USER PREFERENCES FOR SPEECH-BASED INTERACTION WITH MOBILE HEALTH MANAGEMENT APPLICATIONS

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Abstract

This work reports the main results from two lab studies involving elderly users on relevant usability aspects during the interaction with assistive systems and simulated speech interaction components, starting from the main interactions for socio-technical health related systems. The first study reports on usability aspects and usage scenarios during the interaction with a smartphone-based prototype for real time vital sign detection and visualization. The second study provides insights on user preferences toward different speech-based output variants for an activity reporting feature. Design recommendations are given toward the enhancement of perceived control of the service as well as of means and quality of health related data documentation.

1. Introduction

Taking the growing popularity of smartphones (Cook et al., 2013) into account, today's users can choose from over 800,000 medical apps that are available for the dominant mobile platforms (Android, Apple). 86 iOS applications are solely focussed on reminders while 408 applications support users to keep track of their health data (Seabrook et al., 2014). Accordingly personal medical data are collected via context-sensitive sensors and further processed in a social frameset with increasing complexity when involving several persons beside the user such as formal or informal caregivers and medical professionals. As part of a European Project named AHEAD a tool for heart rate data recording and visualization is developed and improved toward providing a good usability of health data collection and management as well as positive user experience of speech-based interaction components, especially for people with hearing impairment and their formal caregivers. In a usability study an early functional was evaluated with elderly people in the city of

Vienna. The goal was to ensure that issues regarding usability and quality of experience are detected at early stage and to unveil problems a future user would probably encounter with vital data detection, retrieval and visualization. A second lab study was conducted in the city of Munich focusing on concrete user preferences regarding the speech-based presentation and interpretation of the measured health data as well as of medication reminders.

Overall the two studies aimed at uncovering principal user needs and preferences toward mobile applications for health data collection and management as well as setting out the design space regarding speech-based interaction elements. Generally speaking the use of such data generated by e.g. wearables like a smartwatch or blood pressure measurement devices, blood sugar devices etc. brings the data and the use of it with a certain aim, the aim of increasing the health status of the person who the data is about, makes it health related data. Going one step further and defining the interaction system for the use makes the health related data to hDATA, referring to health-related contextual data processing to information. By this statement, there is a clear system theoretical approach visible. This asks for a definition of the core system and the framework of it as well.

1.1. Core System for hDATA

The central element is the patient. This role is directly linked to all other elements (physicians, informal caregivers and formal caregivers). These four roles have an interaction pattern that includes all elements and can – by following strictly just the aim of improving health – act as a closed system with self-referring interaction patterns. This is an autopoietic system (Maturana, Varela, 1982) as it is a living system that is reproducing its own elements by the roles and partly cybernetic circuits. Time passing by, the system becomes more and more complex. The interaction models between the elements of the system are increasing in complexity because of the social aspects that add up to the pure data. In comparison to its environment, the social system is an island of low complexity (Insel von geringer Komplexität) (Luhmann, 1970 in Kneer, Nassehi, 2000). But by building up its own structures and working autopoietic, it is re-fracturing its structure and increases its stability against external stimuli.

To access this social system and to implement modi operandi for a more efficient way of building its internal structures for achieving the major aim of the system, technology could be one way. Technology is the combination of hardware, software and way of use (Weyer, 2008). So it is possible to use technology for a better – more efficient – interaction between the roles within the social system. More determined: there are three interactions for a socio-technical system for hDATA: *control*, *documentation* and *support*. Technology provides solutions for *control* and *documentation* by using monitoring tools like wearables and includes assistance systems for an increasing effect in adherence by its specific *support* – like an app with medication reminders or activity tracking. The AHEAD project is one potential way for realising these interactions.

1.2. The AHEAD Project

Hearing, eye-sight, memory, and coordination capacities decrease with age. To improve quality of life of elderly people, sensory impairments could be technologically compensated. However, still many elderly remain rather skeptical toward the emphasis of daily use of technology-supported services for personal health management. The project AHEAD (Augmented Hearing Experience and Assistance for Daily life) aims at increasing the quality of life of elderly (55+) by assisting them for keeping an active and independent lifestyle. The focus is set on devices that elderly people have already adopted: eyeglasses and hearing aid. Within the early phase of the project the user needs and requirements analysis (interviews, focus groups) elderly users and formal care givers revealed two relevant service scenarios to be deployed: vital signs monitoring and medication intake reminders (Barrolon et al., 2015). Following a scenario-based design approach accordant interface and interaction prototypes are developed and evaluated in an iterative way by adopting a user-centered design process (Vredenburg et al., 2001), an approach demanding for the continuous involvement of the addressed target group (i.e. by asking or observing users for their needs, by presenting design ideas frequently to users for their feedback and updating the design iteratively). In the current stage usage preferences of the features vital sign monitoring and medication reminder were addressed in the two lab studies which are presented in the following.

