You and me, how (in)active are we?
the potential of sharing physical activity information to increase motivation

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You and me, how (in)active are we?

The potential of sharing physical activity information to increase motivation

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Contents

Preface

This document describes the project that was conducted at Philips Research as part of my master's degree in Human-Technology Interaction. During a period of seven months, I had the opportunity to be the "director" of my own project, having the freedom to choose the direction and the type of approach that I thought was most suitable. I experienced this freedom as a great privilege and want to thank my company supervisor Aart van Halteren, to give me this freedom, while staying involved and providing guidance at the right time.

During this project I had the opportunity to go through a full design cycle. Starting with an extensive literature research, continuing with several user-centered design methods, and finishing off with a proper four-week field study in a real-world environment. All this could not have been done alone; I received lots of assistance during all parts of this project. I want to thank Shalu and Joost Houtsman for giving feedback from their perspective at the beginning of the project. Their feedback helped to get a better grasp on the context of the study and to make choices regarding the direction to aim for. Also, the university supervisors have been supportive in this respect. Giving me positive feedback regarding the chosen direction and providing me with points for attention.

During the design process I received support from Philips Research employees and students. Without them it would have been impossible to have effective brainstorm sessions and feedback meetings. Also, lunchtime would have been a lot less fun without the company of all the students.

Special thanks go to several people whom supported me with implementing the final application. Jose Liso, Roald Dijkstra and Peggy Nachtigall have been invaluable and very patient in programming the front-end. Without them it would have been impossible to have a fully functional prototype within the posed time limit. Also, Aart's expertise in this was invaluable, his work on the back-end of the system and on the front-end as well, made the success of this project possible.

I want to thank the university supervisors for sharing their expertise in the final phases of the project. With their help it was possible to submit this work to the Intelligent User Interface (IUI) 2010 conference.

And finally, I want to thank my girlfriend, parents and brother for their support and understanding during my graduation process.

Jonathan van Wijngaarden

Abstract

This report describes the theoretical background and development of an application to share physical activity information, as well as the results of a four-week field study in which people shared physical activity information as measured by the Philips Activity Monitor. The existing web-service DirectLife was enhanced with an interface that visualizes similarities activity levels and patterns between users. The application, developed by deploying user-centered design methods, displays several attributes of physical activity. During the field study two groups of seven participants carried the activity monitor and shared activity information; either visualized on a publicly shared or private display. Visualizing similarities in physical activity is expected to increase interpersonal awareness, communication and perceived closeness. From the perspective of self-determination theory (SDT), this should increase the fulfillment of the need to belong. Such a fulfillment is expected to increase intrinsic motivation for physical activity and engagement in using the activity monitor. The results show the promise of using similarity and enhancing connectedness for technology-based persuasion. In addition, several recommendations are made for future efforts aimed at increasing motivation for physical activity.

1. Introduction

The World Health Organization [1] recommends that people have at least 30 minutes of moderate intense activity per day to stay healthy and to protect oneself against several diseases and malfunctions (e.g. diabetes, heart failure and injuries). Although people may be aware of the fact that they should be physically active, many people have difficulty to maintain such an active lifestyle. Common barriers to physical activity adherence are a lack of time and motivation, busy work requirements [13] and a non-supportive environment [21]. Such obstacles on the route to an active lifestyle make it difficult for people to achieve their goals.

This research aims to contribute to the knowledge of motivating people for physical activity by taking the perspective of Self-Determination Theory [9]. SDT helps us to understand that an important aspect of a person's persistence in keeping an active lifestyle is related to the type of motivation a person has with respect to this behavior. Intrinsic motivation is one type of motivation out of a continuum of motivation types [8]. It is an important determinant of persistent, continuous behavior and has been linked to the fulfillment of basic human needs. One of these is the need for relatedness, which refers to people's desire to have enough and satisfying relationships with others [8]. The need for relatedness overlaps with the need to belong. The need to belong, in turn, is described by Baumeister and Leary [4] as a fundamental human "need to form and maintain strong, stable interpersonal relationships". Van Bel, Smolders, IJsselsteijn and De Kort [24] describe how a minimum number of contacts and a certain level of intimacy in these contacts contributes to a sense of interpersonal connectedness and satisfaction of the need to belong. In short, Van Bel et al. [24] describe how social connectedness, constituting several dimensions such as shared understandings, relationship salience and satisfaction with contact quantity, is a measure of the fulfillment of the need to belong.

Given the importance of both physical and mental well-being for personal health, and the difficulty people have to maintain such a healthy lifestyle, the current research aims to support these two aspects of health with a theory-based application. The aim is to develop and test an application that motivates people to be physically active by utilizing the concepts of interpersonal connectedness and theory of intrinsic motivation. In other words, this research explores how we can introduce social dynamics into a technology-driven service or application to help people maintain a healthy lifestyle by improving both physical and mental well-being.

2. Theoretical background

In the context of increasing physical activity and motivating people to be physically active there has been research into several aspects that can increase active behavior [6, 7, 11, 16, 22]. However, theories on intrinsic motivation [8, 9, 20] exemplify the importance of self-determined behavior, and the roles that basic human needs play herein when it comes to persistent behavior. Applying the perspective of self-determination theory provides us with the opportunity to see the potential of intrinsically motivating people to become physically active through the concept of social connectedness. This research attempts to validate this approach by the development and evaluation of an intelligent user interface, while at the same time bringing the approach under broader attention for further research.

2.1. Intrinsic motivation

As mentioned before, an important aspect of a person's persistence in keeping an active lifestyle is related to motivation. Motivation types can range from non self-determined motivation (external motivation and amotivation) that typically result in behavior that does not initiate from the self, but is instead triggered by external factors and influences, to self-determined types of motivation (identified motivation and intrinsic motivation) resulting in behavior initiated by internal, self-determined reasons and personal need-fulfillment. Intrinsic motivation refers to performing an activity because of the pleasure and satisfaction it provides in itself. Therefore, this type of motivation is an important determinant of persistent, continuous behavior.

According to Self-Determination Theory [8], there are three basic human needs that should all three be satisfied to increase intrinsically motivated behavior: the need for competence, autonomy and relatedness. In short, the need for competence refers to the desire to be effective and to be able to do what one wants to achieve. The need for autonomy is related to freedom and the possibility to act in accordance with what one wants to do. The need for relatedness refers to people's desire to have enough and satisfying relationships with others. Relatedness, therefore, is tightly coupled with the previously mentioned need to belong. In fact, the need for relatedness and the need to belong are, in this research, regarded as needs referring to the same pervasive desire to have enough and satisfying contacts with others.

From SDT [9] it can be learned that social contexts and situations that support satisfaction of these basic needs facilitate intrinsically motivated behavior. In the context of the current research this could mean that promoting basic needs in the context of physical activity could have a positive influence on the motivation for physically active behavior. SDT prescribes that it is not only important that the goals people pursue have outcomes resulting in the fulfillment of these basic needs, the process leading to that goal can have important consequences for motivation as well. Therefore, providing a context that supports the fulfillment of basic needs could positively influence the motivation for the end goal in that context, e.g. being physically active.

When behavior helps to satisfy the basic needs of competence, autonomy and relatedness, the motivation for performing that behavior will be of intrinsic, self-determined nature.

2.2. Focus on similarities

The need for relatedness can be satisfied by having pleasant social interactions with others [4]. Such social interactions can be mediated, for example, by having something to talk about and by having a positive attitude towards the other. In addition, for people to have positive social interactions, it is important that people *like* each other to some extent. Liking, in turn, has been shown by past and recent research to be mediated, amongst other factors, by physical proximity ([18] referring to Festinger, Schachter, & Back, 1950), interpersonal contact and communication [5] and similarity [18]. It has been shown that people tend to like other people who are similar in opinions and attitude. Also having a similar lifestyle, clothing and behavior seem important predictors of liking. Therefore, it is expected that visualizing similarities in physical activity amongst peers will increase interpersonal awareness, social interaction and perceived closeness (Figure 1). Such an increase in awareness, interaction and closeness, in turn, is expected to facilitate the fulfillment of the need to belong. As a result, fulfillment of the need to belong can increase intrinsic motivation and engagement in physical activity.

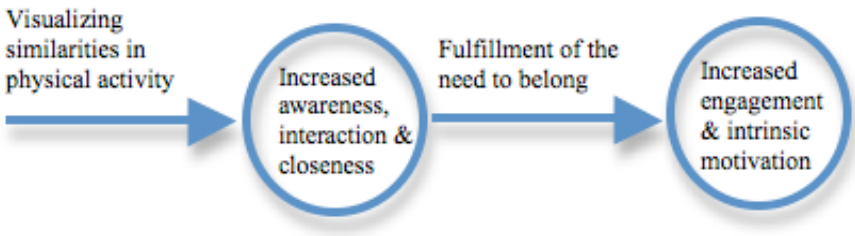


Figure 1: Overview of expected relationships between concepts

The purpose of this research is to increase our understanding of how interpersonal connectedness can be induced by a service or application, with the goal to increase intrinsic motivation for physical activity. Therefore, the focus of this research is the development and evaluation of a theory-based application that visualizes similarities in physical activity, with the aim to increase social interaction, interpersonal connectedness and intrinsic motivation.

3. Related design work

Several design projects describe attempts to increase physical activity using measuring devices (pedometers, accelerometers) in combination with devices such as mobile phones and shared monitors [2, 6, 7, 10, 11, 15-17, 22]. Many of these projects report to successfully engage people in physical activity and thereby contribute to our understanding of physical activity intervention programs. Below, four relevant past projects are described that have contributed to our understanding of the topic of promoting physical activity: UbiFit Garden [7], Neat-o-Games [11], Houston[6], Fish'n'Steps [16]. These projects have inspired the development of the current application and the direction of the current research. The mentioned projects range in focus from motivating an individual to motivating a group of people by deploying social dynamics. Because of this range in focus, each project contributes to our understanding of designing systems to promote physical activity.

A project focused on motivating a single person is described by the work of Consolvo, Predrag, McDonald, Avrahami, Froehlich, LeGrand, Libby, Mosher and Landay [7]. Consolvo et al have done considerable research in the area of encouraging physical activity [6, 7]. In their most recent research [7] an application was developed that provides its users with progress feedback regarding their physical activity and goal attainment. During a three-months field study, participants were provided with a pedometer connected to a mobile phone displaying a garden as background picture. In this garden visualization, different flower types represented different types of physical activity and the presence of butterflies represented weekly goal attainment. This research shows that having an always-on, peripherally available (i.e. glanceable) display available at any time of the day helps to increase awareness of physical activity during the week. Further, it exemplifies the importance of the application supporting a wide range of activities, allowing people to label what type of activity they have done. Having a glanceable display helped participants to maintain their activity level during a holiday period, including Christmas, New Years Eve and Thanksgiving, in which activity levels normally drop.

Fujiki, Kazakos, Puri, Buddharaju, Pavlidis and Levine [11] report results of a three-week field study of their application named Neat-o-Games, which is a race game for two users. The application, which receives input from an accelerometer, aims to encourage physical activity by providing a race game with competitive elements on a mobile phone. The researchers report that the application helped to improve people's engagement in physical activity, increase activity levels and that healthy competition was experienced as fun and enjoyable.

Both research by Toscos, Faber, Connelly and Upoma [22] and by Consolvo, Everitt, Smith and Landay [6] describe applications targeting small groups. Friends are given the opportunity to share step counts on their mobile phones with the aim to leverage social support for physical activity and to increase physical activity levels by competi-

tion between users. Consolvo et al. [6] summarize the results of their 'Houston' application by proposing four key requirements for technologies that encourage physical activity. First, they explain how the measuring device should provide proper credit for the activities of the user. In other words, the device should measure as accurately as possible the efforts of the user, otherwise the user will get demotivated to engage in activities which are not registered properly by the device. Second, people value to have insight in their personal activity level, not only in their current activity level, but also in their activity history and in their progress towards goal achievement. Third, technologies that are meant to engage people in physical activity should support some form of "social influence". And fourth, the practical constraints of users should be kept in mind (which means, for example, that the measuring device should be of a size and form that is suitable to wear without discomfort).

An application aimed to encourage a larger group of people to stay physically active is described by Lin, Mamykina, Lindtner, Delajoux and Strub [16]. Their application received input from a pedometer and mapped step-counts to the growth and emotional state of a virtual pet; a fish in a tank. In their study, one group of people had access to a visualization of their own virtual pet and another group of people had access to a shared display where the fish tanks of other groups were shown as well. Competition was promoted by showing to other groups whose fish tank is most "healthy". Results from their study showed the importance of providing only positive reinforcement and setting realistic, achievable goals.

4. The current research

With this article we extend this line of research by focusing on the importance of social contexts in motivating physical activity. We developed and evaluated an application to share physical activity information with the goal to increase interpersonal awareness, communication and perceived closeness. In this process, several user-centered design methods were used. Keeping the users central in the design process is expected to allow the development of an interesting and engaging application. A field study is deployed to evaluate the application's effectiveness in increasing social interaction, intrinsic motivation and engagement in using the measuring device as well as to test if a *shared* display is more effective in reaching this target compared to a *private* display. Using a shared, public display is expected to better facilitate social interaction, therefore having a larger effect on the fulfillment of the need to belong and intrinsic motivation.

There are two central hypotheses involved in this research:

Hypothesis 1: Visualizing similarities in physical activity will increase interpersonal awareness, communication and perceived closeness. This facilitates the fulfillment of the need to belong and thereby increases intrinsic motivation for physical activity and engagement in using the measuring device.

Hypothesis 2: Visualizing similarities in physical activity on a *shared* display will have a larger effect on intrinsic motivation and engagement than visualizing the same information on a *private* display.

4.1. The existing web-service

The developed application extends the existing web-service *DirectLife*. The device used is the Philips Activity Monitor, which is based on the Tracmor accelerometer [19, 25]. The activity monitor has dimensions of 32x32x12 mm and is small and light enough to be worn in a jeans pocket without discomfort. The device can be connected to a PC through a USB adaptor to get access to the web-service, giving people detailed data regarding physical activity levels, showing graphs that represent burned calories during the past hour, day, week, month or year. It also provides users with feedback on their progress towards a personal calorie target. Calories are calculated by using a person's age, gender, height and weight in combination with the activity count measured by the device.

The current project aims to extend this existing web-service by allowing people to share activity information with others. It puts forward and aims to validate the concept of visualizing similarities in physical activity, targeting intrinsic motivation through satisfying the basic human need to belong. As mentioned earlier, previous literature shows quite some research in the area of encouraging people to keep an active lifestyle. The current research is novel in that it does not investigate the role of progress feedback, setting goals, or providing competitive elements to motivate

people, but it focuses on visualizing similarities in physical activity, targeting intrinsic motivation through satisfying the basic human need to belong.

4.2. User-centered design methods

Several user-centered design methods were deployed to allow the development of an interesting and engaging application to share activity information. The methods used are: contextual (orientating) interviews, sketches, brainstorm sessions, story-boards, focus groups and low fidelity software prototyping.

4.2.1. Orientating interviews

Interviews were conducted with six current users of the activity monitor, using the existing web-service. Questions were asked to get a feeling for the context from the user's perspective and to get an initial grasp on what people liked and disliked about it. Some of the questions asked were: "What do you enjoy about using the activity monitor?", "Are there any aspects missing when using the device?" and "Would you be interested in seeing activity information from others?". These initial interviews gave a range of interesting feedback, which is briefly summarized here:

Sharing information:

- Getting comments from colleagues about physical activity levels and goal attainment is fun (e.g. while meeting informally in the corridor or elevator).
- If sharing information would be possible, this should be objective and with people that have roughly the same calorie target.
- It would be nice to be able to choose the people with whom you share activity information.

