Flowie: A Persuasive Virtual Coach to Motivate Elderly Individuals to Walk

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Abstract—**The use of context-aware technology in the home enables new ways to stimulate elderly in increasing their exercise levels, and consequently prevent age-related health issues amongst an increasing elderly population. This paper describes the design of a persuasive virtual coach that encourages seniors to walk more. In order to incorporate the user values and needs in the design concept, a user panel of elderly people was actively involved in the design process. A range of persuasive principles and interaction metaphors were evaluated with the user panel, resulting in a design concept that was approved and appreciated by the user panel. The design concept combines a pedometer with wireless connectivity with a touch-screen photo frame. As a first step towards a longer evaluation, an experimental prototype was tested in the field with two participants for 11 days each. Whereas the participants of the exploratory intervention did appreciate the virtual coach and they did feel more motivated to exercise, the quantitative figures did not yet show an increase in physical activity in time; a possible explanation could be the limited activity-sensing capabilities of the prototype in combination with the changing weather conditions in the course of the user study. Furthermore, the participants would like to see a system with a better awareness of the context of use, such that the system can better select the right timing for motivational cues. These findings will be used to improve the design concept and perform a longitudinal user study in the field.**

Persuasive technology; context-awareness; physical activity; behavior modification; preventive healthcare; healthy lifestyles; elderly.

I. INTRODUCTION

One of the main consequences of the progressive aging of our society is the rise of expensive age-related disabilities and diseases [1]. Over the last decades experts have drawn an extensive list of benefits that healthy exercise can bring to the physical and psychological function of older individuals [2]. Despite of this, in Europe only 20 % of persons aged 65 and older engage in strenuous physical activity, whereas 45 % engage in moderate activity [3]. Similar percentages apply to the US, where barely 25 % of older adults are sufficiently active to benefit from physical activity [4]. For both the economy and public health, it is necessary to activate the elderly segment of the population.

An accessible way of physical exercise for elderly people is walking. Walking adheres to the three basic training needs of older individuals: endurance, strength, and flexibility. For this reason, walking has been prescribed as a health exercise by physicians from health centers many times [5].

The use of context-aware technology enables new ways to encourage healthy walking among the elderly. Using context-aware technology, actual activity patterns can be monitored, elderly people can be made aware of their activity patterns, and a system can pro-actively promote exercise. Advancements in the design of pedometers, which now often have on-board memory and wireless connectivity, have made it possible to monitor walking patterns in a non-obtrusive way [6].

The research area that covers the use of technology to persuade people in changing their behavior has been labeled *persuasive technology* by Fogg [7]. Fogg makes a distinction between intrinsic and extrinsic strategies that can be used to persuade people into a behavior change. *Individual motivation* is based on triggering the intrinsic drive of the individual, e.g., by setting goals, creating awareness, or by conditioning through positive reinforcement. Extrinsic strategies build on social psychology; other people can be the source of motivation, e.g., through competition, cooperation or comparison.

Apart from intrinsic and extrinsic persuasion strategies, Fogg identifies four strategies that can be used to increase the persuasive power of persuasive systems. First, a persuasive system can best be bundled with an application that has value to the user; *value integration* increases the likelihood of adoption. Second, interactive experiences that are easy to access and *convenient* have greater opportunity to persuade. Third, *simplicity* of tasks and technology increases the chances of success. Fourth, in order to achieve the optimal result, a system should trigger the user when the user is most open to persuasion. This capability to select the opportune moments, *kairos*, could be linked to contextual information such as physical location, living routines, tasks or emotions.

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Persuasive technology has been applied in many application domains, including education, Internet commerce, and entertainment. For example, Nawyn, Intille, and Larson showed how a persuasive remote control could lead to reduced TV watching levels by steering the user towards more dynamic activities [8]. In the health domain, there are several examples of how persuasive technology can be used to encourage healthy behavior. For example, *Chick Clique* [9] and *Fish'n'steps* [10] use pedometer-driven interventions to encourage respectively teenage girls and adults to walk within a cooperative framework. Likewise, the *UbiFit Garden* [11] monitors and stimulates physical activities other than walking. Accelerometers and other on-body sensors are used to detect activities; their target user group is young adults from 25 to 35 years old. In terms of persuasion, UbiFit Garden is limited to monitoring of activities and progress in time. These studies do suggest that persuasive technology can be effectively used to motivate young and adult individuals, but so far the user studies have been limited in duration.

