Proceedings of the 3rd Annual
IEEE Conference on Automation Science and Engineering
Scottsdale, AZ, USA, Sept 22-25, 2007

TuRP-A01.6

Usability of a Mobile Self-Help Tool for People with Diabetes: the Easy Health Diary

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***Abstract*—Changes in diet and lifestyle are leading to a dramatic worldwide increase in chronic diseases, including Type 2 diabetes [1]. The demand for health-related support is thus growing, and many self-help tools are available. However, few of these are easy to use and to integrate with users' daily routines and necessary medical or fitness equipment in a way that motivates long-term use. Our research group is working with the Easy Health Diary, a self-help tool for people with Type 2 diabetes. The tool is based on Smartphones, and its functionality applies to each of the three cornerstones of diabetes management: physical activity, nutrition and healthy blood glucose values. The target user group is typically aged 50 or more, so it is especially important that a self-help tool should have low technical thresholds and a highly usable design. Such tools may also support applications to help the general population meet today's vast health challenges. A prototype has been designed and tested on 32 people: 12 users with Type 2 diabetes and 20 individuals without diabetes. All informants had a generally positive reaction to the prototype and the user group was more positive than the reference group. The informants emphasized the importance of making the tool extremely easy to use and integrated with the everyday routines of the users.**

I. Introduction

SELF-management of diabetes is a complex task which involves maintaining healthy blood glucose levels through a balanced diet, physical activity, and for many, medication. Success depends on extensive monitoring of these parameters. We are designing an interactive mobile tool to help people with Type 2 diabetes to manage their health, called the Easy Health Diary (eDiary). Blood glucose and physical activity data are captured wirelessly from sensors, and nutrition data are registered through a simple user interface. The data are processed and presented to the user.

Our strategy, which may differentiate the tool from other similar initiatives, e.g. [2], aims for an especially easy way of interacting with the system, ideally in a "no-touch" manner as achieved with our system for wireless transfer of blood glucose values [3] and step counts (work in progress). For other parameters, it may mean as few physical interactions (finger touches) as possible. The self-help tool is not intended to suggest changes to the user's health regime directly, but to provide her with both general and specific information about her health parameters, so that she may be inspired and/or enlightened to change to more healthy habits.

While mobile and wireless terminals are now emerging as user platforms for self-help tools, most tools are still made for PCs. A wide range of applications for lifestyle management already exists. Some of these applications are designed for athletes or dieters, but there are also tools especially designed for people with diabetes. Smartphones have recently emerged as relatively stable and uniform terminals, which are gaining market penetration. For data capture, sensors with wireless communication capabilities are emerging too. Of these, Bluetooth short-range communication technology is perhaps still the most promising, in spite of its relative high power consumption. Generally, we find existing self-help tools for patients very ambitious in terms of the user effort and technical skills they require.

The target group for our tool is users with Type 2 diabetes. As the prevalence of diabetes increases with age, and older users tend to be less familiar with mobile phones and mobile technology, design focused on usability is especially important. The tool must have a very easy interface for data capture as well as highly intuitive and user-friendly output procedures, enabling both context awareness and self-adjusting capabilities. The overall aim is to design a tool that is easy to use, helpful and motivating enough to be used in everyday life.

The concept presented in this paper is part of an ongoing project within the eHealth and telemedicine, involving interdisciplinary research which draws on informatics, psychology and medicine. The results presented are the users' reactions and preferences to a self-help prototype, and also ideas and concepts for the future generation of self-help patient tools. The self-help tool is being designed and tested in two phases; this paper presents the first phase.

Manuscript received May 18, 2007. This work was supported by financial support from the Research Program for Telemedicine, Helse Nord RHF, Norway, and by the Center for Research Driven Innovation, Tromsø Telemedicine Laboratory (TTL), Norwegian Research Council Grant Nr. 174934.

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II. Background – Diabetes Self-Help Tools

The main challenge associated with stationary self-help tools running on PCs is that users have to remember to record their input data (the cornerstone data for diabetes are nutrition, physical activity and blood glucose values) on a mobile medium when away from home and then enter or transfer these details to the stationary PC system when they get home. One often used approach to this challenge is the use of a PDA-based tool, e.g. [4]. Unless the users already use a PDA as a tool for other purposes, this introduces an extra gadget which they must remember to carry, charge and maintain.