Positive remarks related to using the activity monitor:

- Seeing detailed information in the form of progress feedback and activity history is valued.
- The activity monitor works well to start conversations at parties (by showing the device).

Possible improvements:

- The type of activity should be recognized, not only calories.
- Not all activities are captured equally well by the device.

These interviews gave a good starting point for the project. The feedback indicated that users liked the activity monitor and could imagine that sharing activity information could be fun and engaging. Apart from the tangible information that was gathered, the interviews contributed to a better understanding of the context and the current status of using the activity monitor and accompanying web-service.

4.2.2. Sketches

Throughout the project, starting in an early phase, sketches were used to communicate initial ideas and possible directions for developing the application. These drawings greatly improved the efficiency of communicating and enabled others to provide feedback at different stages in the project.

4.2.3. Brainstorm sessions

Two brainstorm sessions of 1,5-2 hours were conducted. The first brainstorm session had the goal to come up with ideas about *what* information to visualize in the context of sharing activity information. The second brainstorm session had the goal to come up with concrete ideas on *how* to visualize this sort of information.

Brainstorm session 1 – What information to visualize

The first brainstorm session was conducted with six experts in the domain, all affiliated with the research topic and familiar with the activity monitor. This brainstorm session was organized to generate ideas regarding what attributes of activity information could be shared with others to indicate similarity. Five rounds were used to generate as many ideas as possible, starting with a round of writing down initial ideas, the second round was meant to broaden the scope by thinking in what respect twins can be similar in doing sports. The third round included a random word game of which the generated words were used to come up with more ideas about information to visualize. The last two rounds were used to select the favorite ideas and cluster ideas on a matrix of feasibility and effectiveness. The output of this brainstorm session contained twelve useful attributes that could be used as input for the second brainstorm session. Listed here are possible attributes of activity information to indicate similarity.

Information could indicate that people have the same:

- Active days
- Lazy days
- Calorie target
- Average activity level
- Days on which the activity monitor is forgotten
- Number of uploads (i.e. connecting the device to a PC)
- Time of the day to upload
- Time of the day to perform activities / being active
- Starting / ending time for wearing the activity monitor
- Activity level for x minutes
- Activity duration
- Number of peak activity moments

Brainstorm session 2 – How to visualize activity attributes

The second brainstorm session was conducted with six students with either an industrial design or interaction design background. The attributes of the first brainstorm session were used as input for this session, which had a more visual focus. Since participants of this brainstorm session were less affiliated with the monitoring device and the background of the study, more care was given to inform them about the scope and aim of the session. The problem description that guided this session was: “How to visualize activity monitor data so that people can easily see which of their colleagues or friends have similar activity patterns?”. Also, the technological requirements were outlined: the existing activity monitor had to be used in combination with a display and PC (decisions made in earlier steps).

Four rounds then followed, three of them having a different focus and the fourth containing an assignment to combine the results of the first three rounds in one detailed concept. The first round focused on “how to visualize physical activity information”, the second round on “how to visualize time” and the third round on “how to visualize people”. And, as mentioned, in the fourth round people were asked to form couples and to pick their favorite ideas of each round to work out a detailed concept that could indicate similarity in physical activity between two or more people.

This session created a richness of sketches as output which are summarized here as concepts that can be used to visualize similarity in physical activity:

- Closeness / proximity
- Connecting lines

Having the same:
- Location / position
- Movement / vibration
- Color
- Form
- Size
- Mood (smiley face, sad face, etc)

In short, the output of these two sessions gave an enormous amount of usable ideas; both attributes and concepts to visualize similarities in physical activity. These ideas were used as building blocks to create three different design concepts.

4.2.4.Storyboards and focus groups

The three detailed design concepts were used to show how an application could visualize activity information of a group of people. These designs were each molded into a storyboard resulting in three cartoonish sketches explaining how the application could be used in a specific scenario (Appendix 1).

Three focus group sessions of 1.5 hours each were conducted with a mixed audience (5 to 6 people, plus one moderator) from different backgrounds and with different professions. During these sessions the storyboards were used as a means to communicate the conceptual ideas and to receive feedback on the strength and weaknesses of each design.

The outcome of these focus groups is briefly summarized as follows:

- Visualizing individuals close together is expected to communicate similarity most strongly.
- The visualization should contain movement. This is expected to attract attention and to be interesting to look at.
- There should be a balance between the amount of information displayed and having something left to talk about.
- Keeping the visualization abstract is good; “less is more” applies in this case.

- Information should not be too detailed for privacy purposes.

The feedback gathered during these sessions was used to start the development of a lo-fi software-based prototype.

4.2.5. Low-fidelity software prototyping

After gathering all the information from the previous steps, a design was made for the final concept and a prototype was developed using Adobe flash. This allowed gathering feedback on the level of understandability of the displayed information and usability issues related to interactive elements.

Interface and interaction improvements were made iteratively based on feedback during sessions with several people, either users of the activity monitor or people unfamiliar with the device and its background. Adjustments made ranged from color and look and feel changes, to adding labels and conveying more detailed mouse-over information. This software based prototype allowed to quickly make adjustments and improvements while already generating graphics and a structure for the final application.

4.3. The final application

This section describes the application in terms of the information it displays, the interaction it allows for users and its underlying system architecture. The final application shows several attributes of physical activity information from a group of users (Figure 2). Each user is represented by a circle with his or her name on it, and activity information is conveyed abstractly without providing detailed information such as burned calories and exact calorie targets. Using a stylized, abstract visualization instead of detailed information is expected to prevent privacy issues while still being informative and fun.

4.3.1. Displayed information – position of the circles

The attributes of physical activity that are visualized are each person's most active or least active day – a person's circle is positioned on one day and depending on the selected view this day corresponds with either that person's most active or least active day compared to the last seven days. Further, the distance of a person's circle from the center gives an indication of how active or inactive that day was compared to the person's own average activity level over the other days. More precisely, in the 'most active day'-view the day with a person's highest physical activity level (PAL) is used and the ratio of that day's activity level to the person's average activity level is calculated. This ratio determines the radius of each person's circle from the centre of the screen. A ratio of 1 corresponds with a position just outside the center of the screen labeled with 'personal average', and a ratio of 3 or higher corresponds to a position at the outside periphery of the screen. In the 'most lazy day'-view the same calculation is made to determine the ratio between the least active day and the average activity level. Thus, depending on the view selected, being far away from the center of the screen means that this day was either very

active (most active day view) or very inactive (most lazy day view). In both views being far away from the center indicates that a person's activity level on that day was 'far away' from his or hers average. Further, from the position of the circle it can be determined what a user's most (or least) active moment on the day was. If this was at noon, the person's circle is positioned in the middle of the day, if this was late in the evening, the position of the circle is towards the edge of the day, close to the next day.

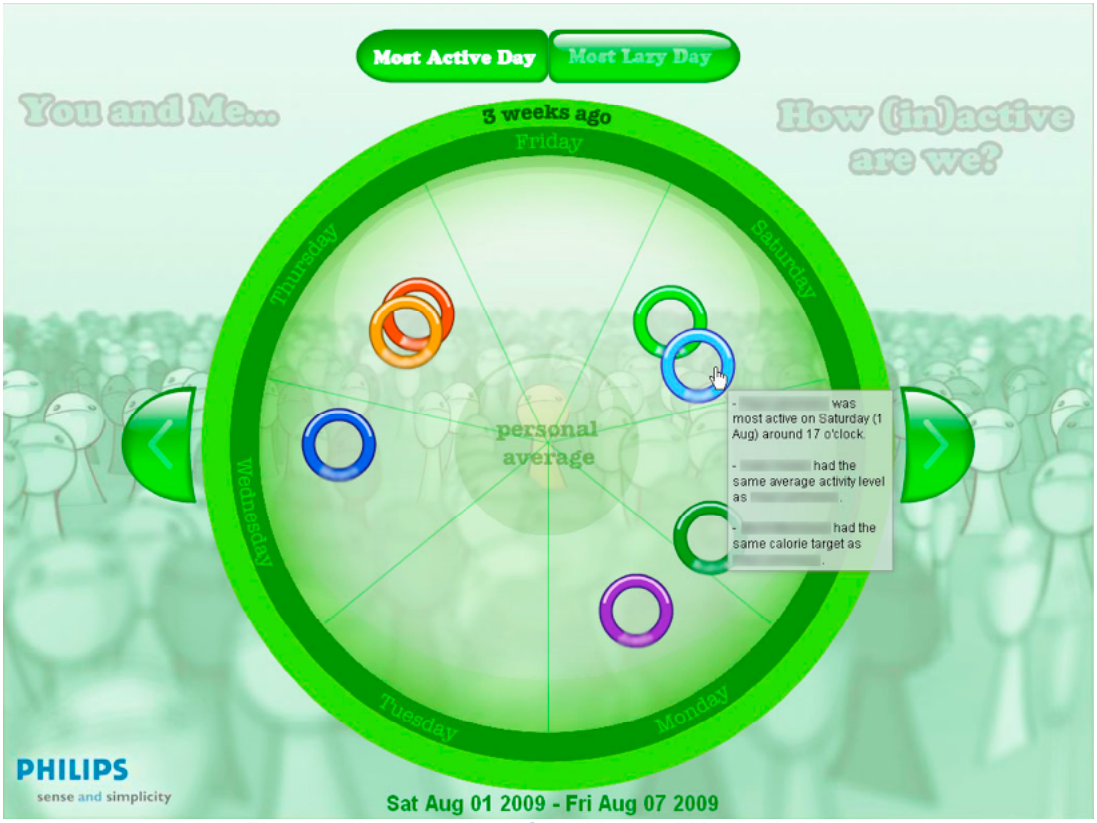


Figure 2: A screenshot of the *You and Me* application

4.3.2. Displayed information – mouse-over information

Hovering over a person's circle conveys information about that person's active or inactive hour of the day and shows if peers have had the same average activity level or the same weekly calorie target.

4.3.3. User interaction

There are four buttons in the interface; two buttons at the top are used to switch between two views, either the 'most active day' view or the 'most lazy day' view. Depending on the view selected, people's circles are positioned to represent either their most active or least active day. On the left and right side of the screen are two arrowed buttons. By clicking these buttons, users can navigate seven days backward or forward in time.

4.3.4.System architecture

Users connect their activity monitor to their PC through a USB adaptor. After connecting the device, a browser window opens and automatically navigates the user to the current web-service. During the field study, a modified version of the client software was used to redirect the uploaded data and to display the developed application instead of the current web-service. To achieve this, data was sent first to a custom database and subsequently forwarded to the original database belonging to the web-service. In this way data could be collected without affecting usage of the existing web-service (Figure 3).

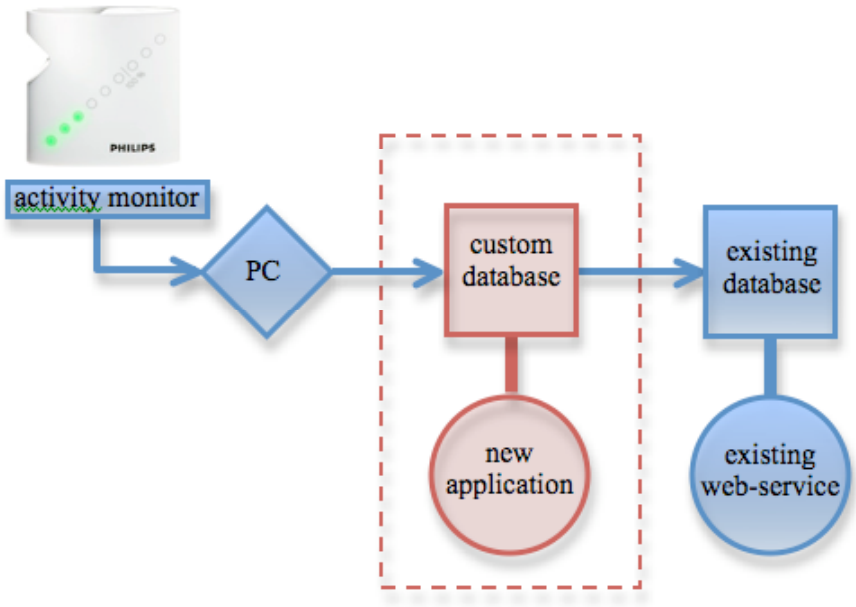


Figure 3: High-level overview of system architecture

5. Field study

To test the hypothesis regarding an application's ability to increase interpersonal awareness, communication and perceived closeness with the goal to increase engagement and intrinsic motivation for physical activity (first hypothesis), a quasi-experimental field study was set up.

In addition, the study was aimed at providing insights into the differences of providing such an application on either a private or a shared display (second hypothesis). The expectation is that showing the application on a shared display will facilitate interaction more, thereby having a larger effect on engagement and intrinsic motivation.

During a four-week quasi-experimental field study participants had access to the application for two weeks. One week before using the application was used as a pre-measure interval and one week after using the application was used as a post-measure interval, resulting in a total time of four weeks.

5.1. Experimental conditions

The field study contained two conditions, with seven participants in each condition. In one group participants were all working on the same floor and received access to the application in the form of a *shared* display in the coffee corner on their corridor (Figure 4). The other condition contained a group of participants that were all working in the same building as the first group, but were instead spread out over different floors.

Figure 4: Left: The application in use in the *private display* condition. Right: A setup illustrating use of the application in the *publicly shared* condition.

This group received *web-access* to the application, allowing participants in this group to use the application on their own office-PC (hence, this is called the *private* display group). For this group, the application showed up after connecting the activity monitor to the PC through a USB adaptor. Note that people were not encouraged to wear the device more often or connect it more often to the PC as they would normally do.

5.2. Participants

Participants in this study were employees working in the same building as the researchers, on the High-Tech Campus in Eindhoven, The Netherlands. It is important to note, however, that although the participants in the field study were working in the same building as the authors, participants were in no way affiliated with them or with the research project. The recruited participants were all (except for one) existing users of the activity monitor and web-service, and had been wearing the device for several weeks or several months. One user received the activity monitor one week prior to the start of the field study, for the purpose of joining in the study with her colleagues, and because of difficulties in finding participants. Since most participants were already users of the activity monitor a novelty effect for using the device is minimal, which has been reported in previous studies to be an important confounding effect [6]. Of course, there is also a novelty effect for the application under study, which should be kept in mind while interpreting the results.

Informed consent was received from all participants regarding the collection of activity data and to inform participants about their freedom to end their participation at any time without consequences.

5.2.1. Existing group dynamics

Existing group dynamics and relationship closeness prior to the field study should not be neglected. From previous research [6], and from the orienting interviews at the start of this project, it can be learned that sharing activity information would be most interesting if done within an existing group of friends or if users can select their own peers with whom information is shared. Although it was attempted to let participants choose their group members, several constraints let the researchers to eventually pick participants mostly based on availability and physical location and less on existing relationships with others. More specifically, participants in the *private* display condition were selected on availability and with the additional requirement that the participant knew all the other group members at least *by name*. In contrast, selection of participants in the *public* display condition was done by availability as well, and with the additional requirement that group members were working on the *same floor*. For this group it was *assumed* that participants would at least know each other to some extent as the result of working on the same floor. But it was not checked if participants in this shared display group knew each other by name prior to the field study.

