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PersonA: Persuasive Social Network for Physical Activity

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Abstract— **Advances in physical activity (PA) monitoring devices provide ample opportunities for innovations in the way the information produced by these devices is used to encourage people to have more active lifestyles. One such innovation is expanding the current use of the information from self-management to social support. We developed a Persuasive social network for physical Activity (PersonA) that combines automatic input of physical activity data, a smartphone, and a social networking system (SNS). This paper describes the motivation for and overarching design of the PersonA and its functional and non-functional features. PersonA is designed to intelligently and automatically receive raw PA data from the sensors in the smartphone, calculate the data into meaningful PA information, store the information on a secure server, and show the information to the users as persuasive and real-time feedbacks or publish the information to the SNS to generate social support. The implementation of self-monitoring, social support, and persuasive concepts using currently available technologies has the potential for promoting healthy lifestyle, greater community participation, and higher quality of life. We also expect that PersonA will enable health professionals to collect *in situ* data related to physical activity. The platform is currently being used and tested to improve PA level of three groups of users in Pittsburgh, PA, USA.**

Physical activity, persuasive, smartphone, self-management, social support, social network

I. INTRODUCTION

Considerable evidence suggests that a moderate level of physical activity (PA) reduces the risks of coronary heart disease [1] and virtually all causes of mortality. Physical inactivity is also considered a risk factor for stroke [2], cancer [3], non-insulin dependent diabetes [4], and osteoporosis [5]. In the United States, the Surgeon General and Centers for Disease Control and Prevention (CDC) have developed guidelines to quantify the amount of PA required for healthy living [6, 7]. The guidelines state that, to maintain health, individuals with no known cardiovascular disease should accumulate at least 30 minutes of PA every day of at least moderate intensity for five or more days per week, or at least 20 minutes of vigorous-intensity aerobic PA for three or more days per week. During 2002-2004, despite the numerous benefits of PA and well-publicized exercise guidelines, only 38% of US adults engaged in regular leisure-time PA and at least 25% were completely inactive [8]. Worse still, during the following three years (2005-2007), only 30% engaged in regular leisure-time PA and at least 40% were completely inactive [9]. Furthermore, most individuals who did begin exercise programs did not continue [10].

Advances in PA monitoring devices provide ample opportunity for innovations in the way the information produced by these devices is used to encourage people to have more active lifestyles. One such innovation is expanding the current use of the information from self-management to social support. Evidence suggests that individuals in health behavior programs must be motivated to adhere to a regimen through monitoring, motivation, and support from community of interest (COI) such as health care professionals [11], friends, peers, and family. The social support itself has been widely implemented in health behavior programs and has shown positive impacts [12-14].

Considering the importance of social support in health behavior programs, researchers have been hard at work to develop social network systems (SNSs) specifically designed for health promotion. As a result, this effort has led to the creation of health related SNSs such as PatientLikeMe [15], DailyStrength [16], SecondLife [17], and Healia [18] that are being used by many today. Unfortunately, those SNSs largely depend on manual data entry that requires users to upload the content and to share it with other users. For example, when pedometer users want to share their PA information (e.g. number of steps) with peers for social support purposes, they have to upload the information manually to those SNSs.

We developed Persuasive social network for physical Activity (PersonA) that combines automatic input of physical activity data, a smartphone, and a social networking system. PersonA is designed to intelligently and automatically receive raw PA data from the sensors, calculate the data into meaningful PA information, store the information on a secure server, and show the information to the users as persuasive and real-time feedback or publish the information to the SNS for further social support purposes. PersonA is a general platform that can work on various health-intervention and rehabilitation applications using self-management and social support as the main strategies. From the technological perspective, the difference in these applications lies mainly in the data collected, information presented, and data point of input (POI), but they are generally the same in communication infrastructure and interface for information presentation. As the first leverage, PersonA is implemented in the promotion of PA using a smartphone-based pedometer application called SocioPedometer.

II. PERSONA DESIGN

A. Smart Phone and Social Networking Platforms

We use a smartphone as a pedometer for monitoring PA. Most current smartphones have two sensors (accelerometer and gyroscope) that can be used to generate PA information similar to that of a traditional pedometer. The use of smartphones for PA monitoring and encouragement is appealing for a number of reasons. First, they have widespread use; smartphones represent 12 percent of total global handsets in use in 2012 [19]. In the US, their use has steadily increased, with 35-36.4% of the population currently using smartphones, compared to 16.4% two years ago [19-23]. Second, the smartphone's constant proximity to the user means that users can perform self-management and social interaction at any time or place. The addition of positive social support from COI can amplify the smartphone's persuasive power. Third, the ongoing improvements in mobile computing power and internet connection allow for more sophisticated assessment, calculation, analysis, and intervention, which can be remotely processed on the device itself or on a server. Together with more convenient interaction features (e.g. bigger screen size, touch screen), these advanced functions may lead people toward better adherence and quality in health behavior programs. The innumerable opportunities to use smartphones in PA programs have led to several mobile applications for PA such as iTreadmill 3.1.0, iFitness Hero 1.0, and Exercise Tracker 1.12. Unfortunately, these ''apps'' are not based on established health behavior change theories and strategies, and most do not include evidence-based features such as reinforcement and goal setting [24].