2. Study 1: Vital Signs Detection

With the emergence of the "quantified self" trend these days very popular fitness trackers (fitbit, Withings, Jawbone, etc.) are available for multiple platforms. Apps specialised in training for different kinds of (outdoor) endurance sports like Runtastic, Runkeeper or Endomondo also aim at counting ones activity, recording routes, acting as fitness coaches and building up communities around personal training via hDATA processing. Also more and more telemedicine systems constituting of different variations of smart and wearable systems have penetrated the mobile technologies´ markets (Chan et al., 2012). However still many solutions provide a dedicated collection database and interfaces failing important requirements. In this study elderly users´ needs and preferences were investigated through the evaluation of a heart rate detection prototype.

2.1. Study design

The study procedure was structured along three phases: introduction and pre-interview, main task phase, and post-interview and questionnaires. In the pre-interview participants indicated their previous experience with mobile phones and smartphones, and whether they had impaired hearing. In the task phase participants were asked to conduct certain tasks with the mobile app and to provide verbal feedback. A user scenario being defined earlier in the design phase was introduced by the facilitator before the participants took over with the three tasks i.e. i) attaching the sensor to the ear independently, ii) generating real time vital sign data and ii) setting heart rate threshold for alarm. Hearing impaired participants removed their hearing aid to accomplish this task. Participants were instructed to comment on everything that comes into their mind (Thinking aloud) and to provide criticism. The post-interview targeted at participants´ general opinion about the tested functions covering participants´ answers regarding their general impression (positive and problematic aspects) and perceived satisfaction with the tested components.

In the actual prototype version the vital signs detection module can measure various vital signs using photoplethysmography (light-emitting technique used to determine skin blood flow) and contact thermometer. As the module needs access to the ear canal, a wireless silicon cap, a so called dome, with the sensing elements was inserted (see Figure 1, left). The prototype provides real time heart rate data collection and visualization on the display of the smartphone (see Figure 1, center), as well as options for setting alarms in case a certain heart rate or temperature value has been reached (see Figure 1, right).

Participants

In total eighteen elderly people, 14 male and 4 female participated in the first lab study. Participants were between 57 and 80 (Mean = 66.2, SD = 8.1) years old. Among

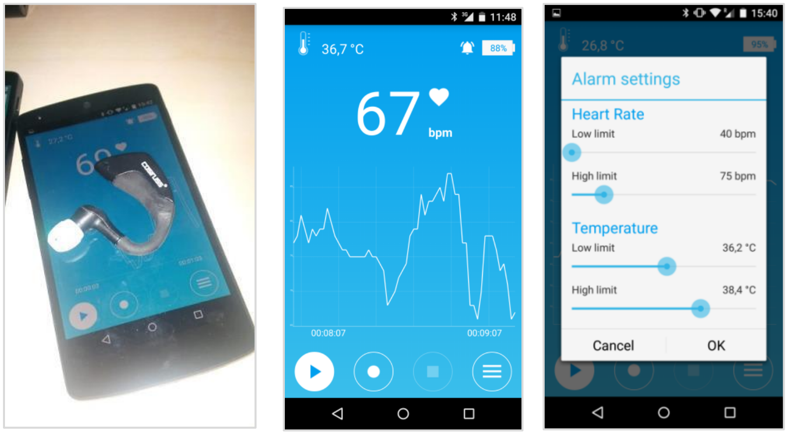

Figure 1: heart-rate and temperature sensor (left), data visualization screen (center), settings screen (right)

the involved sample 9 out of 18 participants (50%) had a hearing impairment in some way. From these 9 persons 7 had a diagnosed hearing impairment. Overall 13 participants (72.2% of the final sample) own a mobile phone. All of these 13 participants were able to initiate a phone call via contact list or calling list, while the majority (11 out of 13) was able to write a short text message (7 persons with word recognition and 6 persons without word recognition). Overall 10 participants owned a smartphone. Among them all were able to initiate a phone call via contact list or calling list, write a text message, take pictures and to set an alarm.

2.2. Results

Overall 9 out of 14 participants managed to attach sensor without help, while 5 needed help to insert the sensor successfully to produce real time heart rate data (due to technical problems i.e. device activation and BT connectivity the task could be accomplished by 14 participants only). Problems with mounting the sensor occurred due to anatomical characteristics such as size differences of the auditory meatus, as the sensor was loose and fell out. After having examined the data visualization, participants were asked to exemplarily set the alarm for maximum heart threshold level. Then they should provoke a raise of the heart rate level to activate an alarm by performing physical activity (see Figure 1, center). The majority of participants managed successfully to find the setting (11 participants), use the slider to set the alarm for the maximum heart rate level (see Figure 1, right).