5.3. Data gathering

During the field study the following quantitative and qualitative data was collected a) self-report responses to a questionnaire b) logs of the activity monitors and c) in depth interviews regarding the experience of using the application.

5.3.1. Quantitative data – compiled questionnaire

To gain insight in changes in motivation and social dynamics within the groups a number of instruments were used to capture these changes during the field study. A compiled questionnaire composed of five existing measurement instruments was given to participants at the beginning and end of the field study. The pre-measure before using the application was used to determine levels of interpersonal closeness, social connectedness and motivational aspects prior to using the application. After two weeks of using the application a post-measure questionnaire was sent to the participants to determine if using the application changed any of the measured factors.

The measurement instruments included in this questionnaire were: the Competitiveness Index [14], the Social Support for Physical Activity scale [23], the Inclusion of Other in the Self scale [3], the Social Connectedness Questionnaire [24] and the Situational Motivation scale [12].

The Competitiveness Index (CI) is a personality instrument consisting of 20 true-false items concerning competition preference in everyday contexts. The original CI has high internal consistency (alpha = .90), indicating that the items measure what they are expected to measure [14]. People high in competition preference might be less tempted by the application in the current research since engaging people through competition is not the main goal of the application. On the contrary, this application is meant to minimize the experience of competition in order to emphasize other aspects of physical activity, namely what you have in common with others in terms of several physical activity attributes.

In the Social Support for Physical Activity scale 12 statements are listed describing things that people might do or say to support someone who is trying to be physically active [23]. It would be interesting to see an increase in social support for physical activity as a result of using the application. This could help to understand if people using the application encouraged each other to be physically more active and how this support changed over time. If people received more support, this could explain a possible increase in physical activity or in motivation for physical activity.

The Inclusion of Other in the Self (IOS) scale has been applied to a variety of interpersonal relationships in different contexts [3]. It has typically been used to assess closeness in romantic relationships. The IOS scale is a 1-item measure and for the current research it is adjusted to refer to the self (“Me”) and to the group of people with whom the application is being used (“Group”). This scale will help to understand if people’s perception of closeness with the group in general has changed over time. Seeing an increase in perceived closeness will be interesting since this could be a result of using the application and having the opportunity to communicate with others. As explained earlier, an increase in social interaction and perceived closeness, in turn, could contribute positively to the fulfillment of the need to belong. Such a fulfillment, in turn, could lead to increased engagement and intrinsic motivation for physical activity.

The Social Connectedness Questionnaire [24] is a measure of connectedness, and measures the fulfillment of “the need to belong”. It has been adapted to the current research by selecting 27 relevant items. Answers are rated on a 7-point scale. Finding an increase in feelings of connectedness as a result of using the application would be an interesting finding, since this would indicate an increase in the fulfillment of the need to belong, which can contribute to an increase in intrinsic motivation.

The 16 items from the Situational Motivation scale contain questions to measure the type of motivation people experience: intrinsic motivation, identified motivation, external motivation or amotivation. The questions have been framed to reflect both motivation regarding physical activity as well as motivation regarding use of the activity monitor, adding up to a total of 32 items. For both types of behavior it is desirable that people are intrinsically motivated to engage in it.

5.3.2. Qualitative data – interviews

Interviews with participants at the end of the field study were conducted to gather rich, qualitative data about participants’ experiences during the field study. Inteviews were semi-structured, containing questions such as:

- Can you tell something about your experience while using the application during the past two weeks?
- Did you talk with colleagues about the application, or as a result of using the application?

These interviews will contribute to a deeper understanding and help to better interpret the collected quantitative data.

6. Results

This section describes the results from the field study. It shows how effective the developed application was in increasing engagement and intrinsic motivation and to what extent the fulfillment of the need to belong was facilitated. Further, results show the type of communication between group members and how perceived closeness changed over time. In addition, the results outline differences found between the two conditions: one group having access to a *shared* display and one group having access to a *private* display. Results are obtained from data logged from the activity monitors, answers to the questionnaire and feedback from interviews.

6.1. Method of analysis

Data obtained through questionnaires and data logs was analyzed quantitatively using a statistical software package (SPSS). Where variable distributions showed no significant deviation from a normal distribution, the reported significance levels are the result of t-tests (either for independent variables or paired variables) and ANOVAs. Equivalent non-parametric tests have been used in cases where significant deviations from normality were reported (Mann-Whitney test as equivalent for the independent samples t-test, Wilcoxon Signed Ranks test as equivalent for the paired t-test and Kruskal-Wallis and Friedman tests as alternatives for the ANOVA). Qualitative data was examined with a view to explain quantitative results and for identifying patterns of behavior of participants.

6.2. Engagement in using the activity monitor

Figure 5 shows usage statistics from the activity monitors. The graph illustrates that participants from the shared display group connected their devices more often during the period of the field study compared to the private display group. More specifically, the number of uploads (connecting the activity monitor to the USB adaptor to upload the data) increased significantly for the shared display group in the first week ($p = .004$, Table 1). And during this week the number of uploads was significantly higher for the shared display group compared to the private display group ($p = .039$, Table 2).

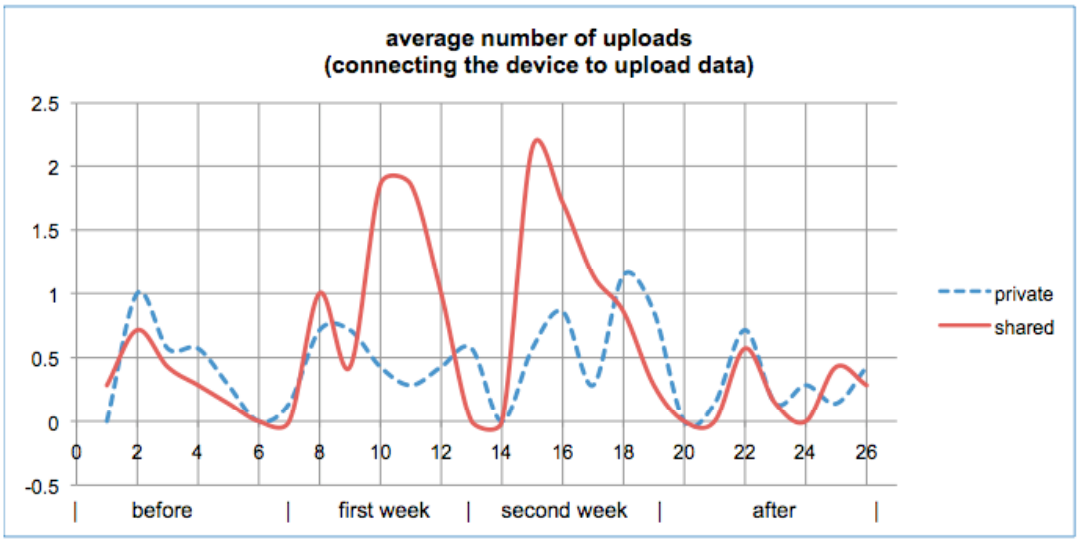


Figure 5: Average number of uploads during the field study[1]

	before – week 1 (sign. level)	week 1 – week 2 (sign. level)	week 2 – after (sign. level)
Private display	.499	.418	.009*
Shared display	.004*	.701	.000*

Table 1: Within group significance levels of the average number of uploads over the period of the field study

	Before (mean)	First week (mean)	Second week (mean)	After (mean)	Sign. level (within groups)
Private display	.40	.48	.62	.24	.040*
Shared display	.31	.95	.95	.19	.000*
Sign. level (between groups)	.220	.039*	.309	.768	

Table 2: Average number of uploads per day during the field study (connecting the activity monitor to upload data)

Further examination of the logged data shows that on average participants from the private display group carried their activity monitors with them longer during the day compared to the shared display group. This number of 'wearing hours' is significantly higher for the private display group compared to the shared display group except during the first week of using the application, where the number of wearing hours is not significantly different between the groups (Table 3).

[1] Uploads from the same user within a time-interval of ten minutes were counted as one upload; users sometimes reconnected their devices to double check if their upload was successful.

	Before	First week	Second week	After	Sign. level (within groups)
Private display	11.0	11.6	11.0	11.0	.753
Shared display	9.0	10.7	7.7	8.1	.125
Sign. level (between groups)	.014*	.928	.049*	.01*	

Table 3: Average wearing hours of the activity monitor during the field study

Some participants expressed their increased engagement in using the device during the period of the field study. During the interviews a participant from the private display group mentioned[2]:

> *"I noticed also, that I uhm.., normally I always carry that thing in my pocket, but I know that when you are cycling than it doesn't work so well, not very so while I was joining in this I put it in my sock again while cycling, so it was something like, well now I better be sure that it works well."*

6.3. Intrinsic motivation

Next, we look at how motivational aspects changed over time. Answers to items directed at motivation in the questionnaire provide some insight in this. Results of the Situational Motivation scale show a small increase in intrinsic motivation for using the activity monitor for the shared display group and a slight decrease for the private display group (Figure 6), although these changes were not significant above a 90% confidence level (Table 4).

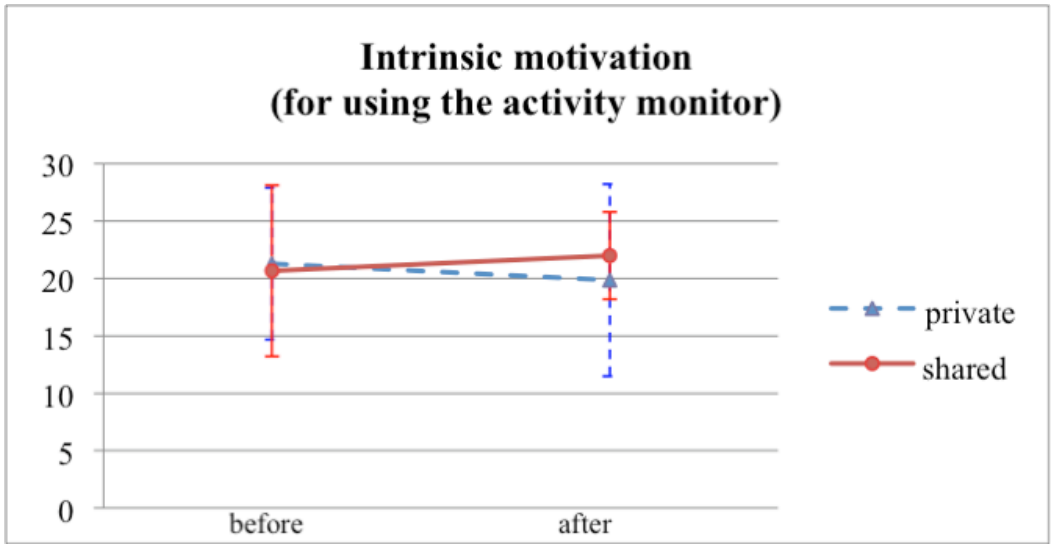


Figure 6: Before and after measure of intrinsic motivation (for using the activity monitor)

[2] All quotes have been translated from Dutch. This was done carefully and as accurately as possible to maintain the original meaning.

	Before	After	Sign. level (within groups)
Private display	21.29	19.86	.118
Shared display	20.67	22.00	.102
Sign. level (between groups)	.898	.274	

Table 4: Before and after mean scores of intrinsic motivation for using the activity monitor (factor of the Situational Motivation scale - SIMS)

For motivation items directed at physical activity similar results were obtained (Figure 7); intrinsic motivation for physical activity increased slightly, but not significantly for the shared display group, and remained unchanged for the private display group (Table 5).

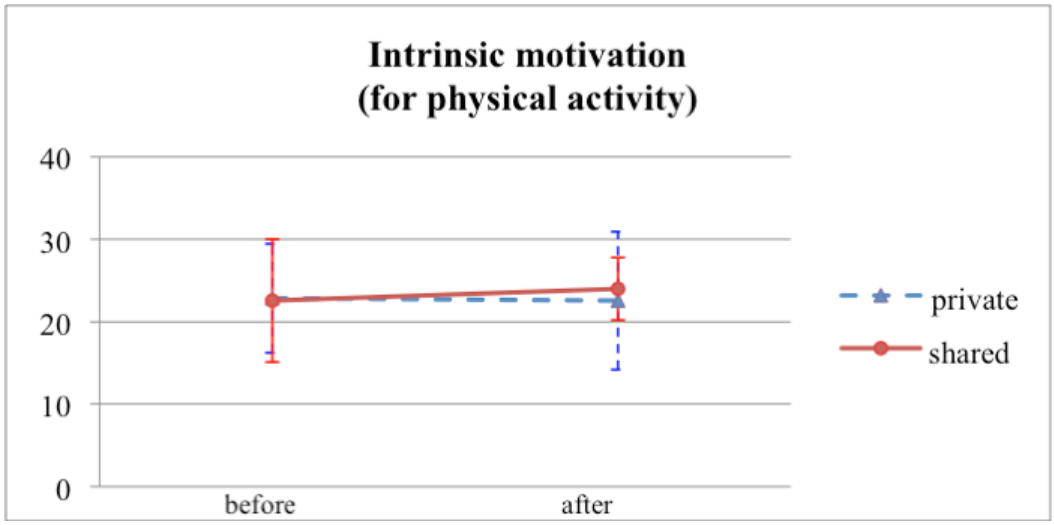


Figure 7: Before and after measure of intrinsic motivation for physical activity (factor of SIMS)

	Before	After	Sign. level (within groups)
Private display	22.86	22.57	.703
Shared display	22.57	24.00	.223
Sign. level (between groups)	.899	.467	

Table 5: Before and after mean scores of intrinsic motivation for physical activity

A general statement about motivation was made by a user from the private display group. He explained how it would be more motivating for him to receive comments from a group member instead of looking only at data from a screen:

> *"For me it would be much more motivating if I received a message from a colleague, or an unfamiliar person in the group… receive a message like hey, or ask hey what did you do to get so many points?"*

6.4. Interpersonal awareness, communication and perceived closeness

Feedback from the interviews shows what type of interactions the application elicited between group members. Several participants mentioned how they had conversations with group members as a result of the application. Some conversations were related to physical activity and others were about how the application's intention was not entirely clear. One participant from the private display group explained how a conversation went:

> *"..somebody asked me when were you most active last week and then I asked and what about you.. what did you do, what did I do and what was I planning to do later that day. And then he said oh that is going to count extra for you. Yes that is the sort of discussion we had."*

In the shared display group similar comments were made. Interestingly, one participant from the shared display group mentioned how she had mostly spoken with people not belonging to her group, but with people that were present around the display while she was connecting her activity monitor to upload data:

> *"… people that didn't participate with the test made comments like 'Ooh M. I see you have been most active on Sunday!'. (..) These were people printing over there, or looking at the screen."*

And another participant from the same group explained:

> *"…in the beginning we were standing there with some people for a while to have a look and shouting like uhm, 'hey I see that you are also in it!' More like that."*

Some people from the private display group expressed how they missed some kind of communication functionality in the application. One user from the private display group explained how he expected to be able to leave messages for peers and how he got disappointed because he didn't find such functionality:

> *"...the interface invited to do more, (..) to.. uhm, to move the circles, or to click on it, or, or, maybe even send a message through the circles. (..) Some sort of message which you can then leave in the interface of the other person.., (..) that you can say hey what did you do to get so many points on a Sunday afternoon or something like that."*

Apart from feedback referring to the type of conversations or about missing functionality, several participants mentioned how the application had *not* made them feel closer to their group members:

> *"It's not that I felt closer in contact with others due to the application or by doing activities together with colleagues or that... nobody took the initiative, neither me nor the others."*

Looking at the self-report measures of perceived closeness in the questionnaire, both closeness measured by the Inclusion of Other in the Self (IOS) scale, as well as the closeness factor in the Social Connectedness Questionnaire show a *decrease* of perceived closeness over the period of the field study for both groups. Figure 8 shows the before and after measure of the IOS scale, showing a marginally significant decrease in perceived closeness for the private display group (p = .083, Table 6).