PersonA uses Facebook as the platform for social support and networking. Facebook is the most widely used SNS in the world, with 845 million active users. Over 250 million users log in every day, and almost 72% of all US Internet users now use Facebook [25]. We utilize Facebook's social interaction functions that are open to third party applications. The third party can access Facebook functions through an open application programming interface (API), called Graph API. The API provides almost all functions necessary for the online interactions used in PA promotion. These functions include posting feeds, giving comments, authentication, security settings, and privacy/confidentiality settings.

PersonA is designed with self-management and social support capabilities required to promote PA. Those capabilities are proposed based on analytical study of theories and models concerning behavior change, as well as the intersection between behavior change and technology. These include the Health Belief Model, Theory of Planned Behavior (TPB) by Fishbein & Ajzen (1975, 1980), Social Cognitive Theory (SCT) / Self-Efficacy by Bandura (1977-2001), Technology Acceptance Model (TAM) by Davis and Bagozzi (1989, 1992)), and Fogg Behavioral Model (FBM) by BJ. Fogg (2009). An illustration of PersonA capabilities designed to meet the functional requirements is depicted in Figure 1. A detailed description of each capability and its screenshots follows this section.

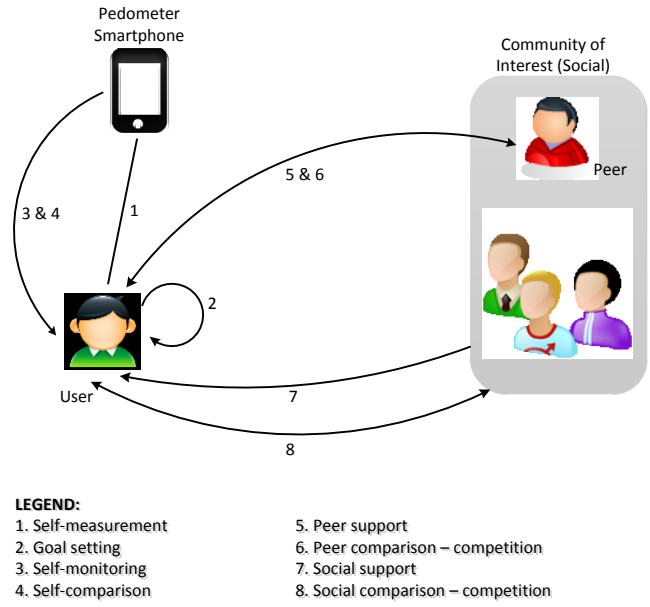

Figure 1. Functional Requirements

B. Self-management Capabilities

PersonA includes the four most important self-management capabilities: self-measurement, goal setting, self-monitoring, and self-comparison.

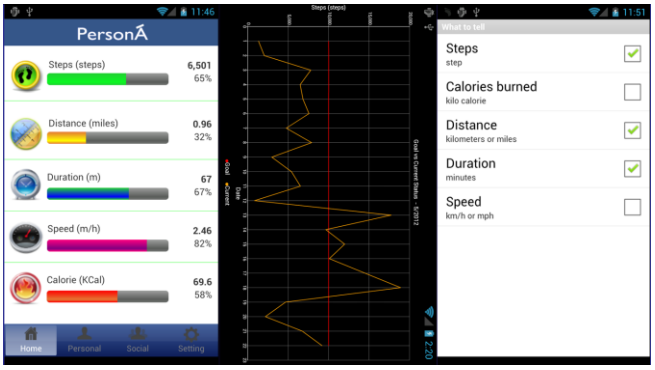

Figure 2. Self-management Features

1) Self-measurement allows expected PA data to be captured automatically using sensor devices and then transferred to a smartphone. Once the data are stored in the smart phone, they can be displayed as immediate and persuasive feedback. Alternatively, they can be sent to the health portal server for further analysis or for display on the portal side. The automatic data collection can potentially increase user's adherence to the PA program. It allows patients to measure their physical phenomena and to obtain reliable data with less dependency on health practitioners. Moreover, it reduces the users' effort and is more comfortable than a system with manual data collection.