Some of the existing tools based on mobile phones/Smartphones are designed for people interested in dieting, e.g. the software "DietOrganizer Pocket for Pocket PC" [5] or exercise, e.g. the "Sony Ericsson W710 Walkman phone" with an integrated step counter [6]. These tools usually offer the option to record food intake and/or exercise at a very detailed level. This may be suitable for a highly motivated user group, but not usually for a user group of people with a chronic disease, like Type 2 diabetes.

Generally, electronic patient management tools are comprehensive, like INTERLIFE [7], which offer feedback on sensor data such as blood glucose levels and physical activity. Manual initiation of sensor data transfer as well as launching and navigating in a PC-based tool are often perceived as too cumbersome for everyday use. Specifically, existing tools for the Type 2 diabetes user group do not yet seem to be either user-friendly enough or sufficiently integrated with the user's daily routines and necessary medical/fitness equipment to motivate long-term use. Some blood glucose measurement devices are equipped with diary functions, e.g. the OneTouch Ultra2, the OneTouch UltraSmart, and the BD Logic Blood Glucose Monitor [8], where the user can record meals, exercise, and/or insulin doses. However, such devices require a considerable effort from the user in the form of many and comprehensive inputs, and all of these have small non-color LCDs.

III. Methodology

In this study we employed an engineering approach, extended with clinical trials. The system was prototyped in close cooperation with the user group. Trials were performed both with people with Type 2 diabetes, called the user group, and with people without diabetes, called the reference group. The intervention was approved by the Regional Committee for Medical Research Ethics.

A. Participatory Design

Our research group has worked with the design of self-help tools for people with diabetes for several years, observing many projects that have ended up as prototypes only. The overall aim is of course to end up with long-term tools for the target group. To this end, in this study we emphasized intensive user involvement. Four user meetings were arranged, each lasting two hours, in which 14 users with Type 2 diabetes were divided in two groups to obtain groups of a suitable size. It has to be underlined that the users were recruited from the local diabetes association; they accepted a letter of invitation to participate, and were therefore probably both more motivated to work with their disease and more knowledgeable than an average person with Type 2 diabetes. Not everybody had the possibility to participate in each meeting, but the attendance rate was fairly high, i.e.: first meeting: n=14, second meeting: n=12, third meeting: n=13, and fourth meeting: n=12. Each meeting was assigned a main discussion theme—physical activity, blood glucose measurements, food habits, and using a Smartphone as the main terminal for a self-help tool. For the first three themes, the discussions in the groups were related both to the users' associations with the theme and to how they could use information and communication technology (ICT) tools to enhance their current situation. The fourth user meeting was dedicated to investigating the users' reactions to a concrete prototype that comprised the first three themes, in order to gain knowledge about how the next version of the self-help tool should be designed. All meetings and user interactions were recorded as video and audio, and the participants were asked to fill in several questionnaires.

B. Prototyping

Paper prototyping was used as a first approach to explore users' preferences regarding screen feedback. The users were also asked to rate types of screen feedback from hand-drawn examples. Hand-drawn examples were used instead of graphics to convey to the users that they were influencing the tool from the beginning, and not just giving comments on an existing tool. The users were also asked to build up experience with current technology and routines related to recording their physical activity using ordinary step-counters, and recording their blood glucose values and nutrition habits in analog diaries. The eDiary prototype was implemented on two types of Smartphones, one with a navigation button and the other with a touch-sensitive screen. The main functionalities apply to the three cornerstones of diabetes management: physical activity, nutrition and managing healthy blood glucose values. The eDiary user interface used for the tests was implemented in html, but is currently programmed in C#.