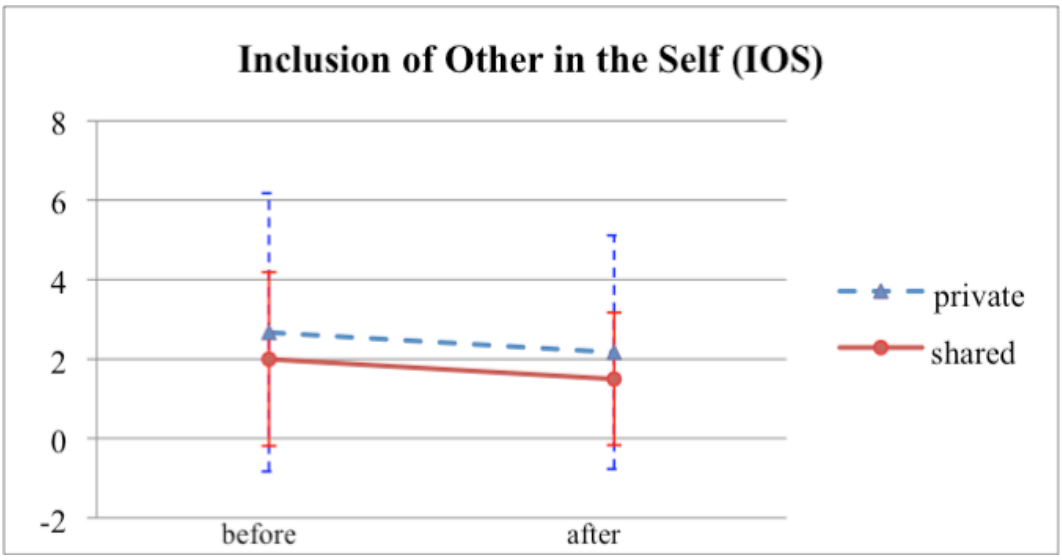


Figure 8: Before and after measure of perceived closeness measured by the IOS scale

	Before (mean)	**After (mean)**	Sign. level (within groups)
Private display	2.67	2.17	.083
Shared display	2.00	1.50	.408
Sign. level (between groups)	.258	.278	

Table 6: Before and after means as measured by the Inclusion of Other in the Self (IOS) scale

Figure 9 illustrates how the closeness factor of the social connectedness questionnaire shows the same decreasing trend. This factor (consisting of four items) shows a significant decrease for the *shared* display group, above a 95% confidence level (p = .033, Table 7).

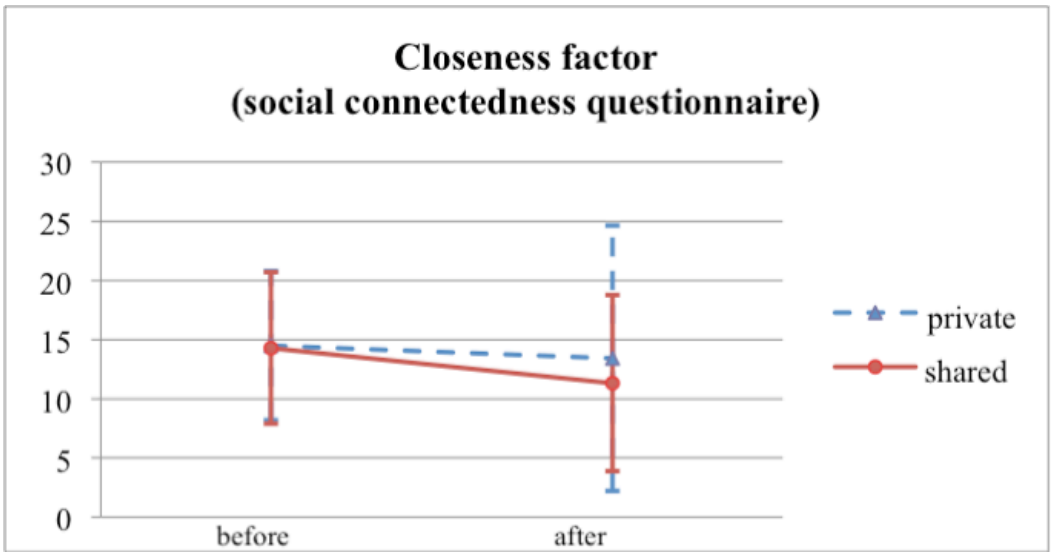


Figure 9: Before and after measure of the closeness factor from the social connectedness questionnaire

	Before (mean)	**After (mean)**	Sign. level (within groups)
Private display	14.50	13.43	.584
Shared display	14.29	11.33	.033*
Sign. level (between groups)	.922	.472	

Table 7: Before and after means as measured by the closeness factor from the social connectedness questionnaire

6.5. The need to belong and social connectedness

Results from the social connectedness questionnaire indicate how all factors (relationship salience, shared understandings, low contact quality, knowing each others experiences, satisfaction with contact quantity) do not reveal any significant differences between conditions, or before and after the intervention. Figure 10 illustrates this as the overall social connectedness scores for both conditions, where all factors of this measure have been added together, summing up to a total 'social connectedness score' (keeping in mind reverse-scored items).

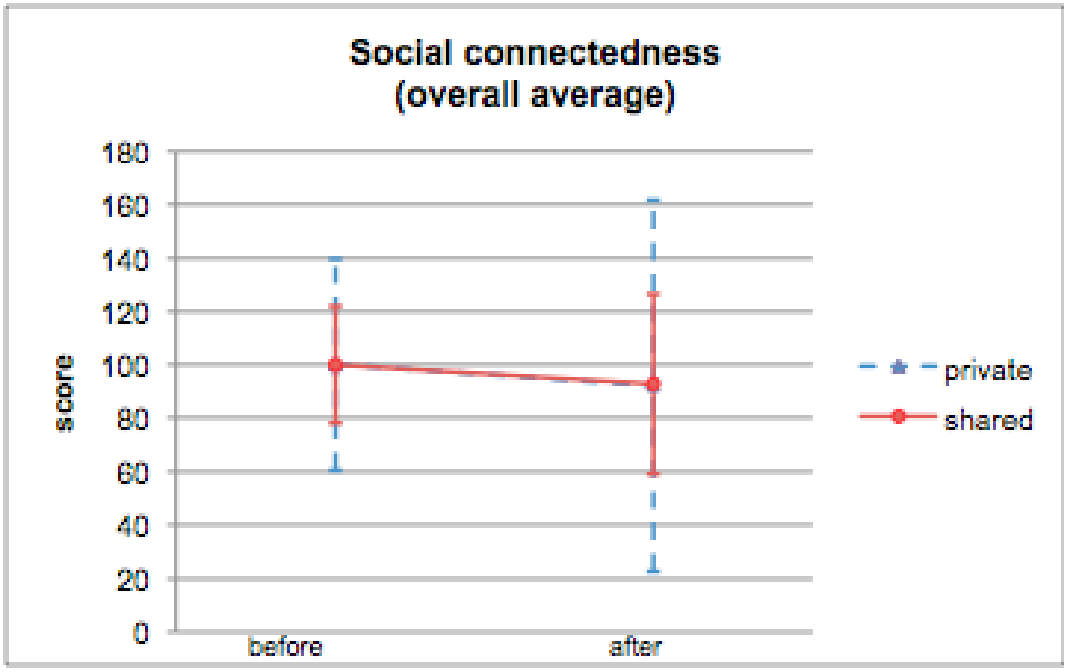


Figure 10: Before and after measure of the closeness factor from the social connectedness questionnaire

	Before (mean)	**After (mean)**	Sign. level (within groups)
Private display	100.17	92.14	.397
Shared display	100.00	92.83	.131
Sign. level (between groups)	.987	.963	

Table 8: Before and after means as measured by the social connectedness questionnaire

7. Discussion

We now look at how effective the developed application was in increasing interpersonal awareness, communication and perceived closeness between group members. And to what extent the results show how the fulfillment of the need to belong was facilitated and if changes in engagement and intrinsic motivation were brought about (first hypothesis). In addition, we outline differences found between the two conditions: one group having access to a *shared* display and one group having access to a *private* display (second hypothesis).

7.1. Supported communication

Based on feedback from participants we learnt that the application triggered conversations, sometimes directed at technicalities of the interface, but more interestingly others directed at calories burnt or activity levels or in other ways related to physical activity. Further, a participant in the shared display group mentioned how people who were not part of the field study made comments while she was uploading data on site. This indicates how the application provoked short exchanges between colleagues on the same floor. In addition, comments from participants in the private display group showed us how the application invited more interaction, and how users expected communication functionality by leaving messages.

7.2. Increased engagement

The logged data shows that users from the shared display group started connecting their activity monitors significantly more during the first week of the field study compared to the week before using the application and compared to users from the private display group. Although this could be the result of having a novel application, it also indicates that there was an increase in engagement for the shared display group. Feedback during the interviews supports the finding of increased engagement in using the activity monitor. In addition, the number of wearing hours was significantly higher for users of the private display group during most of the field study, but with exception of the first week of using the application. This further suggests that interest and engagement increased for participants from the shared display group as a result of having access to the application.

7.3. Intrinsic motivation

In line with the expectations, intrinsic motivation showed a change in the expected direction. For the shared display group intrinsic motivation for using the device and for physical activity increased slightly over the period of the field study. Nevertheless, these changes were not statistically significant so interpretation should be done with care.

7.4. Perceived closeness and fulfillment of the need to belong

Several results showed trends that were contrary to our expectations. First of all, measures of perceived closeness showed a strong, significant decreasing trend, and comments from participants confirmed this result. Second, the same decreasing trend was found for the social connectedness measure, indicating that the application did not fully support the fulfillment of the need to belong.

Feedback from participants helps us to get a better understanding of why conversations did not occur often and how this could be better facilitated. Suggestions range from functionality to support communication, to changes that can be made to the context in which the application is used and with whom it is used. These results, supported by quotes from participants, are described as design recommendations in the next section.

8. Design recommendations

This section describes recommendations for designing a service or application that aims to increase motivation for physical activity. Based on the results and on feedback from participants we formulate design recommendations for systems in which users can share physical activity information with peers. These recommendations are structured according to the categories: supporting communication, carefully consider group composition and provide a supportive social context.

8.1. Supporting communication

Participants from the private display group made several comments that explained how they expected more functionality in terms of communication. One participant described how he expected to be able to leave a message for another user by clicking a peer's circle. Another participant explained how he could see a Twitter or Facebook-like functionality to show to others what one has achieved:

> *".. I was thinking more about, something similar to Twitter, and things like Facebook, where you can also, well, where you can publish things, as a sort of 'show off', saying hey, this was my most active day and that you can say what exactly you've done, I ran the marathon, I am training for the marathon of Eindhoven..."*

Similar comments were made about functionality that allows you to 'tag' what sort of activity you have been doing during your active moment(s). Several users explained how this could be interesting information for others to get ideas for activities:

> *"You would like to tag well in this hour I just walked for 20 minutes, and during that hour for half an hour or these 10 minutes I have been really busy working in the garden and then you can really see the difference in activity and others can read and say well what similar things could I do in my daily routine."*

And from another participant:

> *"If you know what a person did, then that could give more an idea like hey I could try that, or well it's nice that you do that.., do you enjoy it... something like that."*

As these comments show, participants were clearly interested in sharing thoughts and ideas about physical activity. They think it is both interesting to see what others did, partly to know who is similar to them and partly to share ideas for doing activities. Knowing this, we look at why people did not have more of these conversations as a result of the developed application. As mentioned, part of the reason might be the lack of functionality to support communication. Nevertheless, people in the shared display group had the opportunity to come together and start such conversa-

tions readily at the shared display. The following two design recommendations explain how such conversations can be further supported.

8.2. Carefully consider group composition

It seems that, apart from practical constraints as being far away from the display, and being busy at work (which were both mentioned by participants from the shared display group), several social factors play a role in facilitating conversations about physical activity. In particular, several participants mentioned how it would be easier to talk about physical activity when some kind of shared context is created. A participant in the private display group stated this as follows:

> *"Because many of the people in the group do not know, or hardly know each other (..) it is not so natural to start a conversation about your activities, my activities.., can we support each other, I mean (..) it was very open, (..) there is no group goal."*

From these comments it appears that people need some kind of shared understanding or a shared context to start a conversation about physical activity. As noted by participants, this could be achieved by setting some kind of group goal, which more clearly defines the group, possibly making it easier to start a conversation.

Other comments suggested that changing the group of people you use the application with could make a difference:

> *"If you know each other a bit better, than the barrier is lower already, then you might know each other's routines, also by seeing each other's data, but than I might know that those peaks in the weekend are because he is cycling. Then you have already a reason to say hey, what did you do."*

And from a user from the private display group:

> *"Look it would have been different if uh.. if this tool had been used with people that.. (..), already did something with sports together (..) because then part of the relationship you have is already linked to activity, which is not the case now."*

8.3. Provide a supportive social context

Apart from providing a shared context, other possibilities were mentioned by participants that could positively contribute to having conversations about physical activity. Some participants mentioned, for example, how it is not very common to start a conversation about physical activity when you are in a work related setting, especially when other people are not very familiar. A user from the private display group stated this as follows:

"In a work environment, I think the boundary conditions are more strict and specific to elicit such interaction. It is more than purely offering the possibility, a shared goal is needed, you have to put the right group together…"

A participant from the shared display group explained:

"The application is nice, it's only that I think you should do it at a location where people are more… involved with it. You could better place it somewhere where people are busy with this topic. (..) I think this is not the priority what we are here for, we have a different priority here you know, just working. So, maybe if it was at a uh… at a fitness center, than it would do something more."

One participant from the shared display group mentioned how he would like to use the activity monitor at home, together with his wife and how talking about activity and health is more common at home than at work:

"What I would like to have is one for my wife. That means that I, the two of us can do it together. Because in your family the point of attention is different too, you know, you are here to work, but at home there you talk about your health, there you talk about eh…, well shall we go for a walk."

These comments teach us that supporting communication about physical activity in a work related setting is a more delicate matter than might be expected. Part of the hassle lies in colleagues not knowing each other well enough to start such conversations, and part of the solution seems to lie in providing a clear group goal, creating a shared understanding which makes it easier to approach each other and start talking about physical activity.

9. Conclusion

This research contributed to a better understanding of how a service or application can help to improve personal health, by combining both aspects of physical well-being and mental well-being. We have outlined a novel approach by reasoning that intrinsic motivation can be increased by facilitating the fulfillment of the need to belong in the context of physical activity.

Using several user-centered design methods, an application was developed that demonstrated the feasibility of using relatedness as a persuasive approach. The application allowed people to monitor physical activity of group members on a shared public display. By doing this we have successfully introduced social dynamics into the existing service DirectLife, which was originally targeted at promoting physical activity of an individual.