2) Goal setting allows users to define a target that they want to accomplish. Using this goal setting capability, users can more easily set a realistic PA goal for a specific time. Before doing so, however, users can compare the new target with one that is already set. Comparing the two may encourage them to set and accomplish a better goal.

3) Self-monitoring helps users to monitor and compare the predefined goal against the current status. It also helps users to positively self-enforce a commitment to that predefined goal. The ideal scenario is that automatic, real-time data collection is available along with immediate feedback so that users know how far they are from their target. The self-monitoring chart (Figure 2 - left) shows how users can easily check the actual value for each activity item while they are performing a physical task. They can also monitor the progress they make by looking at the progress bar for each item and its percentage count, all on the same screen. The progress bar is used in order to convey the user's progress in the PA tasks. For example, Figure 2 (left) shows clearly that the user has reached 6,501 steps, which is 65% of the target.

4) Self-comparison allows users to monitor and compare their activity data over time. It provides a longitudinal chart which shows them a comparison between their target and its actual achievement; it also occasionally shows long-terms trends or even dips and spikes (Figure 2 - middle).

Being able to monitor all these activities may encourage users to perform better in PA. In relation to the implementation of persuasive concept in health behavior change proposed by BJ. Fogg (2003), the self-monitoring is part of an intrinsic strategy to persuade people to change behavior [26]. Using this strategy, PersonA motivates users by triggering the intrinsic drive in them, such as by setting goals, creating awareness, or by conditioning through positive reinforcement.

In addition to visual feedback, mobile PersonA also provides aural feedback. This aural feedback is implemented because real time feedback is needed when users are performing PA, and it is difficult to view feedback on smartphones while moving. The users can set up which information they want to hear and with what frequency (Figure 2 – right).

C. *Social Support Capabilities*

Social-support capabilities are designed to help users engage with peers or social networks that can positively affect their PA performance. The two most important social-support capabilities implemented in PersonA are peer-social comparison and peer-social support.

1) Peer-comparison and social-comparison capabilities compare individuals' current PA performance and target with those of others in the group, the group average, the larger community average, or the norm standard set by health practitioners. Figure 3 (left) illustrates a chart that compares the summary of a user's caloric expenditure with that of the social network. The chart also provides the comparison longitudinally. We expect that this kind of comparison will lead to rigorous social competition. This usually has a stronger persuasive effect on the involved individuals than a simpler comparison.

2) Peer-support and social-support capabilities allow users to support each other in performing healthier PA. Positive support activities include giving rewards or greetings for reaching a goal, sharing experiences or activities, and "liking" others' status or data. The user can choose to share data with a friend, a member group, or even all friends on Facebook. As an illustration, Figure 3 (middle) shows that users can share their selected data with members of a Facebook group. As with other standard posts on a Facebook wall, these posts can be liked or commented upon by friends of users. PersonA also provides users with a message archive where the users can access all related communication that they made using PersonA and perform further social interaction (Figure 3 – right).

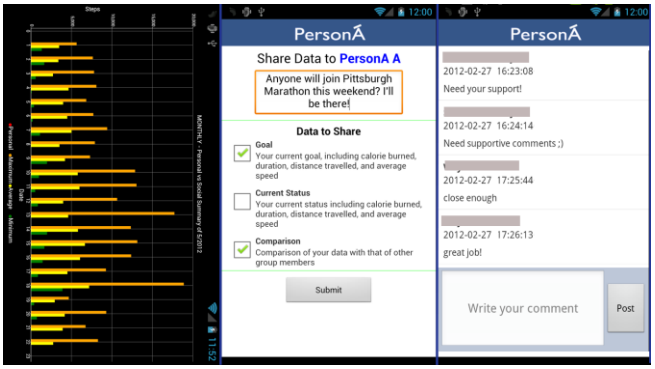

Figure 3. Social Support Features

It is expected that these positive social interactions would boost users' performance and increase the likelihood of their adherence to the program. In relation to the persuasive concept, the social-comparison and peer-support are part of an extrinsic strategy to persuade people to change behavior [26]. Using this strategy, PersonA motivates users to build on social psychology where other people are the source of the motivation, e.g. through competition, cooperation, or comparison.

D. *Persuasiveness*

To maximize PersonA's effectiveness in encouraging people's PA performance, the persuasiveness requirements of this platform are addressed using the following methods. First, PersonA is bundled with an application that has psychological and social value to the users. This is because an integration value increases the likelihood of adoption of a system to behavior change program [26, 27]. Thus PersonA is bundled with the most widely used SNS, Facebook. Second, the PersonA interface is designed to be as interactive as possible. This is because interactive experiences that are easily accessible and convenient have greater persuasive effects [26-28]. Third, PersonA is designed to have simple tasks. This is because task simplicity may increase user's adherence to a health promotion program [26, 27]. For example, automatic input in PersonA is simpler than paper-pencil or manual typing input. Fourth, in order to achieve an optimal result, PersonA will trigger users' attention when they are most open to persuasion by designing a system that gives immediate feedback, reminders, and greetings at opportune moments according to users' preferences, health professional recommendations, or specific contextual information.