II. DESIGN CHALLENGES

Few studies have yet been conducted in which persuasive technology has been applied specifically at the elderly user group. Virtual agents have been used to promote walking for older patients at health care centers with promising results [12], but there are no known studies targeted at elderly users in the home environment. This paper presents a design case, in which the design of a persuasive virtual coach for elderly users is described. The design challenges are to motivate elderly people to exercise more, and to apply persuasive technology in a way that fits the target user group.

The target user group was limited to elderly who do walk regularly, but who do need to be motivated in order to maintain healthy walking levels.

The user-centered design process, which started with idea generation, and which includes two design iterations, is described in Section III. Section IV describes the field study, in which the prototype was tested with two participants for 11 days each. Section V presents the results and discussion. The conclusions and future work are described in Section VI.

III. DESIGN STEPS

Figure 1 visualizes the design steps that were taken when designing the exercise coach. The design process is iterative, with a user panel involved at several stages. The process concludes with a final prototype, and recommendations for improving the design towards a final system.

The user panel, which was to be consulted in several occasions throughout the design process, consisted of six volunteers aged 62-73 who were recruited from a "neighbor group" of Dutch pensioners.

A. Explorative Phase

Towards finding the optimal persuasive mechanisms for stimulating elderly users to exercise more, the principles as described in the introduction were assessed in relation to the target user group and the application.

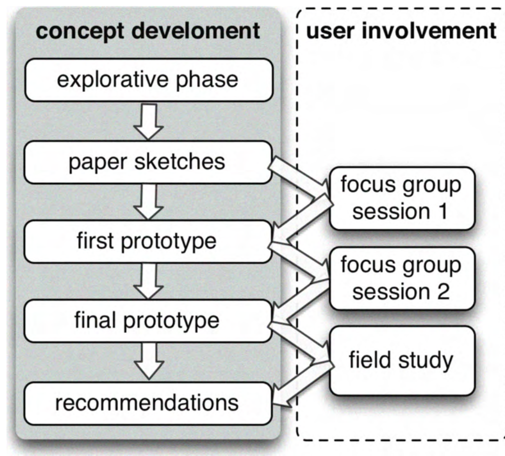

Figure 1. Process diagram depicting the design steps. Users were involved in the design process at several stages, as depicted on the right.

The effectiveness of the use of pedometers to increase physical activity has been assessed by Bravata et al. [6]. They found that pedometer use alone, without goal setting or counseling, results in an increase of physical activity by about 1 mile of walking per day. Users of pedometers, who were given a step goal, significantly increased their physical activity over baseline. Apparently, the use of intrinsic motivation does contribute to motivation. Surprisingly, they did not find that physical activity counseling increased steps walked per day.

In our exploration, we did at first consider extrinsic motivation to be a suitable way to stimulate elderly. A persuasive system could be linked to a social network, and the social network could be leveraged for motivating the elderly user. Nevertheless, there were two arguments against the use of social cues: (1) in the focus group session, participants expressed concerns regarding the sharing personal information with others and (2) the deployment of a social networked-system would be more complex since the system would need to contact external actors in order to activate a persuasive action. Because the effectiveness of intrinsic motivation in the area of stimulating physical exercise had already been shown in related work, and intrinsic motivation would lead to a more elegant system design, it was decided to focus on intrinsic motivation only.

The designer found five strategies for individual motivation suitable for a virtual coach for elderly. *Goal setting* (1) and *self-monitoring* (2) have been used for stimulating physical exercise before, and did lead to significant results for a non-elderly population. *Conditioning* (3), by means of positive or negative reinforcement, might be a suitable mechanism, but no studies are available reporting on the effect of this mechanism in relation to physical activity. *Consistency* (4) refers to the intrinsic desire to do what we promise to do. *Intrinsic motivation* (5) is based on classic learning theory; by finding elements of challenge, curiosity and control, one can increase the attention and engagement levels. It was decided to evaluate these strategies with the user panel before a selection would be made.

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B. Paper Sketches

In a focus group session, we wanted to find out how the persuasive principles were perceived by target users. Figure 2 shows the three paper sketches that were used to facilitate the discussion with the user panel. Each poster depicted different combinations of persuasive principles; the posters were used to explore the design space together with the user panel.

Figure 2. Paper sketches were used early in the design process to assess persuasive principles together with the end user panel.