A field test of this application has shown the importance of group composition and of the context in which the application is used; these factors influence the ease with which conversations about physical activity are initiated.

Several recommendations were made to make future applications more engaging and effective in increasing connectedness amongst peers. We have pointed out the importance of an application's ability to support communication, either by leaving messages or by providing the ability to label the type of activity. The latter allows people to share ideas for activity as well as to lower the threshold to start a conversation. Further, to make an application for sharing physical activity information more effective in increasing motivation, it is important to provide group members with a shared context. For example, setting a group goal can create a shared understanding that can facilitate conversations about physical activity. A shared context can also be present by sharing activity information with friends or family. Other than in a work environment, talking about health related topics is more common with friends and family members. Sharing activity information with friends or family members is recommended because of the existing shared context.

The research presented addresses an approach to persuasion through social influence that has to date not been explored. While non conclusive, our results are encouraging for the use of relatedness as a motivating factor; on the basis of our findings it seems advisable to combine our approach with other ways of leveraging social influence that have been explored by previous research, such as competition and cooperative goal setting, which can provide a shared context for the group of users. Combining such approaches in future applications or services has the potential to result in successful intervention programs for promoting physical activity.

References

[1] World Health Organisation (WHO), http://www.who.int/dietphysicalactivity/pa/en/index.html

[2] I. Anderson, J. Maitland, S. Sherwood, L. Barkhuus, M. Chalmers, M. Hall, B. Brown and H. Muller, Shakra: Tracking and Sharing Daily Activity Levels with Unaugmented Mobile Phones, *Mobile Netw Appl*, **vol. 12**, pp. 185–199, 2007

[3] A. Aron, E. N. Aron and D. Smollan, Inclusion of Other in the Self Scale and the structure of interpersonal closeness, *Journal of Personality and Social Psychology*, **vol. 63**, pp. 596-612, 1992

[4] R. F. Baumeister and M. R. Leary, The need to belong: Desire for interpersonal attachments as a fundamental human motivation, *Psychological Bulletin*, **vol. 117**, pp. 497-529, 1995

[5] R. B. Cialdini, Influence: science and practice, Pearson Education, 1999.

[6] S. Consolvo, K. Everitt, I. Smith and J. Landay, A., Design requirements for technologies that encourage physical activity, *Proceedings of the SIGCHI conference on Human Factors in computing systems*, Montreal, Quebec, Canada, pp. ACM, 2006

[7] S. Consolvo, K. Predrag, W. M. David, A. Daniel, F. Jon, L. Louis, L. Ryan, M. Keith and A. L. James, Flowers or a robot army? Encouraging awareness & activity with personal, mobile displays, *Proceedings of the 10th international conference on Ubiquitous computing*, Seoul, Korea, pp. ACM, 2008

[8] E. L. Deci and R. M. Ryan, The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior, *Psychological Inquiry*, **vol. 11**, pp. 227-268, 2000

[9] E. L. Deci and R. M. Ryan, Self-Determination Theory: A Macrotheory of Human Motivation, Development, and Health, *Canadian Psychology*, **vol. 49**, pp. 182-185, 2008

[10] A. Fialho , H. Van den Heuvel, Q. Shahab, Q. Liu and L. Li, ActiveShare: Sharing Challenges to Increase Physical Activity, *CHI 2009*, Boston, Massachusetts, USA, pp. 2009

[11] Y. Fujiki, K. Konstantinos, P. Colin, B. Pradeep, P. Ioannis and L. James, NEAT-o-Games: blending physical activity and fun in the daily routine, *Comput. Entertain.*, **vol. 6**, pp. 1-22, 2008

[12] F. Guay, R. J. Vallerand and C. Blanchard, On the Assessment of Situational, Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS), *Motivation and Emotion*, **vol. 24**, pp. 175-213, 2000

[13] V. H. Hildebrandt, W. T. M. Ooijendijk and M. Hopman-Rock, Trendrapport Bewegen en Gezondheid, **vol.** pp. 1-338,

[14] J. M. Houston, S. McIntire, J. Kinnie and C. Terry, A factor analysis of scales measuring competitiveness, *Educational and Psychological Measurement*, **vol. 62**, pp. 284-298, 2002

[15] N. Jafarinaimi, J. Forlizzi, A. Hurst and J. Zimmerman, Breakaway: An Ambient Display Designed to Change Human Behavior, *CHI 2005*, Portland, Oregon, USA, pp. 1945-1948. 2005

[16] J. Lin, L. Mamykina, S. Lindtner, G. Delajoux and H. Strub, Fish'n'Steps: Encouraging Physical Activity with an Interactive Computer Game, *UbiComp 2006: Ubiquitous Computing*, **vol.** ch. pp.261-278. 2006

[17] R. d. Oliveira and N. Oliver, TripleBeat: enhancing exercise performance with persuasion, *Proceedings of the 10th international conference on Human computer interaction with mobile devices and services*, Amsterdam, The Netherlands, pp. 255-264. ACM, 2008

[18] H. Park and S. J. Lennon, Beyond Physical Attractiveness: Interpersonal Attraction as a Function of Similarities in Personal Characteristics, *Clothing and Textiles Research Journal*, **vol. 26**, pp. 275-289, 2008

[19] G. Plasqui and K. R. Westerterp, Physical Activity Assessment With Accelerometers: An Evaluation Against Doubly Labeled Water[ast][ast], *Obesity*, **vol. 15**, pp. 2371-2379, 2007

[20] R. M. Ryan and E. L. Deci, Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being, *American Psychologist*, **vol. 55**, pp. 68-78, 2000

[21] K. A. Schutzer and B. Sue Graves, Barriers and motivations to exercise in older adults, *Preventive Medicine*, **vol. 39**, pp. 1056– 1061, 2004

[22] T. Toscos, A. Faber, K. Connelly and A. M. Upoma, Encouraging physical activity in teens: Can technology help reduce barriers to physical activity in adolescent girls?, *Pervasive Computing Technologies for Healthcare*, pp. 218-221. 2008

[23] F. A. Treiber, T. Baranowski, D. S. Braden, W. B. Strong, M. Levy and W. Knox, Social Support for Exercise - Relationship to Physical Activity in Young Adults, *Preventive Medicine*, **vol. 20**, pp. 737-750, 1991

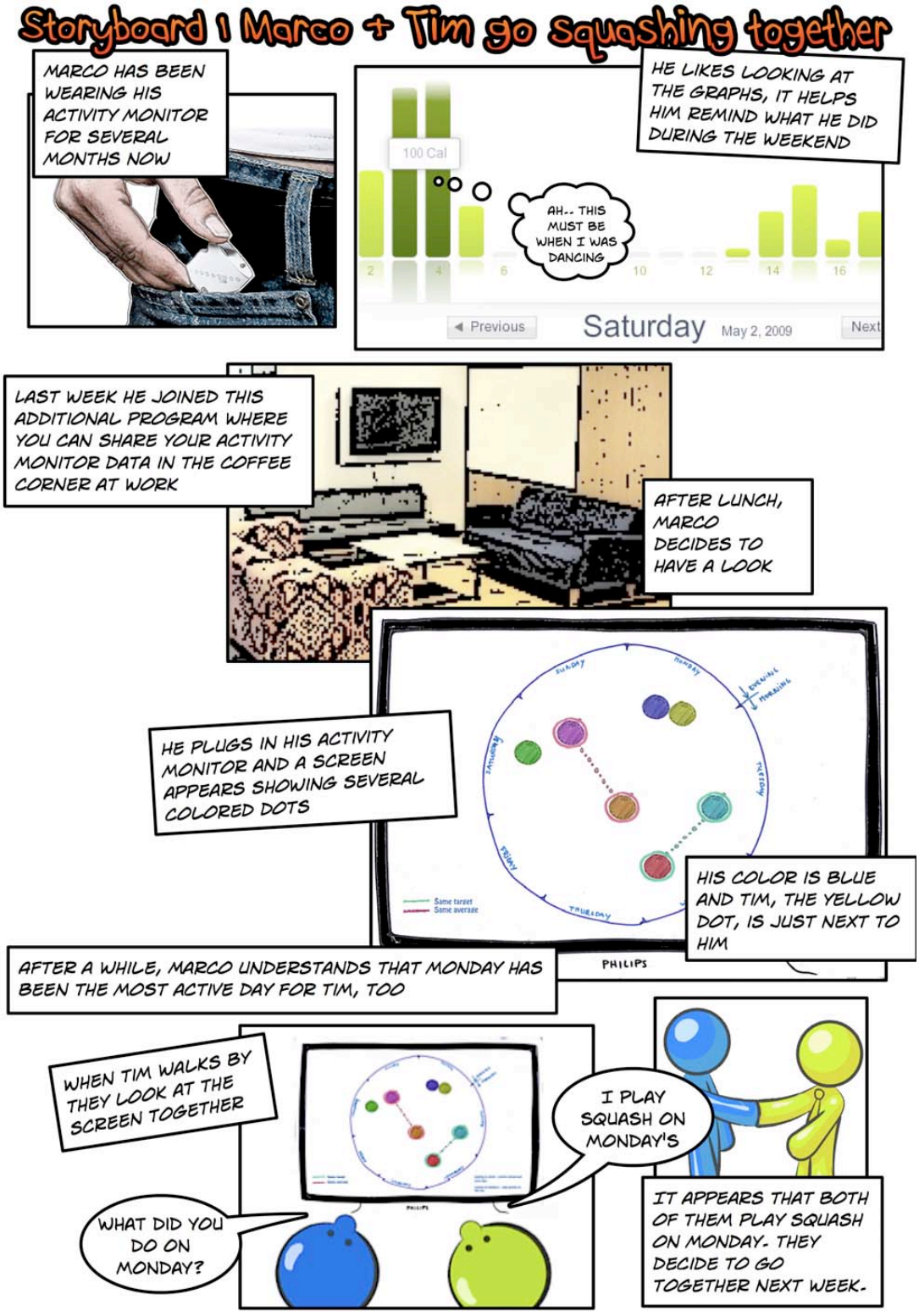
[24] D. T. Van Bel, K. C. H. J. Smolders, W. A. IJsselsteijn and Y. A. W. De Kort, Social connectedness: concept and measurement, *5th International Conference on Intelligent Environments*, Amsterdam, pp. 67-74. IOS Press, 2009

[25] D. S. Ward, K. R. Evenson, A. Vaughin, A. B. Rodgers and R. P. Troiano, Accelerometer use in physical activity: Best practices and research recommendations, *Medicine & Science in Sports & Exercise*, **vol. 37**, pp. 582-588, 2005

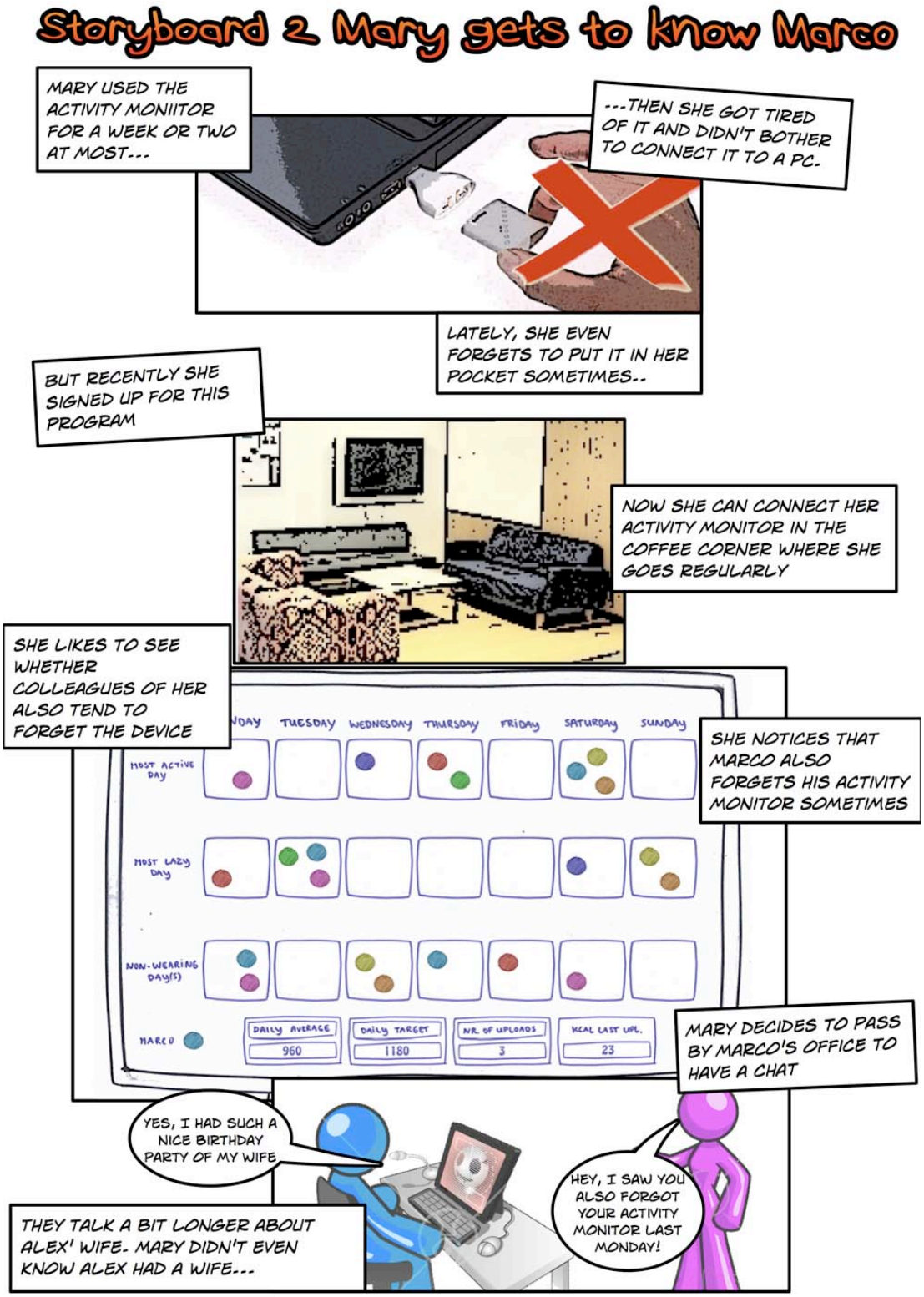
Appendix 1 Storyboards

This appendix contains three storyboards showing three design concepts.