All participants correctly anticipated the main UI elements on the main screen i.e. real time heart rate detection curve, temperature and battery level of the Bluetooth sensor. Although the three tasks (attaching the sensor, generating data, setting the heart rate threshold for the alarm) were perceived as being easy to solve, some usability issues were observed related to

- Data visualization: participants had difficulties understanding the purpose of the visualization. Changing scales and axe labels were confusing, while the potential benefit of such visualization was not always perceived.
- Feedback: While participants performed physical activity to raise heart rate level, the smartphone was put on a table nearby. Perceptibility of the alarm triggered by the detected heart rate was low, as most of the time the vibratory signal was not recognized.

The mounting of the ear sensor was well accepted by especially participants without hearing loss who provided useful usability recommendations for the improvement of the future service:

- Flexibility: enable the user to remove the ear piece easily when vital signs are not measured. The application should allow the quick and easy mounting of the sensor and the instant use of the corresponding module on the smartphone according to when and in what situations a measurement needs to be done. This action should be easily undertaken by the elderly user e.g. comfortely activate and connect the device via single button press in the app.
- Understandability: the meaning and purpose of the real time curve should be more clear if depicted, by e.g. providing additional information such as e.g. depicting selected thresholds or activity history. Moreover real time feedback should be provided in form of a stable and consistent information output such as diagrams with fix scales for better orientation.
- Awareness: Alarms and notifications should be given more prominently e.g. via audio signal, a message and corresponding visual feedback information on the display. Moreover, several alarm output modes should be configurable, such as e.g. auditory beep tone when threshold has been reached, or voice-based notification containing a short message (e.g. "maximum heart rate level reached", "please lower your heart rate", "call your doctor" depending on the data).

Overall, participants enjoyed using the application and freely anticipated various use cases for its application, such as monitoring the heart rate level e.g. during long term driving against drowsiness behind the wheel, during physical activity on the home trainer, or in case of heartbeat irregularities.

3. Study 2: Health data presentation and medication reminders

As forgetting medication intakes can lead to increased morbidity and mortality especially for elderly people (Yu et al., 2015), there are various possibilities of medication reminders on the market. Reminders written on paper sheets and phone calls by family members are being increasingly replaced by digital systems. With the endless possibilities, there are some important questions to be answered, most notably which context, type of feedback and device fits best for which user. According to Hartin et al. (2014) there are time-specific reminders on one hand and different emerging context-aware solutions on the other hand. While time-specific reminders tend to be delivered during inconvenient situations, context-aware reminders aim to avoid these situations by connecting location data, activity level or more complex contexts to the reminders. A pilot study of Reidel et al. (2008) showed that especially the technical implementation of the voice interface is key to the success and the acceptability of the whole system. Therefore the second lab study attempted to give answers on issues like the technical implementation and user preferences concerning the structure and content of health related audio messages.

3.1. Study design

The second study aimed at extending the vital signs detection paradigm with corresponding monitoring and reporting features, such as activity reports based on daily heart rate and temperature data. The study followed the same procedure as study 1 (see 2.1). More specifically user preferences regarding different variants of speech-based output were investigated in a simulated lab setting. For the testing of speech interaction, participants were equipped with a wireless bone conducting Bluetooth headset with a built-in microphone (simulating the final AHEAD system providing bone conduction based hearing aid via the hearing glasses). In order to become familiar with the activity monitoring feature, every participant performed six easy voice interaction tasks. To simulate physical activity, the scenario of a hiking tour was introduced and participants were asked to walk a distance of 10 meters twice while wearing the headset. After the first 10 meters, a pre-recorded voice was played back saying ‘Nice that you’re active!’, while another pre-recorded voice at the finish line said ‘Please take a break!’. After that, the participants were asked to give their opinion on the positive reinforcement and the warning.

Addressing the users’ preference of an activity history or a summary report, three different pre-recorded reports were presented (identical message, different level of detail):

- Basic: The report (7 seconds) contained basic information that everything was alright, but the user should move a bit more the next day.
- Recommendation: The report (14 seconds) gave an additional recommendation how to be more active.
- Recommendation and feedback: The report (36 seconds) included several recommendations as well as precise heart rate data (‘your daily low heart rate was 52 and your highest heart rate was 150’).

In addition to preferences on the reports, participants were asked at which moment they would prefer to receive this summary. While giving their feedback, a medication reminder was played back to see if the elderly (and partly hearing impaired) participants were able to keep track of the conversation as well as remember the medication they should take. The reaction of the participants to the medication reminder was carefully monitored by a second facilitator while the main facilitator kept up the conversation in case the participant stopped talking. After giving their comments on the surprising medication reminder and how the system could make these situations easier to handle, each participant gave his overall impression of the evaluated features and further fields of application.