At an early stage in the design process, it was decided to use a touch-screen photo frame as the interaction device. This type of user interface has been used before in products targeted at elderly users [e.g., 13]. The photo frame generally scores high on accessibility and learnability, which are key factors to overcome common limitations -physical and cognitive- of older adults [14]. By selecting the photo frame early in the design process, we could focus on screen interaction and its persuasive principles.

The first poster, entitled "Exercise Monitor", showed a basic system that displays the activity levels that are measured in relation to goals. The poster covers the goals *goal setting* (1) and *self-monitoring* (2). By linking goal setting and self-monitoring, the concept also covers *consistency* (4). The information is displayed both graphically and numerically. The poster was also used to explain how the system could collect the data from the pedometer automatically.

The second poster, entitled "My Photo Album", showed a system that entails *conditioning* (3). Using this poster, we wanted to find out how elderly people consider the use of rewards as an incentive for adopting the desired behavior. The system would reward good behavior by showing new pictures on the screen, for example, a picture of grandchildren.

The third display, entitled "The Health Garden", showed a flower as a metaphor to create awareness of activity levels. Rather than showing the detailed figures, the flower showed only abstract feedback. The flower relates to *self-monitoring* (2) and *intrinsic motivation* (5); the flower supposedly triggers curiosity and a social bond with the system. Three considerations have led to selection of the flower. First, the flower communicates at an abstract level, and thereby simplifies the interaction. Second, the flower does not evoke false expectations, as a realistic avatar resembling for example a medical doctor-avatar probably would. Third, it is expected that people easily empathize with the flower, thereby creating intrinsic motivation.

The posters were presented to the six participants of the user panel during a first focus group session, and the design concepts were discussed in depth with the panel. The focus group session was located in a social meeting place outside the university, and took about 75 minutes.

The main findings of the panel discussion were:

- All participants appreciated the touch-screen interface.
- Some participants were surprised by the technical possibilities, e.g., the automatic connection between the pedometer and the system.
- The participants would like to see their progress in time and in relation to goals, as shown in the first sketch.
- The participants were skeptical regarding the use of rewards. The photos were considered to be childish. They indicated that the benefits in terms of improved health is rewarding in itself.
- The participants questioned the goal setting. They would prefer the goals to be set by a professional, rather than by the system itself.
- The participants did like the flower metaphor. Regarding the states of the flower, they suggested not to use a dead flower, since this would be perceived as a negative trigger.

When asked to describe their preferred interface, the participants agreed to combine the exercise monitor with the health garden. They would like to combine the detailed information regarding progress in relation to goals from the exercise monitor with the pleasurable presentation of the information through the flower metaphor.

C. First Prototype

Based on the feedback from the focus group session, it was decided to combine the flower metaphor with the exercise monitor. In terms of persuasive principles, the system would then cover g*oal setting* (1), *self-monitoring* (2), *consistency* (4) and *intrinsic motivation* (5). Based on these design choices, a first prototype was developed, entitled *Flowie*.

1) General Setup

Figure 3 shows the hardware components used in the first prototype. The ActiPED® pedometer was selected for measuring the activity levels; the device registers the ambulation levels up to 21 days, and automatically transmits the data to a server when the user walks within the vicinity of a USB antenna. A series of software components running on the computer retrieve, process, and compare the real-time data incoming from the pedometer with a set of pre-established goals. A small touch screen displays the performance levels while it allows the user to request more detailed information.

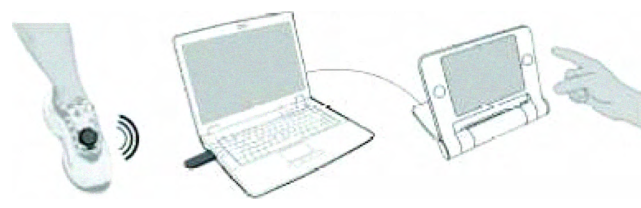

Figure 3. The first prototype consists of three hardware components: a wireless pedometer, a laptop, and a touch-screen.

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2) Graphical Interface Design

A Flash application was created for the information display and user-system interaction via the touch-screen. Figure 4 shows the three views on the information. The flower image shown in the *general overview* gives high-level feedback on the activity level in relation to the goals. Flowie remains in the periphery of the user as much as possible; users can see their progress in relation to the goal at a glance. Since the user panel preferred to see concrete figures in combination with the flower, it was decided to add a step counter at the bottom right; the step counter shows the number of steps and the day-goal. By clicking on the step counter, the user could go to the day overview. The calendar icon in the top right gives access to the week overview.

