Stroke is the first cause of motor handicap worldwide. Approximately 40% of stroke victims suffer from chronic upper-extremity impairment. Stroke rehabilitation takes time and relies heavily on patient motivation.

The design: Us’em
Us’em is a wearable system that helps stroke patients self-monitor how much they use their impaired arm in relation to their non-damaged arm. This feedback can be provided both in relation to the last few days or in relation to a specific activity, e.g., eating dinner. This feedback is intended to motivate patients to increase the usage of their impaired arm, which is crucial for their rehabilitation.

Modes of operation
The movement data collected by the hardware is translated to feedback dependent on the choice of the user. The system offers three modes of operation which can be selected by using buttons on the feedback module. In the default “clock” mode the device acts as a watch displaying the time. In the “overview” mode, the system provides feedback about impaired arm-hand use ratio in the last few days. This data is monitored and stored continuously, independent of the mode of operation. In the “activity” mode, the patient can use the module to monitor arm-hand use in a specific activity by starting and stopping the measurement as with a stopwatch.

Feedback
A watch-like module communicates the use ratios during the current day and compares it to the ratios of the last six days when the user presses the corresponding button. The ratios are represented by a bar graph. A yellow reference line displays the ideal use ratio. The leftmost bar represents the use ratio of the present day and can be colored green or orange. The color of the bar depends on whether the ratio increased (green) or decreased (orange) with respect to the use ratio of the previous day. The comparison between the present use ratio and the use ratio of the previous day is underpinned by simple textual feedback (Figure 1).

The prototype can also be used to monitor specific activities. This functionality allows the user to start and stop monitoring a specific exercise of the affected arm. The monitored movement is translated into a score that is rendered in real-time on the display. The display also provides information of the previous measurement so that the user can quickly compare his current score to the previous one. When pressing the stop-button stops the measurement, an overview of the last seven measurements is displayed represented by a bar graph similar to the bar graph that represents the daily use ratios. This bar graph doesn’t contain a reference line since the monitored exercises may change (Figure 2).

User-centered design process
The design resulted out of a user-centered design process involving patients, therapists, rehabilitation researchers, and interaction design experts. The implementation proceeded in three phases. First, a tethered proof of concept prototype of the feedback mechanism was implemented on Phidgets. In a second iteration un-tethered wrist-worn devices were built that communicated wirelessly with a PC. This prototype was evaluated informally by therapists (N=4) and patients (N=7). In the third phase, the whole software was ported to the embedded microprocessors allowing for the independent operation of the device.

Evaluation
Participants
A group of 9 patients (3 in subacute stage, 6 in chronic stage, age range 41-70 years old) participated in the evaluation. All of them received rehabilitation at the rehabilitation center where the evaluation was conducted.

Procedure
Participants were asked to complete a short questionnaire with background information and carried out a performance test. The performance test consisted of a set of tasks concerning the use of different functions of the device by pressing the correct buttons. They were given a small leaflet with explanations regarding the purpose of the buttons. After the test tasks participants completed the Credibility Expectancy Questionnaire (CEQ). Credibility and expectancy of the design are regarded as important factors for daily use.

Results
All participants reported that the size of the modules was too large. All but one participant found the feedback text easy to read. Most however did complain that the buttons are too much concealed into the casing, so were difficult to find and to press.

The results of the questionnaire indicate that patients find the Us’em system credible for treating their arm-hand symptoms. A trend was found for credibility scores to be higher in chronic stroke patients and expectancy scores to be higher in subacute stroke patients.

Conclusions
Our initial evaluation has shown that subacute and chronic stroke patients find that Us’em is credible as a treatment device and expect improvement of their arm-hand performance when using it. Furthermore, the performance test indicates that patients are able to use the system without prior experience and knowledge.

Current developments of Us’em focus on resolving the usability issues identified in this study, miniaturization, and on making the device shock-proof. Further we are currently working on extending battery life to enable sustained field tests which can provide stronger evidence than the survey regarding the effects on patient motivation.