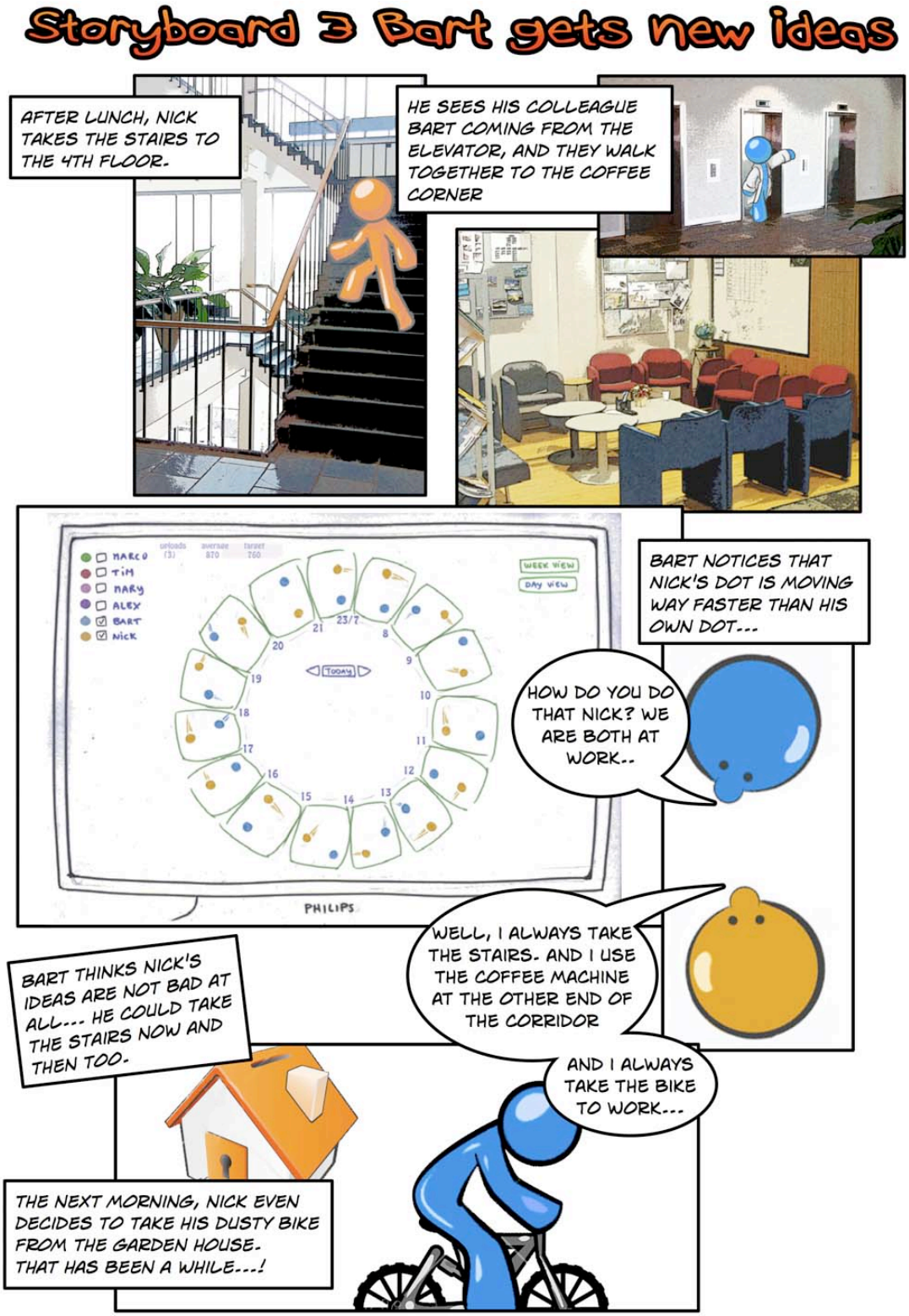
Storyboard 1 Marco & Tim go squashing together



Storyboard 2 Mary gets to know Marco



Storyboard 3 Bart gets new ideas



Appendix 2 Questionnaire

On the following pages the questionnaire is printed which participants received before using the application. A second, similar, questionnaire was used after two weeks of using the application. This second questionnaire was the same as the first with exception of the Competitiveness Index items (these were only asked once, prior to using the application). Where “for the last few days” was used in the first questionnaire, the second questionnaire stated “for the past two weeks”.

1. Competition Index

For the statements below, please indicate what is true or false for you.
Answering scale:
True / False

1. I get satisfaction from competing with others.
2. It is usually not important for me to be the best.
3. Competition destroys friendships.
4. Games with no clear cut winners are boring.
5. I am a competitive individual.
6. I will do almost anything to avoid an argument.
7. I try to avoid competing with others.
8. I would like to be on a debating team.
9. I often remain quiet rather than risk hurting another person.
10. I find competitive situations unpleasant.
11. I try to avoid arguments.
12. In general, I will go along with the group rather than create conflict.

13. I don't like competing against other people.
14. I don't like games that are winner-take-all.
15. I dread competing against other people.
16. I enjoy competing against an opponent.
17. When I play a game I like to keep scores.
18. I often try to outperform others.
19. I like competition.
20. I don't enjoy challenging others even when I think they are wrong.

2. Social Support for Physical Activity scale

The following statements describe what people might do or say to others that are trying to be physically active. For the last few days, please indicate how often the people in your group (the people you are using the application with) have done or said what is described.
Answering scale:
Never / Rarely / A few times / Often / Very often / Does not apply

The people in my group:

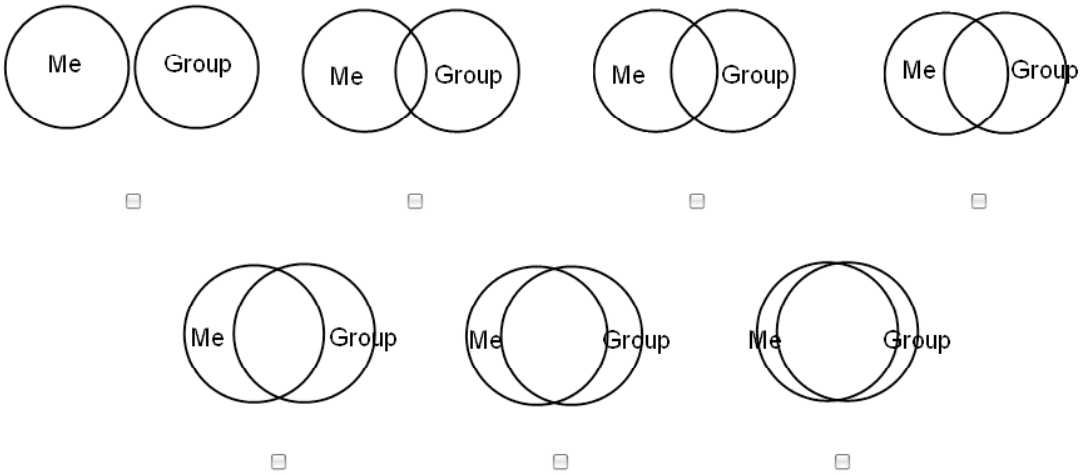
1. Have joined in activities with me.
2. Gave me encouragement to stick with my activity program.
3. Changed their schedule so we could exercise together.
4. Offered to exercise with me.
5. Gave me helpful reminders to stay more active.
6. Planned for physical activities on recreational outings.
7. Discussed physical activity with me.
8. Talked about how much they like to be active.
9. Helped to plan around my active moments.
10. Asked me for ideas on how they can get more active.
11. Took over chores so I had more time to be active.
12. Made positive comments about my physical appearance.

People in your group are: (names of group members are listed here)

3. Inclusion of Other in the Self scale

Please indicate which picture below best describes how you experience your relationship with the people in your group (the people you are using the application with).

1. Please select one of the pictures below:



People in your group are: (names of group members are listed here)

4. Social Connectedness questionnaire

See Van Bel et al [24].

5. Situational Motivation scale

For the last few days, please indicate how well the statements below correspond with your experience by answering the question:

Why are you using the Philips Activity Monitor?

Answering scale
Strongly disagree / Disagree / Somewhat disagree / Don't agree Don't disagree / Somewhat agree / Agree / Strongly agree

1. I think that using the activity monitor is interesting.
2. I am using the activity monitor for my own good.
3. I am supposed to use the activity monitor.
4. There may be good reasons to use the activity monitor, but personally I don't see any.
5. I think that using the activity monitor is pleasant.
6. I think that using the activity monitor is good for me.
7. Using the activity monitor is something that I have to do.
8. I am using the activity monitor, but I am not sure if it is worth it.
9. Using the activity monitor is fun.

10. I use the activity monitor by personal decision.
11. I use the activity monitor because I don't have any choice.
12. I don't know; I don't see what using the activity monitor brings me.
13. I feel good when using the activity monitor.
14. I believe that using the activity monitor is important for me.
15. I feel that I have to use it.
16. I use the activity monitor, but I am not sure if I will keep using it.

People in your group are: (names of group members are listed here)

For the last few days, please indicate how well the statements below correspond with your experience by answering the question:

Why are you engaging in physical activity?

Answering scale
Strongly disagree / Disagree / Somewhat disagree / Don't agree Don't disagree / Somewhat agree / Agree / Strongly agree

1. I think that engaging in physical activity is interesting.
2. I am engaging in physical activity for my own good.
3. I am supposed to engage in physical activity.
4. There may be good reasons to engage in physical activity, but personally I don't see any.
5. I think that engaging in physical activity is pleasant.
6. I think that engaging in physical activity is good for me.
7. Engaging in physical activity is something that I have to do.
8. I engage in physical activity, but I am not sure if it is worth it.
9. Engaging in physical activity is fun.
10. I engage in physical activity by personal decision.
11. I engage in physical activity because I don't have any choice.
12. I don't know; I don't see what physical activity brings me.
13. I feel good when engaging in physical activity.
14. I believe that engaging in physical activity is important for me.
15. I feel that I have to do it.
16. I engage in physical activity, but I am not sure if I will keep doing it.

People in your group are: (names of group members are listed here)

Please fill out your personal details below.

Gender: Female / Male
Age:
E-mail address: @philips.com

Space for comments or questions:

Appendix 3 IUI article format

This section contains the article format of this graduation project as submitted to the Intelligent User Interfaces (IUI) conference, 2010.

Submission date: 25 September 2009.

You and me, how (in)active are we? The potential of sharing activity information to increase motivation

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ABSTRACT
This article describes the theoretical background and results of a four-week field study of a smart interface for social comparison of physical activity information. An existing web service was enhanced with an interface that visualizes salient similarities in activity levels and patterns between different users. In the field study 14 participants carried an activity monitor to measure physical activity, sharing their activity information on either a private or publicly shared display. The results show the promise of using similarity and enhancing connectedness for technology-based persuasion. Combining this approach with other ways of social influence is recommended.

Author Keywords
Physical activity, connectedness, intrinsic motivation, Self-Determination Theory, similarity, persuasive technology.

ACM Classification Keywords
H5.2 [User Interfaces]: User-centered design; H5.3 [Group and Organization Interfaces]: Asynchronous interaction, synchronous interaction, Web-based interaction.

INTRODUCTION
The World Health Organization [1] recommends that people have at least 30 minutes of moderate intense activity per day to stay healthy and to reduce the risk of several diseases and malfunctions (e.g. diabetes, heart failure and injuries). Although people may be aware of the fact that they should be physically active, many people have difficulty to maintain such an active lifestyle. Common barriers to physical activity adherence are a lack of time and motivation, busy work requirements [12] and a non-supportive environment [16]. Such obstacles on the route to an active lifestyle make it difficult for people to achieve their goals.

Self-Determination Theory [8] helps us to understand that an important aspect of a person's persistence in keeping an active lifestyle is related to the type of motivation a person has with respect to this behavior. Intrinsic motivation is one type of motivation out of a continuum of motivation types [7]. It is an important determinant of persistent, continuous behavior and has been linked to the fulfillment of basic human needs. One of these is the need for relatedness, which refers to people's desire to have enough and satisfying relationships with others [7]. The need for relatedness overlaps with the concept of the need to belong. The need to belong, in turn, is described by Baumeister and Leary [3] as a fundamental human "need to form and maintain strong, stable interpersonal relationships". Van Bel, Smolders, IJsselsteijn and De Kort [18] describe how a minimum number of contacts and a certain level of intimacy in these contacts contributes to a sense of interpersonal connectedness and satisfaction of the need to belong. In short, Van Bel et al. [18] describe how social connectedness, constituting several dimensions such as shared understandings, relationship salience and satisfaction with contact quantity, is a measure of the fulfillment of the need to belong.

Given the importance of both physical and mental well-being for personal health, and the difficulty people have to maintain such a healthy lifestyle, the current research aims to support these two aspects of health with a theory-based application. The aim is to develop and test an application that motivates people to be physically active by utilizing the concepts of interpersonal connectedness and theory of intrinsic motivation. In other words, this research explores how we can introduce social dynamics into a technology-driven service or application to help people maintain a healthy lifestyle by improving both physical and mental well-being.

THEORETICAL BACKGROUND
In the context of increasing physical activity and motivating people to be physically active there has been research into several aspects that can increase active behavior [5, 6, 10, 13, 17]. However, theories on intrinsic motivation [7, 8]

exemplify the importance of self-determined behavior, and the roles that basic human needs play herein when it comes to persistent behavior. Applying the perspective of self-determination theory provides us with the opportunity to see the potential of intrinsically motivating people to become physically more active through the concept of social connectedness. This research attempts to validate this approach by the development and evaluation of an intelligent user interface, while at the same time bringing the approach under broader attention for further research.

Intrinsic motivation

As mentioned before, an important aspect of a person's persistence in keeping an active lifestyle is related to motivation. Motivation types can range from non self-determined motivation (external motivation and amotivation) that typically result in behavior that does not initiate from the self, but is instead triggered by external factors and influences, to self-determined types of motivation (identified motivation and intrinsic motivation) resulting in behavior initiated by internal, self-determined reasons and personal need-fulfillment. Intrinsic motivation refers to performing an activity because of the pleasure and satisfaction it provides in itself. Therefore, this type of motivation is an important determinant of persistent, continuous behavior.

According to Self-Determination Theory [7], there are three basic human needs that should all three be satisfied to increase intrinsically motivated behavior: the need for competence, autonomy and relatedness. The need for relatedness refers to people's desire to have enough and satisfying relationships with others. Relatedness, therefore, is tightly coupled with the previously mentioned need to belong. In fact, the need for relatedness and the need to belong are, in this research, regarded as needs referring to the same pervasive desire to have enough and satisfying contacts with others.

From SDT [8] it can be learned that social contexts and situations that support satisfaction of these basic needs facilitate intrinsically motivated behavior. In the context of the current research this could mean that promoting basic needs in the context of physical activity could have a positive influence on the motivation for physically active behavior. SDT prescribes that it is not only important that the goals people pursue have outcomes resulting in the fulfillment of these basic needs, the process leading to that goal can have important consequences for motivation as well. Therefore, providing a context that supports the fulfillment of basic needs could positively influence the motivation for the end goal in that context, e.g. being physically active. When behavior helps to satisfy the basic needs of competence, autonomy and relatedness, the motivation for performing that behavior will be of intrinsic, self-determined nature.

Focus on similarities

The need for relatedness can be satisfied by having pleasant social interactions with others[3]. Such social interactions can be mediated, for example, by having something to talk about and by having a positive attitude towards the other. In addition, for people to have positive social interactions, it is important that people *like* each other to some extent. Liking, in turn, has been shown by past and recent research to be mediated, amongst other factors, by physical proximity ([14] referring to Festinger, Schachter, & Back, 1950), interpersonal contact and communication [4] and similarity [14]. It has been shown that people tend to like other people who are similar in opinions and attitude. Also having a similar lifestyle, clothing and behaviour seem important predictors of liking. Therefore, it is expected that visualizing similarities in physical activity amongst peers will increase interpersonal awareness, social interaction and perceived closeness (Figure 1). Such an increase in awareness, interaction and closeness, in turn, is expected to facilitate the fulfillment of the need to belong. As a result, fulfillment of the need to belong can increase intrinsic motivation and engagement in physical activity.