The *day overview* (Fig. 4, middle) provides the detailed figures for the day. It presents the figures for the number of steps, the distance and the time, as measured by the pedometer (in blue) and the targets of the day (in red).

The *week overview* (Fig. 4, right) presents the progress of the user in time. A graph in combination with a table present the targets and the actual scores for each day of the past week.

The main objective of the flower is to provide immediate feedback of the performance level at every moment. Early in the morning, the flower will be positive even when the performance figures are low. At the end of the day, however, the flower expects the user to be close to the target of the day. The flower uses a progressive target that starts with zero in the morning, and ends with the day target at the end of the day. The progress of the user in relation to the progressive goals is also displayed as a percentage in the bottom left of the general overview, and as a gauge on the left of the day overview.

3) Goal-setting

A practical challenge that was encountered in the design process was related to goal setting. The setting of goals requires professional experience. In the design concept of the virtual coach, we therefore envisioned a professional-in-the-loop. The professional could then for example use a website to monitor the status of a group of users, and set the goals using the website. At this stage of the design, however, we decided to focus on the client-side of the system. In the prototype, goals had to be set manually by the designer.

4) Evaluation

The first prototype was evaluated by the user panel in the second focus group session. The group session was aimed at detecting usability issues and design flaws, which might affect the later evaluation in the field. The participants were enthusiastic about the design concept. They appreciated the simplicity of the interaction and the way in which Flowie would give them insight in their activity behavior. They described the prototype as easy-to-use, clear and appealing.

The user panel identified several minor usability problems related to the size and layout of some visual components. Furthermore, they had some problems understanding the feedback of the flower.

D. *Final Prototype*

Based on the user feedback, minor changes were made to the prototype. After these changes were implemented, the prototype was ready to be tested in the field. Figure 5 shows the final prototype that was used in the field tests.

Figure 5. The final prototype was packaged in a wooden frame.

IV. Evaluation

To find out how the prototype was experienced in a realistic setting with real users, a small-scale preliminary field-study was conducted with two participants. The evaluation aimed to find out if Flowie was capable of motivating elderly to exercise more (design challenge 1), and if the design concept and the motivational mechanisms used were appreciated by the end-users (design challenge 2). Measuring the efficacy of Flowie

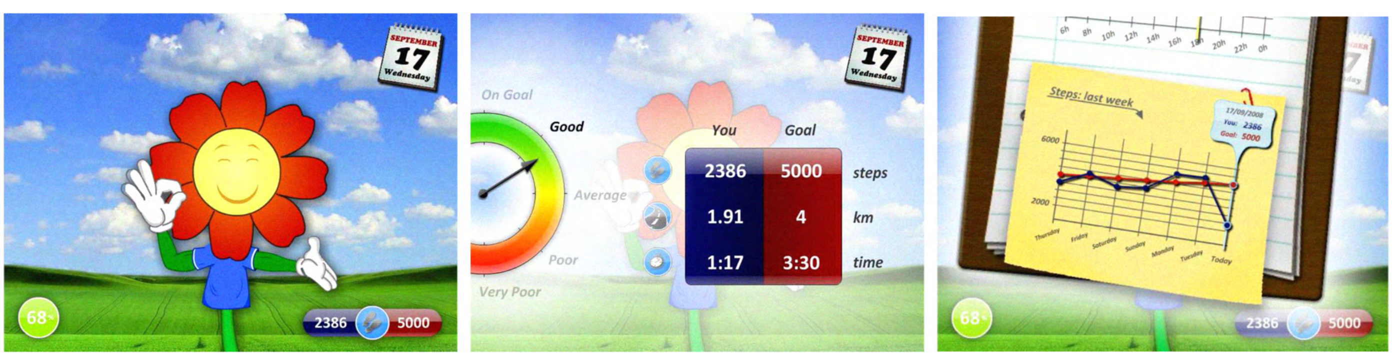

Figure 4. The user interface consists of three views: the *general overview* (left), the *day overview* (middle), and the *week overview (right)*.

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towards provoking a change in the users' behavior is beyond the scope of this case study. A future user study is foreseen in which a larger number of participants will use Flowie for a longer period of time; in this future study, a physiotherapist will be in the loop to monitor the progress of the participants, and to set the exercise goals.