C. Testing on the User Group and the Reference Group

The prototype was tested on 12 of the 14 participants in the main user group and on a non-diabetic reference group of 20 people. Both these groups tested the eDiary on two different Smartphones (navigation button vs. touch-sensitive screen), where all functions were demonstrated (A-E in Fig. 2), but without the logic, procedures and wireless data transfer that the next version of the self-help tool will include. The tests with the main user group were performed at the fourth user meeting, while the tests with the reference

group were performed as part of a poster stand at an eHealth conference. The reference group comprised adults without diabetes, but with a competence and/or interest in health issues. The concept was presented in the same way to both groups, and all were asked to fill in the same questionnaire.

D. Critique of the Methods Used

An experimental method requires a comprehensive testing phase. Even more extensive testing is necessary for a randomized clinical trial. In this project, the emphasis was on the engineering aspects. The clinical trial thus functioned as an acceptance test, and not as a test to provide evidence-based medical results. The above-mentioned recruitment of the user group involved highly motivated and knowledgeable users, which must be taken into account in drawing conclusions from our work.

IV. Results – The Users' Preferences

Below, we present qualitative and quantitative data from the use of focus groups, questionnaires and paper prototyping, the design and implementation of the current prototype, and the user reactions to the prototype.

A. The Users' Input to the Design

All four user meetings were videotaped, resulting in 16 hours of recording from the two sets of meetings. Excerpts from these meetings are presented and discussed below.

Of eight hand-drawn suggestions on how the feedback related to physical activity should be reflected on a Smartphone screen, the two suggestions in Fig. 1 were ranked highest by the 14 informants with Type 2 diabetes.

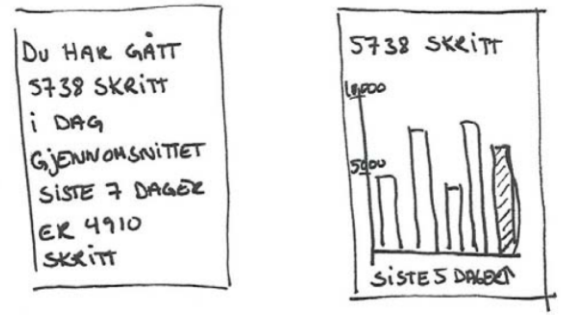

Fig. 1. Of eight suggestions for how to present a summary of the number of steps taken, the two above were ranked highest. The leftmost presents the steps taken today and the average of the last seven days, while the rightmost states the number of steps today with a graphical presentation of the last five days.

It surprised our research team that the leftmost example with simple plain text was ranked highest. It was also surprising that an example with graphics only was clearly ranked lowest. The users were also asked to sketch their own suggestions on how they would like to receive feedback, and the suggestions were: sound/music feedback, colorful screen and/or vibrating phone when daily/weekly aim is achieved, bar graphs of this week compared with the previous week, appealing picture once a week, grandchild's picture when aim is achieved, smiley when aim is achieved, negative smiley for poor result, average steps for the last week, bar graph with the target indicated as a line to reach for, instrument panel like a watch, percentage indication of the extent to which your goal has been achieved.

When use of blood glucose (BG) measurements was discussed in the second user meeting, these main responses were the most common: "when something is wrong with the blood glucose values, it should have been possible to discover what caused the irregular value", "I measure BG each morning, but I do not use the value actively", "there should have been a reminder throughout the day to encourage me about healthy habits", "sometimes I discover that food affects my BG in a strange way, and wonder if this is true for others in my situation as well", "the BG values are considerably higher than normal when I am ill", "I need to focus on other things than BG, e.g. food and physical activity", "BG measuring is tedious at times". Generally, the user group measured their BG value once a day, but some measured it several times a day in periods and some measured it very seldom. It was clear that very few of the users used their BG measurements actively in adjusting their lifestyle, and those who aimed for this reported that they did not manage to make long-term commitments.