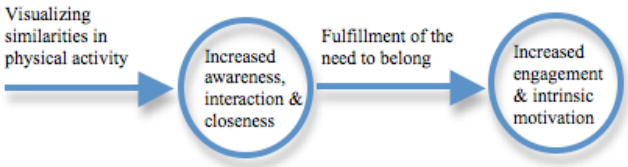

Figure 1: Overview of expected relationships between concepts

The purpose of this research is to increase our understanding of how interpersonal connectedness can be induced by a service or application, with the goal to increase intrinsic motivation for physical activity. Therefore, the focus of this research is the development and evaluation of a theory-based application that visualizes similarities in physical activity, with the aim to increase social interaction, interpersonal connectedness and intrinsic motivation.

RELATED DESIGN WORK

Several design projects describe attempts to increase physical activity using measuring devices (pedometers, accelerometers) in combination with devices such as mobile phones and shared monitors [5, 6, 9, 10, 13, 17]. Many of these projects report to successfully engage people in physical activity and thereby contribute to our understanding of physical activity intervention programs. Below, four relevant past projects are described that have contributed to our understanding of the topic of promoting physical activity: UbiFit Garden [6], Neat-o-Games [10], Houston[5], Fish'n'Steps [13]. These projects have inspired the development of the current application and the direction of the current research. The mentioned projects range in focus from motivating an individual to motivating a group of people by deploying social dynamics.

A project focused on motivating a single person is described by the work of Consolvo, Predrag, McDonald, Avrahami, Froehlich, LeGrand, Libby, Mosher and Landay [6]. Consolvo et al have done considerable research in the area of encouraging physical activity [5, 6]. In their most recent research [6] an application was developed that provides its users with progress feedback regarding their physical activity and goal attainment. During a three-month field study, participants were provided with a pedometer connected to a mobile phone displaying a garden as background picture. In this garden visualization, different flower types represented different types of physical activity and the presence of butterflies represented weekly goal attainment. This research shows that having an always-on, peripherally available (i.e. glanceable) display available at any time of the day helps to increase awareness of physical activity during the week. Further, it exemplifies the importance of the application supporting a wide range of activities, allowing people to label what type of activity they have done. Having a glanceable display helped participants to maintain their activity level during a holiday period, including Christmas, New Years Eve and Thanksgiving, in which activity levels normally drop.

Fujiki, Kazakos, Puri, Buddharaju, Pavlidis and Levine [10] report results of a three-week field study of their application named Neat-o-Games, which is a race game for two users. The application, which receives input from an accelerometer, aims to encourage physical activity by providing a race game with competitive elements on a mobile phone. The researchers report that the application helped to improve people's engagement in physical activity, increase activity levels and that healthy competition was experienced as fun and enjoyable.

Both research by Toscos, Faber, Connelly and Upoma [17] and by Consolvo, Everitt, Smith and Landay [5] describe applications targeting small groups. Friends are given the opportunity to share step counts on their mobile phones with the aim to leverage social support for physical activity and to increase physical activity levels by competition. Consolvo et al. [5] summarize the results of their 'Houston' application by proposing four key requirements for technologies that encourage physical activity. First, they explain how the measuring device should provide proper credit for the activities of the user. In other words, the device should measure as accurately as possible the efforts of the user otherwise the user will get de-motivated to engage in activities which are not registered properly by the device. Second, people value to have insight in their personal activity level, not only in their current activity level, but also in their activity history and in their progress towards goal achievement. Third, technologies that are meant to engage people in physical activity should support some form of "social influence". And fourth, the practical constraints of users should be kept in mind (which means, for example, that the measuring device should be of a size and form that is suitable to wear without discomfort).

An application aimed to encourage a larger group of people to stay physically active is described by Lin, Mamykina, Lindtner, Delajoux and Strub [13]. Their application received input from a pedometer and mapped step-counts to the growth and emotional state of a virtual pet; a fish in a tank. In their study, one group of people had access to a visualization of their own virtual pet and another group of people had access to a shared display where the fish tanks of other groups were shown as well. Competition was promoted by showing to other groups whose fish tank is most "healthy". Results from their study showed the importance of providing only positive reinforcement and setting realistic, achievable goals.

THE CURRENT RESEARCH

With this article we extend this line of research by focusing on the importance of social contexts in motivating physical activity. The goal is to increase interpersonal awareness, communication and perceived closeness by sharing physical activity information with peers.

There are two central hypotheses involved in this research:

Hypothesis 1: Visualizing similarities in physical activity will increase interpersonal awareness, communication and perceived closeness. This facilitates the fulfillment of the need to belong and thereby increases intrinsic motivation for physical activity and engagement in using the measuring device.

Hypothesis 2: Visualizing similarities in physical activity on a *shared* display will have a larger effect on intrinsic motivation and engagement than visualizing the same information on a *private* display.

The existing web-service

The developed application extends an existing web-service and measuring device. The device used is the Philips Activity Monitor, which is based on the Tracmor accelerometer [15]. The activity monitor has dimensions of 32x32x12 mm and is small and light enough to be worn in a jeans pocket without discomfort. The device can be connected to a PC through a USB adaptor to get access to a web-service, giving people detailed data regarding physical activity levels, showing graphs that represent burned calories during the past hour, day, week, month or year. It also provides users with feedback on their progress towards a personal calorie target. Calories are calculated by using a person's age, gender, height and weight in combination with the activity count measured by the device.

The current project aims to extend this existing web-service by allowing people to share activity information with others. It puts forward and aims to validate the concept of visualizing similarities in physical activity, targeting intrinsic motivation through satisfying the basic human need to belong.

Design process

Several user-centered design methods were deployed to allow the development of an interesting and engaging application to share activity information. The methods used are: contextual (orientating) interviews, sketches, brainstorm sessions, storyboards, focus groups and low fidelity software prototyping.

Orientating interviews

Interviews were conducted with six current users of the activity monitor, using the existing web-service. Questions were asked to get a feeling for the context from the user's perspective and to get an initial grasp on what people liked and disliked about it. Some of the questions asked were: "What do you enjoy about using the activity monitor?", "Are there any aspects missing when using the device?" and "Would you be interested in seeing activity information from others?". These initial interviews gave a range of interesting feedback, which is briefly summarized here:

Sharing information:

- Getting comments from colleagues about physical activity levels and goal attainment is fun (e.g. while meeting informally in the corridor or elevator).
- If sharing information would be possible, this should be objective and with people that have roughly the same calorie target.
- It would be nice to be able to choose the people with whom you share activity information.

Positive remarks related to using the activity monitor:

- Seeing detailed information in the form of progress feedback and activity history is valued.
- The activity monitor works well to start conversations at parties (by showing the device).

Possible improvements:

- The type of activity should be recognized, not only calories.
- Not all activities are captured equally well by the device.

Based on the initial interviews three design concepts were developed iteratively. These designs were each molded into a storyboard resulting in three cartoonish sketches explaining how the application could be used in a specific scenario. Three focus group sessions of 1.5 hours each were conducted with a mixed audience (5 to 6 people, plus one moderator) from different backgrounds and with different professions. During these sessions the storyboards were used as a means to communicate the conceptual ideas and to receive feedback on the strength and weaknesses of each design.

The final application shows several attributes of physical activity information from a group of users (Figure 2). Each user is represented by a circle with his or her name on it, and activity information is conveyed abstractly. Using a stylized, abstract visualization instead of detailed information is expected to prevent privacy issues while still being informative and fun.

Figure 2: A screenshot of the *You and Me* application

Displayed information – position of the circles

The attributes of physical activity that are visualized are each person's most active or least active day – a person's circle is positioned on one day and depending on the selected view this day corresponds with either that person's most active or least active day compared to the last seven days. Further, the distance of a person's circle from the center gives an indication of how active or inactive that day was compared to the person's own average activity level over the other days. More precisely, in the 'most active day'-view the day with a person's highest physical activity level (PAL) is used and the ratio of that day's activity level to the person's average activity level is calculated. This ratio determines the radius of each person's circle from the centre of the screen. A ratio of 1 corresponds with a position just outside the center of the screen labeled with 'personal average', and a ratio of 3 or higher corresponds to a position at the outside periphery of the screen. In the 'most lazy day'-view the same calculation is made to determine the ratio between the least active day and the average activity level. Thus, depending on the view selected, being far away from the center of the screen means that this day was either very active (most active day view) or very inactive (most lazy day view). In both views being far away from the center indicates that a person's activity level on that day was 'far away' from his or hers average activity level. Further, from the position of the circle it can be determined what a user's most (or least) active moment on the day was. If this was at noon, the person's circle is positioned in the middle of the day, if this was late in the evening, the position of the circle is towards the edge of the day, close to the next day.

Displayed information – mouse-over information

Hovering over a person's circle conveys information about that person's active or inactive hour of the day and shows if

peers have had the same average activity level or the same weekly calorie target.

User interaction

There are four buttons in the interface; two buttons at the top are used to switch between the two views, either the 'most active day' view or the 'most lazy day' view. Depending on the view selected, people's circles are positioned to represent either their most active or least active day. On the left and right side of the screen are two arrowed buttons. By clicking these buttons, users can navigate seven days backward or forward in time.

FIELD STUDY

To test the hypothesis regarding an application's ability to increase interpersonal awareness, communication and perceived closeness with the goal to increase engagement and intrinsic motivation for physical activity (first hypothesis), a quasi-experimental field study was set up. Also, the study was aimed at providing insights into the differences of providing such an application on either a private or a shared display (second hypothesis). The expectation is that showing the application on a shared display will facilitate interaction more, thereby having a larger effect on engagement and intrinsic motivation.

During a four-week quasi-experimental field study participants had access to the application for two weeks. One week before using the application was used as a pre-measure interval and one week after using the application was used as a post-measure interval, resulting in a total time of four weeks.

Experimental conditions

The field study contained two conditions, with seven participants in each. In one group participants were all working on the same floor and received access to the application in the form of a *shared* display in the coffee corner on their corridor. The other condition contained a group of participants that were all working in the same building as the first group, but were instead spread out over different floors. This group received *web-access* to the application, allowing participants in this group to use the application on their own office-PC (hence, this is called the *private* display group, Figure 3).

Figure 3: Left: The application in use in the *private display* condition. Right: A setup illustrating use of the application in the *shared display* condition.

For this group, the application showed up after connecting the activity monitor to the PC through a USB adaptor. Note that participants were not encouraged to wear the device more often or connect it more often to the PC as they would normally do.

Participants

Participants were office workers working in the same building as the researchers, on the High-Tech Campus in Eindhoven, The Netherlands. It is important to note, however, that they were in no way affiliated with the researchers or acquainted with the research project. The recruited participants were all (except for one) existing users of the activity monitor and web-service, and had been wearing the device for several weeks or several months. Only one user received the activity monitor one week prior to the start of the field study, for the purpose of joining in the study with her colleagues, and because of difficulties in finding participants. Since most participants were already users of the activity monitor a novelty for using the device is minimal, which has been reported in previous studies to be an important confounding factor [5]. Informed consent was received from all participants regarding the collection of activity data and to inform participants about their freedom to end their participation at any time without consequences.

Existing group dynamics

Existing group dynamics and relationship closeness prior to the field study should not be neglected. From previous research [5], and from the orienting interviews at the start of this project, it can be learned that sharing activity information would be most interesting if done within an existing group of friends or if users can select their own peers with whom information is shared. Although it was attempted to let participants choose their group members, several constraints let the researchers to eventually pick participants mostly based on availability and physical location and less on existing relationships with others. More specifically, participants in the *private* display condition were selected on availability and with the additional requirement that the participant knew all the other group members at least *by name*. In contrast, selection of participants in the *public* display condition was done by availability as well, and with the additional requirement that group members were working on the *same floor*. For this group it was *assumed* that participants would at least know each other to some extent as the result of working on the same floor. But it was not checked if participants in this shared display group knew each other by name prior to the field study.

Data gathering

During the field study the following data was collected a) self-report responses to a questionnaire b) activity logs regarding the activity monitoring and c) in depth interviews regarding the experience of using the application.

Quantitative data – compiled questionnaire

To gain insight in changes in motivation and social dynamics a compiled questionnaire composed of three existing measurement instruments was used to survey participants at the beginning and at the end of the field study. The pre-measure before using the application was used to determine levels of interpersonal closeness, social connectedness and motivational aspects prior to using the application. A post-measure was obtained to determine if any changes persisted after the intervention period.

The Inclusion of Other in the Self (IOS) scale [2] is typically used to assess closeness in romantic relationships. The IOS scale is a 1-item measure and for the current research it is adjusted to refer to the self ("Me") and to the group of people with whom the application is being used ("Group"). This scale will help to understand if people's perception of closeness with the group in general has changed over time. Seeing an increase in perceived closeness will be interesting since this could be a result of using the application and having the opportunity to communicate with others. As explained earlier, an increase in social interaction and perceived closeness, in turn, could contribute positively to the fulfillment of the need to belong. Such a fulfillment, in turn, could lead to increased engagement and intrinsic motivation for physical activity.

The Social Connectedness Questionnaire [18] is a measure of connectedness, and measures the fulfillment of "the need to belong". It has been adapted to the current research by selecting 27 relevant items. Answers are rated on a 7-point scale. Finding an increase in feelings of connectedness as a result of using the application would be an interesting finding, since this would indicate an increase in the fulfillment of the need to belong, which can contribute to an increase in intrinsic motivation.

The 16 items from the Situational Motivation scale [11] contain questions to measure the type of motivation people experience: intrinsic motivation, identified motivation, external motivation or amotivation. The questions have been framed to reflect both motivation regarding physical activity as well as motivation regarding use of the activity monitor, adding up to a total of 32 items. For both types of behavior it is desirable that people are intrinsically motivated to engage in it.

Qualitative data – interviews

Interviews with participants at the end of the field study were conducted to gather rich, qualitative data about participants' experiences during the field study. Interviews were semi-structured, containing questions such as:

- Can you tell something about your experience while using the application during the past two weeks?
- Did you talk with colleagues about the application, or as a result of using the application?

RESULTS

Data obtained through questionnaires and data logs was analyzed quantitatively. Where variable distributions showed no significant deviation from a normal distribution, the reported significance levels are the result of t-tests and ANOVAs. Equivalent non-parametric tests have been used in cases where significant deviations from normality were reported (Mann-Whitney test as equivalent for the independent samples t-test, Wilcoxon Signed Ranks test as equivalent for the paired t-test and Kruskal-Wallis and Friedman tests as alternatives for the ANOVA). Qualitative data was examined with a view to explain quantitative results and for identifying patterns of behavior of participants.

Engagement in using the activity monitor

Figure 4 shows usage statistics from the activity monitors. The graph illustrates that participants from the shared display group connected their devices more often during the period of the field study compared to the private display group. More specifically, the number of uploads (connecting the activity monitor to the USB adaptor to upload the data) increased significantly for the shared display group in the first week ($p = .004$, Table 1). And during this week the number of uploads was significantly higher for the shared display group compared to the private display group ($p = .039$, Table 2).