Participants

The second study featured ten participants between 56 and 79 years old (Mean = 69.2, SD = 8.4). Seven of them were wearing hearing aids to compensate their diagnosed hearing impairment. Unfortunately one participant had serious problems with his hearing aid and wasn’t able to understand the pre-recorded voice samples even on the highest volume level. Because of that, only nine participants completed the whole test.

Six of the ten participants owned a smartphone, four owned a mobile phone. Interestingly two of the four mobile phone owners stated, that they would only use their device in case of emergency or not at all. While every participant was used to calling somebody off the contact list, only 70% had ever written a SMS with their device. Half of the participants were able to send e-mails, install applications, set alarms and navigate to a given destination with their smartphones. Every smartphone owner stated that he had taken and sent pictures as well as video files. 60% had made experiences with voice user interfaces before, two in their car for navigation purposes, two with dialogue systems on the phone (tele-banking) and two of ten participants had already tried the voice assistant on their smartphone. On a scale from 1 (extremely bad) to 10 (ideal), these participants rated their experience with voice user interfaces as ‘poor’ (Mean = 2.8).

3.2. Results

After the participants had experienced both a positive reinforcement (‘Nice that you’re active!’) and a warning (‘Please take a break!’) they shared their thoughts. 80% of the participants appreciated the warning and freely anticipated numerous situations where audio warnings could be beneficiary (e.g. on hot sunny days and if users are overly ambitious). The audio message should be clear, short and unmistakable. Only one participant (10%) said that he needed further information like the reason of the warning. Conversely the positive reinforcement was rated poor as the majority of the participants (60%) did not see any benefit, questioning if the system could properly assess when praise was justified.

Almost every participant (90%) liked the idea of a regular health and activity summary. Recommendations can be summarized as follows:

- According to 80% of the elderly participants this summary shouldn't be too extensive (longer than 14 seconds) but nonetheless contain concrete information such as heart rate values (70%). It was mentioned three times that a short basic report with the possibility to ask for further information would be the ideal solution.
- Suggestions for physical activities were also rated well, but needed to be customized to the activity level and the preferred activities of the user. Asked for their favourite time to hear the summary, participants had substantially different opinions. Three preferred a particular time, two liked the idea of a time span of two hours and three wanted the summary to be played back when sitting in front of the television or after lunch. One participant stated that the summary shouldn't be played back on a regular basis and only come up on his command.

The medication reminders were rated as a very useful feature in general as some participants immediately remembered the last time they had forgotten their medication. But as the reminder was played back in the course of a conversation only 30% could correctly reproduce which medication they had to take. Most participants (60%) noticed that the system said something but as they wanted to follow the ongoing conversation they just suppressed the reminder. In total three participants (1 of 7 hearing impaired participants) were able to keep up the conversation and understand what medication they had to take. To address this common problem the participants could basically think of two solutions:

- A mute button attached to the audio system so the user can mute the message in inconvenient situations. In this case the message should be repeated after a certain period of time, e.g. after half an hour.
- A short but unique announcing sound that is played a short time before the message starts. This way the user would be more aware and could probably listen to the message and the conversation.

4. Conclusion and Outlook

Real time measurement of the heart rate impressed study participants in the first study who envisioned potential use cases for future *support* by such functionality. The wearable sensor was well accepted and easy to handle. Referring to the claim for adequate *documentation* mechanisms in hDATA processing systems, the visualization should be enhanced with additional information on set thresholds, e.g. for specific activities and contexts. Vital signs summary reports should not be too extensive but nonetheless contain concrete health data such as heart rate values toward complete and comprehensive information and useful behavioral implications for *control* and increased adherence. In study 2 questions on information amount and timing for speech-based medication intake reminders were tackled as a key aspect for perceived *control* in interaction with hDATA. For the users to be able to understand every medication reminder, audio messages should start with a unique sound enabling the users to shift their attention to the reminder. To handle audio messages in inconvenient or social situations participants suggested a button attached to the audio system which mutes and postpones the message.

Taken together the conducted studies provided valuable insights for the advancement of the tested modules (vital signs monitoring, medication reminders). Feedback from user´s attitudes toward gathering hDATA by (health) monitoring and management approaches and elaborated implications for the design of speech-interaction elements will flow into the further development of the AHEAD system. Hence AHEAD demonstrates how to use generated health related data set in a context in the sense of *documentation, control* and *support* with the aim to improve health: if an individual set of threshold is reached by monitored data, the system interacts with the primary user and in some use cases also with health professionals and informal carers (e.g. personal alert system) and gives instructions without annoying the user. The user receives supporting information within the actual situation and is enabled to react in time. AHEAD shows a new dimension of socio-technological systems, a full system, building on its own references and structures, is constructed and can interact with its environment on the base of reports. AHEAD provides an autopoietic system that keeps its core – the patient – alive by using alarms to make the environment react to its needs. This makes it a new kind of socio-technological system. AHEAD is an augmented, bio-supportive socio-technological system.

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