A. *Participants*

Two participants were recruited for the evaluation phase. Both participants were members of the user panel; it was decided that in this explorative evaluation phase, the members of the user panel could give more detailed feedback on the motivational mechanisms used, since they knew better the design alternatives. In the future study assessing the effectiveness of the user interface, all users should be new to the concept, in order to avoid bias.

The participants were a 65-year old woman (participant 1) and a 73-year old male (participant 2). Both participants were retired, living independent of home care and socially and physically active. Since both participants would need to keep up their physical activity levels to stay healthy, they were potential future users of the Flowie system.

B. *Method*

An 11-day evaluation plan was defined which consisted of three phases:

Pre-Intervention (days 1-3): For three consecutive days, baseline activity levels were collected using the ActiPED® wireless pedometer. The baseline activity levels were used to set the walking goals for the intervention phase.

Intervention (days 6-10): After a two-day break, the touch screen with the Flowie user interface was installed in the living room of the participants, at a location visible when walking into and out of the room. The participants did receive a short explanation of the user interface, and were told that the test was aimed to evaluate the system rather than the activity levels of the participants. For five consecutive days, the participants could monitor their activity levels using the interface. During the intervention phase, both the walking levels and the statistics regarding the use of the user interface were logged for later analysis.

Post-Intervention (day 11): The day after the intervention, the participants were interviewed regarding their motivation to exercise, the usability of the system and the motivational mechanisms used in the prototype. To better assess the acceptability of Flowie, the *persuasive technology acceptance model* (PTAM) questionnaire was used to measure the acceptance using five constructs: usefulness, ease-of-use, social influence, trustworthiness and integration [15].

V. Results and Discussion

The exploratory field study resulted in an extensive amount of quantitative data regarding the walking levels, and provided a better understanding of the subjective experiences of the participants.

A. *Walking levels*

Figure 6 shows the actual number of steps for each of the participants during the pre-intervention and the intervention phase. The red line shows the goals that were set by the supervisor. These goals started with the average number of steps from the baseline measurements, and increased by 500 in the course of the intervention.

Surprisingly, the number of steps for participant 1 is higher in the pre-intervention phase compared to the intervention phase. A possible explanation for this deviation could be the weather conditions; during the intervention, it was raining a lot, which might have resulted in lower walking levels.

The graphs in figure 6 also show a high variation in walking levels between days. The variation could be attributed to the high impact of a single activity on the walking levels; for example, participant 2 did play tennis on the final day of the intervention, resulting in a very high number of steps. On the other hand, an extensive bicycling exercise, which could not be detected by the pedometer, would result in a low number of steps, whereas the actual physical activity would be high.

B. *Self-awareness and Motivation levels*

Both participants agreed that both Flowie and the numerical information were the most motivating elements in the system. Although both users appreciated the numerical information that could be accessed through the interface, they valued the stimulus of the flower to keep up motivation levels.

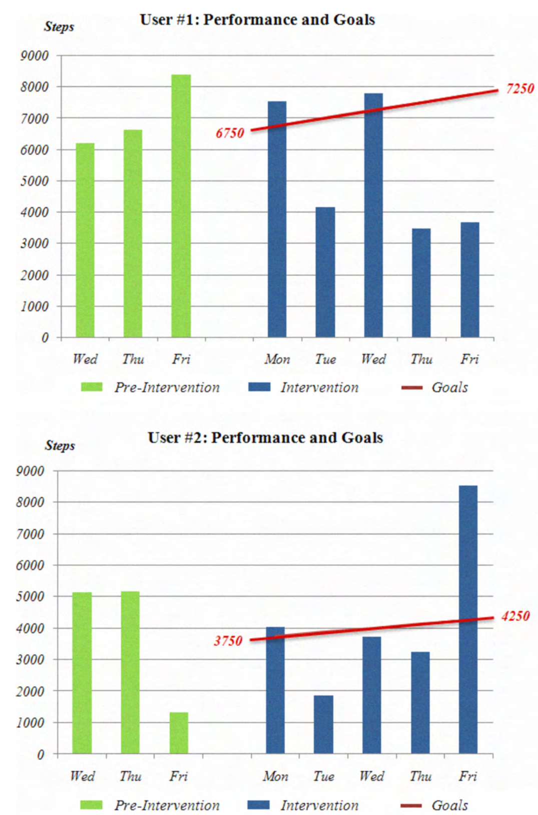

Figure 6. Amount of steps measured on participant 1 (top) and participant 2 (bottom), along with the goals for the 5-day intervention phase.