In relation to the interface design, two of the four aforementioned methods guide the development of PersonA. These are: 1) interactive experiences that are easily accessible and convenient are more likely to persuade, and 2) the simplicity of tasks increases the chances of success. To achieve a simple but interactive interface, the data visualization of PersonA is developed in three themes: numeric, chart, and metaphor. First, the numeric theme is designed as a data dashboard which can help users read data at a glance and obtain an overall picture of the most important data. Second, the chart theme is designed to give a better understanding and interpretation of information presented, especially by comparing the data longitudinally or comparing data among variables. For example, a chart in Figure 2 – left clearly shows a comparison between the target and the current status. Sometimes, it also helps users see long-term trends or even individual dips and spikes (Figure 2 – middle). Third, the metaphor theme is designed as data visualization by which the abstract structure of the data is mapped onto perceivable and interesting representations that hopefully allow users to easily tease out interesting relationships or data structure. Moreover, users who are familiar with the metaphor can easily interpret data at a glance. Two glanceable metaphors are implemented in PersonA: aquarium and garden. These metaphors are chosen because they represent a positive reinforcement—the user is not punished for inactivity. Two relevant studies revealed that their subjects were very positive about the concept and confirmed that the display was understandable [29, 30]. The metaphor functions by making a user's aquarium or garden more beautiful and complete as that user becomes more active and approaches the target. For example, if the current PA status is between 60-80% of the target, the users within this range will have a more beautiful and complete aquarium or garden compared to those who are at less than 60% (Figure 4).

By giving this stratified interface based on PA performance, we expect that users will be encouraged to improve PA performance in order to have a more beautiful personal interface in PersonA. Unfortunately, because of the limited screen size and computing power, PersonA in smartphones only uses numeric and chart themes, while PersonA on the web uses all these themes.

E. Security and Confidentiality

Security and confidentiality in a health application is of paramount importance; thus, we implement the following methods to ensure that communication is secure and confidential. First, the authentication process requires a combination of the device's phone number, International Mobile Equipment Identity (IMEI) number, email address, and a Facebook account. Only devices with a proper and registered combination will be able to push data to PersonA and access information from PersonA. However, the web version of PersonA uses only a combination of email and Facebook account to authenticate users who want to access the information. Second, the communication framework of PersonA handles the encryption and authentication process. Third, the confidentiality setting of PersonA is inherited from the Facebook confidentiality settings. When users want to set up a public page for PersonA on their Facebook, it does so; the confidentiality inheritance also happens when the users want to set the PersonA page as a private page. By default, the health data will be privately protected, but summary data, such as maximum/minimum/average data, will be available for all members of the PA promotion group.

Figure 4. Aquarium Metaphor

III. DISCUSSION

The PersonA platform has been successfully implemented in the SocioPedometer application. The SocioPedometer is specifically designed to record PA (steps, energy expenditure, duration, and distance travelled) and to give online social-support capabilities to its users. The usability study and effectiveness study of SocioPedometer to increase PA are currently underway and the results will be presented in another paper.

A. Barriers to Adoption

Integration of e-health applications with Facebook could potentially increases the likelihood of adoption, but it also could potentially increase the users' security and privacy risks. This is because some health related data, even though not life-threatening, is attached to social interaction when using the Facebook functions in PersonA, and thus may be

exposed to the public. Another drawback of this platform is the battery life of most currently available smartphones, which only last for about 6 hours if the accelerometer and gyroscope sensors are always turned on to capture daily PA.

B. Future Development

The initial usability study identified a number of additional features suggested by users and clinicians. Those features include a live news feed showing current 'best performer' on each and every category, e.g. the highest energy expenditure of the week. This feature can then be combined with the capability of other users to give rewards or greetings. Another potential content for this live news feed is a list of users currently performing PA.

IV. CONCLUSION

PersonA is a new PA monitoring and promotion system. Its simplicity and interactivity provide users with the ability to easily record and monitor PA data; moreover, its seamless integration with the most famous social network system (Facebook) leverages the power of social influence to motivate positive PA behaviors among users. PersonA could also be a useful tool for assisting researchers and clinical professionals to collect *in situ* PA data to advance PA research. The concept and design of PersonA could potentially be extended to various health intervention and rehabilitation settings which use self-management and social support as the main strategies.

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