It was emphasized that we aimed to get to know the user groups' nutrition habits, without detailed discussions on e.g. the nutrient content. Prior to this theme meeting the users had been given a diary (an ordinary almanac) and were told to use it as they wished to record aspects that were relevant to their disease. Their main feedback during the discussions were: "I get more focused when I make notes in the diary", "I should eat more fruit and vegetables", "I should eat fewer sweets", "my eating habits are periodic", "it was difficult to remember to make notes in the diary", "I eat too seldom", "my nutrition knowledge is rather good, but could be better", "there are some contradictory nutrition information that I find frustrating", "I need a reminder from time to time", and "using the diary gave me a fairly good overview". The general comment on the use of this form of diary was that this might be interesting in the beginning, but for it to serve as a sustainable tool a certain degree of follow-up is required. This was largely confirmed in a simple test where five of the users were asked to submit their weekly goal via SMS to one of us in the project group. Although we only provided two simple neutral responses a week, for two weeks, the users perceived this service as very encouraging. The users also expressed a positive attitude to the idea of acting as each other's "support group", underlining that the health care service does not have the ability to provide this degree of social support. This need corresponds to the satisfaction that the users expressed about the user meetings, and comments that they felt fortunate to be invited to participate. Besides a step counter and a diary, no incentives were provided to the participants.

B. The Chosen Design

To optimize usability, blood glucose and exercise data are transferred automatically to the Smartphone. Users may choose to record only the time of their meals, or they can easily add a rough description of what they ate and drank. An overview of the eDiary's functionality is presented in Fig. 2 and further described below.

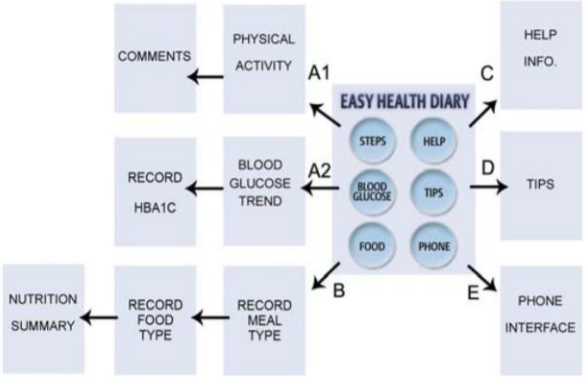

Fig. 2. Diagram of the self-help tool's user interface and main functionality; presentation of physical activity through step counts, presentation of blood glucose data, registration and presentation of nutrition habits, emergency function, general information and access to phone functionality.

1) Automatic Data Transfer (A1 and A2): To capture blood glucose data and exercise data, we used a blood glucose meter and a step counter. To optimize usability, data from these sensors are automatically transferred using a "no-touch" principle, as described in [3]. This means that the users do not need to initiate data transfer from the sensors; the sensors set up short-range communication to the Smartphone automatically. Updated data will therefore be available in the eDiary at any time, just one click away.

2) Entry of Nutrition Data (B): Users can record their food intake using two different levels of detail: a) simply choosing the kind of meal (breakfast, lunch, etc) and b) also choosing the kind of food they eat (bread, pasta, etc). This design has been chosen to make the data entry process as easy as possible, enabling the user to decide on the level of detail to record. Thus, the process requires only two or three touches or navigation moves. After each entry, users are presented with a summary of the current status of their nutrition habits. See leftmost screenshot in Fig. 3.

3) Emergency (C): Pushing the help button presents the most essential health information for the user. Anyone who finds the user unconscious can access this information, or the users themselves can use this button to call their ICE relative (ICE – In Case of Emergency). The call is set up automatically.

4) Motivational Information (D): By including tips and information related to practical situations, i.e. information that is sufficiently "down to earth", we aim to provide a functionality that will motivate, educate and be appreciated by the user group. See the screenshot "Tip of Today" in Fig. 3 for an example. The daily tips are available both as text and audio messages. The functions include a diabetes dictionary in which the user can look up terms related to diabetes.

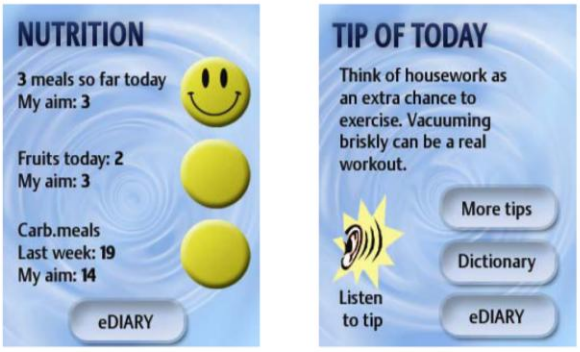

Fig. 3. Screenshots of nutrition summary and tip of the day. The nutrition summary is presented automatically after each food entry, and the tip of the day can be accessed from the main menu.