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Both participants indicated that they found the system very engaging. The female participant identified the numerical data as the element of the system that motivated her the most, whereas the male favored the animated flower. Both participants explicitly mentioned the displayed number of steps as a motivational cue, for example "*it definitely stimulated me to walk. (...) for instance, at 9 o'clock in the morning I saw the [amount of] steps, and I felt that I had to take more.*"

Regarding the flower metaphor, both participants responded very positively. They both found Flowie very encouraging and stimulating. In their perception, the flower was happy most of the times. Sometimes, however, Flowie was unhappy, even though the actual physical activity levels were high. This was caused by the limited sensing capabilities of the pedometer, which could only measure steps. The participants did experience frustration when Flowie pushed them to keep walking after they had already exercised in different ways (e.g. bicycling, swimming, etc.).

C. *Acceptability and Usability*

The results of the PTAM questionnaire indicate a positive attitude towards the adoption of the system. The perceived usefulness was rated on average +1.0 on a scale from -2 (strongly disagree) to +2 (strongly agree). The participants did consider the system to improve their quality of life, and to support critical aspects of their life. The system scored well on ease of use (+1.17) and trustworthiness (+1.08). The scores on social influence were rather neutral (+0.5), which might be caused by a misunderstanding of the questions. For example, the question "people who are important to me use the system" was considered to be not applicable by the participants. In terms of integration, i.e., the ability of the system to unobtrusively incorporate the user's life, the system scored well (+0.92). The participants explicitly valued the convenience to use the system, and the fact that using the system did not take too much time.

When asked if they would use the system in future, participant 2 stated "*of course I would use it, especially if I was recommended to do it by my physician.*" Participant 1, who did not consider herself to be part of the target group, also mentioned the physician as the person who should encourage elderly to start using the system.

VI. Conclusions & Future Work

This paper presented a case study of design a persuasive system targeted at elderly users. A virtual coach was developed which motivated elderly to exercise more. The two participants involved in the field study appreciated the system. They indicated that they were motivated to exercise more by the system. Even though a larger-scale user study is needed in order to collect significant results, these preliminary findings do suggest that the approach taken in terms of applying persuasive technology to the elderly target group is promising.

End user involvement was found to be crucial towards developing an easy-to-use prototype that could be embedded in the existing living routines of the elderly target group. Rather than using incentives, which were considered to be childish and not necessary by the user panel, the final prototype now uses a combination of numerical information and a virtual coach that triggers the end users. Furthermore, the user panel explicitly indicated that they wanted the system to show their progress in time. This suggestion, and many others, was collected during the early stages of the design process and implemented in the final prototype. The iterative design process with user involvement was therefore found to valuable towards designing an acceptable and motivating system.

A virtual coach, as for example the animated flower in our prototype, is not critical for motivating people to exercise more. The use of a pedometer and an information display alone can suffice [6]. Our explorative study did however show that elderly people appreciated the flower as a coach. Participants indicated that they enjoyed interacting with Flowie, and they would like to use the virtual coach for a longer period of time. The case study suggests that use of a virtual coach can add to acceptability of a persuasive system, and eventually people are expected to be more motivated to change their activity patterns. New studies are however needed to support these claims.

The user study did show some limitations of the current system. The limited sensing capabilities of the pedometer made it impossible to monitor activities other than walking. Consequently, the system would push the users to exercise more, even though they had already exercised a lot. Moreover, the system was unaware of contextual factors that did affect the walking levels. For example, the system did not know the weather conditions, and would stimulate people to walk even when it was raining. Next to that, the system was unaware of the actual conditions of the user, and would consequently also stimulate the user to walk in case of for example an illness.

These limitations result in suggestions for future work. First, the system awareness of physical activity should be improved, so that the system could also monitor activities other than walking. Second, the system should be made aware of contextual factors that affect the walking levels, such as the weather conditions. Third, the system needs to be tested with a larger user group, in order to be able to assess the acceptability and adoptability of the system. And fourth, the system needs to be tested for a longer period of time in order to be able to assess the efficacy of the system to provoke a change of in the user's behavior.

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