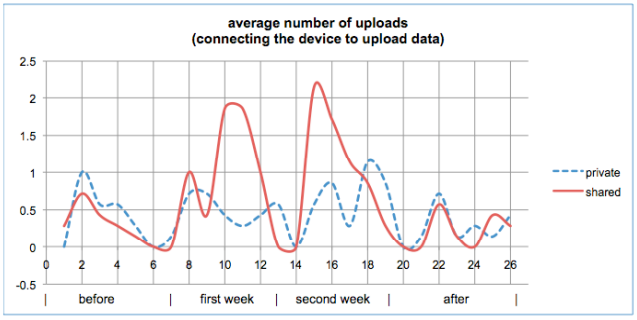

Figure 4: Average number of uploads during the field study[1]

	before – week 1 (sign. Level)	week 1 – week 2 (sign. Level)	week 2 – after (sign. Level)
Private display	.499	.418	.009*
Shared display	.004*	.701	.000*

Table 1: Within group significance levels of the average number of uploads over the period of the field study

	Before (mean)	First week (mean)	Second week (mean)	After (mean)	Sign. level (within groups)
Private display	.40	.48	.62	.24	.040*
Shared display	.31	.95	.95	.19	.000*
Sign. level (between groups)	.220	.039*	.309	.768	

[1] Uploads from the same user within a time-interval of ten minutes were counted as one upload; users sometimes reconnected their devices to double check if their upload was successful.

Table 2: Average number of uploads per day during the field study (connecting the activity monitor to upload data)

Further examination of the logged data shows that on average participants from the private display group carried their activity monitors with them longer during the day compared to the shared display group. This number of 'wearing hours' is significantly higher for the private display group compared to the shared display group except during the first week of using the application, where the number of wearing hours is not significantly different between the groups (Table 3).

	Before	First week	Second week	After	Sign. level (within groups)
Private display	11.0	11.6	11.0	11.0	.753
Shared display	9.0	10.7	7.7	8.1	.125
Sign. level (between groups)	.014*	.928	.049*	.01*	

Table 3: Average wearing hours of the activity monitor during the field study

Some participants expressed their increased engagement in using the device during the period of the field study. During the interviews a participant from the private display group mentioned how he started wearing the activity monitor in his sock while cycling, making sure the device accurately captured his efforts:

Intrinsic motivation

Next, we look at how motivational aspects changed over time. Results of the Situational Motivation scale show a small increase in intrinsic motivation for using the activity monitor for the shared display group and a slight decrease for the private display group although these changes were not significant above a 90% confidence level (Table 4).

	Before	After	Sign. level (within groups)
Private display	21.29	19.86	.118
Shared display	20.67	22.00	.102
Sign. level (between groups)	.898	.274	

Table 4: Before and after mean scores of intrinsic motivation for using the activity monitor (factor of the Situational Motivation scale - SIMS)

For motivation items directed at physical activity similar results were obtained; intrinsic motivation for physical activity increased slightly, but not significantly for the shared display group, and remained unchanged for the private display group (Table 5).

	Before	After	Sign. level (within groups)
Private display	22.86	22.57	.703
Shared display	22.57	24.00	.223
Sign. level (between groups)	.899	.467	

Table 5: Before and after mean scores of intrinsic motivation for physical activity

A general statement about motivation was made by a user from the private display group. He explained how it would be more motivating for him to receive comments from a group member instead of looking only at data from a screen[2]:

"For me it would be much more motivating if I received a message from a colleague, or an unfamiliar person in the group… receive a message like hey, or ask hey what did you do to get so many points?"

Interpersonal awareness, communication and perceived closeness

Several participants mentioned how they had conversations with group members as a result of the application. Some conversations were related to physical activity and others were about how the application's intention was not entirely clear:

"..somebody asked me when were you most active last week and then I asked and what about you.. what did you do, what did I do and what was I planning to do later that day. And then he said oh that is going to count extra for you. Yes that is the sort of discussion we had."

In the shared display group similar comments were made. Interestingly, one participant from the shared display group mentioned how she had mostly spoken with people not belonging to her group, but with people that were present around the display while she was connecting her activity monitor to upload data:

"… people that didn't participate with the test made comments like 'Ooh M. I see you have been most active on Sunday!'. (..) These were people printing over there, or looking at the screen."

And another participant from the same group explained:

"…in the beginning we were standing there with some people for a while to have a look and shouting like uhm, 'hey I see that you are also in it!' More like that."

Some people from the private display group expressed how they missed some kind of communication functionality in the application:

"...the interface invited to do more, (..) to.. uhm, to move the circles, or to click on it, or, or, maybe even send a message through the circles. (..) Some sort of message which you can then leave in the interface of the other person.., (..) that you can say hey what did you do to get so many points on a Sunday afternoon or something like that."

Apart from feedback referring to the type of conversations or about missing functionality, several participants

[2] All quotes have been translated from Dutch. This was done carefully and as accurately as possible to maintain the original meaning.

mentioned how the application had *not* made them feel closer to their group members:

"It's not that I felt closer in contact with others due to the application or by doing activities together with colleagues or that... nobody took the initiative, neither me nor the others."

Looking at the self-report measures of perceived closeness in the questionnaire, both closeness measured by the Inclusion of Other in the Self (IOS) scale, as well as the closeness factor in the Social Connectedness Questionnaire show a *decrease* of perceived closeness over the period of the field study for both groups; the before and after measure of the IOS scale, showed a marginally significant decrease in perceived closeness for the private display group ($p = .083$, Table 6).

	Before (mean)	**After (mean)**	Sign. level (within groups)
Private display	2.67	2.17	.083
Shared display	2.00	1.50	.408
Sign. level (between groups)	.258	.278	

Table 6: Before and after means as measured by the Inclusion of Other in the Self (IOS) scale

The closeness factor of the social connectedness questionnaire shows the same decreasing trend. This factor (consisting of four items) shows a significant decrease for the *shared* display group, above a 95% confidence level ($p = .033$, Table 7).

	Before (mean)	**After (mean)**	Sign. level (within groups)
Private display	14.50	13.43	.584
Shared display	14.29	11.33	.033*
Sign. level (between groups)	.922	.472	

Table 7: Before and after means as measured by the closeness factor from the social connectedness questionnaire

The need to belong and social connectedness

Results from the social connectedness questionnaire indicate how all factors (relationship salience, shared understandings, low contact quality, knowing each others experiences, satisfaction with contact quantity) do not reveal any significant differences between conditions, or before and after the intervention.

	Before (mean)	**After (mean)**	Sign. level (within groups)
Private display	100.17	92.14	.397
Shared display	100.00	92.83	.131
Sign. level (between groups)	.987	.963	

Table 8: Before and after means as measured by the social connectedness questionnaire

DISCUSSION

Based on feedback from participants we learnt that the application triggered conversations, sometimes directed at technicalities of the interface, but more interestingly others directed at calories burnt or activity levels or in other ways related to physical activity. Further, a participant in the shared display group mentioned how people who were not part of the field study made comments while she was uploading data on site. Comments from participants in the private display group showed us how the application invited more interaction, and how users expected communication functionality by leaving messages.

Increased engagement

The logged data shows that users from the shared display group started connecting their activity monitors significantly more during the first week of the field study compared to the week before using the application and compared to users from the private display group. Although this could be the result of having a novel application, it also indicates that there was an increase in engagement for the shared display group. Feedback during the interviews supports the finding of increased engagement in using the activity monitor. In addition, the number of wearing hours was significantly higher for users of the private display group during most of the field study, but with exception of the first week of using the application. A possible explanation could be that interest and engagement increased for participants from the shared display group as a result of having access to the application.

Intrinsic motivation

In line with the expectations, intrinsic motivation showed a change in the expected direction. For the shared display group intrinsic motivation for using the device and for physical activity increased slightly over the period of the field study. Nevertheless, these changes were not statistically significant so interpretation should be done with care.

Perceived closeness and fulfillment of the need to belong

Several results showed trends that were contrary to our expectations. First of all, measures of perceived closeness showed a strong, significant decreasing trend, and comments from participants confirmed this result. Second, the same decreasing trend was found for the social connectedness measure, indicating that the application did not fully support the fulfillment of the need to belong.

DESIGN RECOMMENDATIONS

Based on the results and on feedback from participants we formulate design recommendations for systems in which users can share physical activity information with peers.

Supporting communication

Participants from the private display group made several comments that explained how they expected more functionality in terms of communication. One participant described how he expected to be able to leave a message for another user by clicking a peer's circle. Another explained

how he could see a Twitter or Facebook-like functionality to show to others what one has achieved:

".. I was thinking more about, something similar to Twitter, and things like Facebook, where you can also, well, where you can publish things, as a sort of 'show off', saying hey, this was my most active day and that you can say what exactly you've done, I ran the marathon, I am training for the marathon of Eindhoven..."

Similar comments were made about functionality that allows you to 'tag' what sort of activity you have been doing during your active moment(s):

"You would like to tag well in this hour I just walked for 20 minutes, and during that hour for half an hour or these 10 minutes I have been really busy working in the garden and then you can really see the difference in activity and others can read and say well what similar things could I do in my daily routine."

And from another participant:

"If you know what a person did, then that could give more an idea like hey I could try that, or well it's nice that you do that.., do you enjoy it... something like that."

Participants were clearly interested in sharing thoughts and ideas about physical activity, to see what others did, to know who is similar to them, and to share ideas for doing activities.

Carefully consider group composition

Several participants mentioned how it would be easier to talk about physical activity when some kind of shared context is created. A participant in the private display group stated this as follows:

"Because many of the people in the group do not know each other it is not so natural to start a conversation about your activities, my activities.., can we support each other, I mean.. (..) it was very open, (..) there is no group goal."

From these comments it appears that people need some kind of shared understanding or a shared context to start a conversation about physical activity. As noted by participants, this could be achieved by setting some kind of group goal, which more clearly defines the group, possibly making it easier to start a conversation.

Other comments suggested that changing the group of people you use the application with could make a difference:

"(..) you might know each other's routines, also by seeing each other's data, but then I might know that those peaks in the weekend are because he is cycling."

And from a user from the private display group:

"Look it would have been different if uh.. if this tool had been used with people that.. (..), already did something with sports together (..) because then part of the relationship you have is already linked to activity, which is not the case now."

Provide a supportive social context

Some participants mentioned how it is not very common to start a conversation about physical activity when you are in a work related setting, especially when other people or not very familiar. A user from the private display group stated this as follows:

"In a work environment, (..) it is more than purely offering the possibility, a shared goal is needed, you have to put the right group together…"

A participant from the shared display group explained:

"You could better place it somewhere where people are busy with this topic. (..) I think this is not the priority what we are here for, we have a different priority here you know, just working."

And another participant from the same group mentioned:

"What I would like to have is one for my wife. That means that I, the two of us can do it together (..) you are here to work, but at home there you talk about your health, there you talk about eh…, well shall we go for a walk."

These comments teach us that supporting communication about physical activity in a work related setting is a more delicate matter than might be expected. Part of the hassle lies in colleagues not knowing each other well enough to start such conversations, and part of the solution seems to lie in providing a clear group goal, creating a shared understanding which makes it easier to approach each other and start talking about physical activity.

CONCLUSION

This research contributed to a better understanding of how an intelligent interface can help to improve personal health, by combining both aspects of physical well-being and mental well-being. We developed the argument that targeting the basic human need for relatedness can increase intrinsic motivation for physical activity.

The feasibility of using relatedness as a persuasive approach has been demonstrated with the design of an interface for monitoring physical activity of group members on a shared public display.

A field test of this application has shown the importance of group composition and of the context in which the application is used; these factors influence the ease with which conversations about physical activity are initiated.

The research presented addresses an approach to persuasion through social influence that has to date not been explored. While non conclusive, our results are encouraging for the use of relatedness as a motivating factor; on the basis of our findings it seems advisable to combine our approach with other ways of leveraging social influence that have been explored by previous research, such as competition,

cooperative goal setting, which can provide a shared context for the group of users. Combining such approaches in future intelligent interfaces has the potential to result in successful intervention programs for promoting physical activity.

REFERENCES

1. *World Health Organisation (WHO)*. 2009; Available from: http://www.who.int/dietphysicalactivity/pa/en/index.html.

2. Aron, A., Aron, E.N., and Smollan, D., *Inclusion of Other in the Self Scale and the structure of interpersonal closeness.* Journal of Personality and Social Psychology, 1992. **63**(4): p. 596-612.

3. Baumeister, R.F. and Leary, M.R., *The need to belong: Desire for interpersonal attachments as a fundamental human motivation.* Psychological Bulletin, 1995. **117**(3): p. 497-529.

4. Cialdini, R.B., *Influence: science and practice*. 5 ed. 1999: Pearson Education.

5. Consolvo, S., Everitt, K., Smith, I., and Landay, J., A., *Design requirements for technologies that encourage physical activity*, in *Proceedings of the SIGCHI conference on Human Factors in computing systems*. 2006, ACM: Montreal, Quebec, Canada.

6. Consolvo, S., Predrag, K., David, W.M., Daniel, A., Jon, F., Louis, L., Ryan, L., Keith, M., and James, A.L., *Flowers or a robot army? Encouraging awareness & activity with personal, mobile displays*, in *Proceedings of the 10th international conference on Ubiquitous computing*. 2008, ACM: Seoul, Korea.

7. Deci, E.L. and Ryan, R.M., *The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior.* Psychological Inquiry, 2000. **11**(4): p. 227-268.

8. Deci, E.L. and Ryan, R.M., *Self-Determination Theory: A Macrotheory of Human Motivation, Development, and Health.* Canadian Psychology, 2008. **49**(3): p. 182-185.

9. Fialho , A., Van den Heuvel, H., Shahab, Q., Liu, Q., and Li, L., *ActiveShare: Sharing Challenges to Increase Physical Activity*, in *CHI 2009*. 2009: Boston, Massachusetts, USA.

10. Fujiki, Y., Konstantinos, K., Colin, P., Pradeep, B., Ioannis, P., and James, L., *NEAT-o-Games: blending physical activity and fun in the daily routine.* Comput. Entertain., 2008. **6**(2): p. 1-22.

11. Guay, F., Vallerand, R.J., and Blanchard, C., *On the Assessment of Situational, Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS).* Motivation and Emotion, 2000. **24**(3): p. 175-213.

12. Hildebrandt, V.H., Ooijendijk, W.T.M., and Hopman-Rock, M., *Trendrapport Bewegen en Gezondheid*, T.K.v. Leven, Editor. 2006-2007, TNO Kwaliteit van Leven: Leiden. p. 1-338.

13. Lin, J., Mamykina, L., Lindtner, S., Delajoux, G., and Strub, H., *Fish'n'Steps: Encouraging Physical Activity with an Interactive Computer Game*, in *UbiComp 2006: Ubiquitous Computing*. 2006. p. 261-278.

14. Park, H. and Lennon, S.J., *Beyond Physical Attractiveness: Interpersonal Attraction as a Function of Similarities in Personal Characteristics.* Clothing and Textiles Research Journal, 2008. **26**(4): p. 275-289.

15. Plasqui, G. and Westerterp, K.R., *Physical Activity Assessment With Accelerometers: An Evaluation Against Doubly Labeled Water.* Obesity, 2007. **15**(10): p. 2371-2379.

16. Schutzer, K.A. and Sue Graves, B., *Barriers and motivations to exercise in older adults.* Preventive Medicine, 2004. **39**: p. 1056– 1061.

17. Toscos, T., Faber, A., Connelly, K., and Upoma, A.M. *Encouraging physical activity in teens Can technology help reduce barriers to physical activity in adolescent girls?* in *Pervasive Computing Technologies for Healthcare, 2008. PervasiveHealth 2008. Second International Conference on*. 2008.

18. Van Bel, D.T., Smolders, K.C.H.J., IJsselsteijn, W.A., and De Kort, Y.A.W., Social connectedness: concept and measurement, *5th International Conference on Intelligent Environments,* Amsterdam, pp. 67-74. IOS Press, 2009