5) Integrating Two Tools in One (E): Because the eDiary program can run on a mobile phone, the user does not need to carry an extra device. The user may choose to use the "Easy Health Diary" application or the ordinary phone screen as the main interface, accessing all functionalities in either case. When the diary is used as the main interface, the phone is accessed by activating the lower right button "Phone". If the phone is used as the main interface, the diary is reached by activating an "eDiary" button

C. The Users' Reactions to the Design

1) General View of the Prototype: After the user group (n=12) and the reference group (n=20) had tested the prototype, they were asked to complete a questionnaire of seven questions. Four of the questions were related to their general view of the tool, where they gave each question a score between 0 and 7, where 7 was the most positive. The questions and the results are presented in Table I.

TABLE I
THE INFORMANTS' GENERAL VIEW ON THE SELF-HELP TOOL

Questions	Score user group	Score reference group
What are your thoughts about this idea?	6.67	5.45
Do you see any needs for a solution like this?	6.25	5.40
Do you think the users will use it as a DAILY tool? (0=never, 7=yes indeed)	6.25	5.50
How often is it reasonable to think you/they will use it? (0=never,3=once a day,7=at each meal)	5.67	4.15
Number of informants	12	20

2) Type of Terminal and Navigational Method: Even though we did not present a version of the "Easy Health Diary" on the PC platform, we asked the informants the question "Do you think it matters if this eDiary application is on a PC or a mobile phone?" There were three alternative answers. The view of 50% of the user group and 55% of the reference group was that such an application "should be on both the PC and mobile phone terminal". All the others said that it "should be on a mobile phone". None of the informants chose the third option: "Should be on a PC".

Fig. 4. The two types of Smartphones used in the user test, one with touch-sensitive screen and the other with navigation button for user interaction.

3) Preferred Input Method: We selected two different Smartphones, both with a screen resolution of 240 x 320 pixels, see Fig. 4, but with two different navigational methods. One is equipped with a touch-sensitive screen and the other with a navigation button. The preference of 42% of the user group and 60% of the reference group was using the touch-sensitive screen for navigating within the self-help tool. The same percentage, 42% of the user group, preferred using the navigation button while 30% of the reference group preferred using the navigation button. Respectively 16% and 10% of the respondents were happy with either. There was thus a slight general preference for a tool with a touch-sensitive screen, but more of the informants pointed out that ideally they would like to use both input methods on the same unit.

4) General Comments: In each of the first six questions in the questionnaire, we asked the informants whether they had any additional comments. As the final question, we asked: "Do you have any advice or comments for us to take account of in our further implementation phase? To summarize the 33 answers to this from the reference group (n=20) first, we have generalized and grouped them into four main comments, with the number of informants suggesting them in parentheses: "make a simple, reliable and useful tool" (11), "the use of the tool is age related" (7), "tie the tool to daily routines" (5), "should be on more platforms" (6), and other answers (4). Naturally enough, the 20 general comments from the user group (n=12) were much more advanced, both due to their experience with their disease and from the discussions in the previous three user meetings. Also for this group the largest group of answers was related to the importance of an easy and useful tool (6), including concrete suggestions such as using speech recognition, including the blood glucose meter as part of the phone, and ensuring an easy navigational structure. Other types of comments were: "build up my own profile on the tool" (2), "I will use this tool in periods" (2), "it should be able to sync the tool with my PC" (2), "an ideal tool especially for people with Type 1 diabetes" (2), and "I am ready to use it now" (2). Keywords from the last comments (4) were: "connection to a user database", "data transfer to my GP", "include wire loop for hearing impaired", and "possibilities to track more parameters such as weight and waist measures".

V. Discussion

A. Reasons for the Design Choices

To make it possible for the user to easily incorporate a health diary into their everyday life, we have chosen to use a mobile phone as the terminal. The "Smartphone" variant was chosen for its larger screen size, programmability and ability to use the short-range communication standard Bluetooth for sensor interaction. By creating a good screen design, we want to make the health data presented by the eDiary easy to read for people who are elderly or who have reduced vision. We emphasize the importance of using positive visual feedback directly after health actions by the users, a design choice that was often repeated as positive by the user group. We deliberately exclude negative symbols, for instance as shown in the leftmost screenshot of Fig. 3, where the smiley is faceless rather than having a negative face for user aims that are not achieved. However, some of the participants in the user meetings claimed that they would rather receive punishment-like feedback from the tool. This demonstrates that one has to aim for tailored tools, individually adjusted to each user, preferably as automatic as possible. Taking the user feedback into account, it seems that a combination of smileys, graphs and text is appreciated, and that the feedback should be simple, but informative.

There has been and will still be a discussion on which kinds of applications should run on a central server and which should run on the local terminal. Since applications like the one presented in this paper will have to include software that access short-range communication hardware (Bluetooth) on the Smartphone for use in sensor data transfer, i.e. blood glucose values and step counts, at least this related software must be loaded on the phones.

B. How Valid are the Results?

The use of the reference group is in line with Sears and Zha's [9] emphasis on testing the design on novice users, since initial performance and preferences may affect whether or not a technology is adopted for future use. We saw that the novice reference group was considerably less

positive to the prototype than the user group of people with Type 2 diabetes, but still fairly positive, see Table I. Even though the reference group were health care professionals, health researchers or otherwise interested in health, the difference in score results may be explained by the fact that they did not see a personal use for the tool, and thus ranked it lower than the other group who did see a personal need for such a tool. Both groups were offered a short presentation and test of about 10 minutes each, which gives us only an indication of the perspective for the prototype. The next step is to test the prototype for a longer period, probably first for a week to discover remaining problems and opportunities for additional improvements, before the main test of 3-6 months.

C. *Future Work*

The varying perceptions of the tool between the user group and reference group may suggest adopting different strategies in software development practice in similar cases. Perhaps quite different approaches are necessary when developing systems for people with chronic diseases compared with people with minor challenges? Creating the appropriate routines and methods for easy and user-friendly distant installation of this software will be one of the main challenges in the usability focus of such projects. The eDiary should also learn from the user's habits, and use this knowledge to tailor its services to better fit the user's needs. Manual customization by the user may also be valuable, underlined by stroke patients in a study by Zheng et al. [10] where the users preferred to change font size and background color on the ICT platform themselves. Context sensitivity will be used to avoid interrupting the user when he or she is preoccupied. This should make the tool less intrusive and more useful for the user.

VI. Conclusions

The eDiary will be implemented in a component-based fashion. Each core functionality represented by the buttons on the main screen will be one component. Each component will have a well-defined interface, and will be able to work independently from the others. This will make it easy to configure the eDiary for each user's specific needs. For instance, the blood glucose component can be removed for users who do not measure their blood glucose as part of their disease management.

The current design of the eDiary requires few actions from the user. Nevertheless, the most frequent general comment on the prototype was that it should be even easier to use. This indicates that realistic use of such a tool in the near future will probably not be daily, but in periods, which was also indicated by some of the informants. One of the main findings by Sorvari et al. [11], namely that people will not be willing to put an effort into creating meaningful information themselves "unless they get some valuable benefits as a reward", is a very relevant finding for this kind of design. We have proposed including a dictionary, daily tips, help function, sensor history, nutrition recording, but probably this may not be enough. Context sensitivity and tailoring both need further attention in such tools.

A study by Wolf et al. [12] showed that moderate-cost dietitian-led lifestyle case management may improve diverse health indicators among obese patients with Type 2 diabetes. Thus, if tools like eDiary motivate the user to introduce lifestyle changes, it may have a positive effect on this user group's health, and thus on the worldwide increase in chronic diseases.

Acknowledgment

We want to thank our colleague Geir Østengen for putting so much effort into helping with preparing and assisting in the user meetings. Thanks also to Dag Svanæs for very good advice in the organization and use of methods during the user meetings. We are also deeply grateful to the users for their committed participation.

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