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Integrating Person-to-Person Social Support in Smartphone Apps for Promoting Physical Activity

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Abstract: The epidemic of physical inactivity is a major health hazard in the modern society, therefore creating effective and innovative health programs and interventions is important. This paper presents a novel approach in which person-to-person social support is incorporated in mHealth interventions for increasing physical activity. Social support is already used as a behaviour change technique in mHealth apps for influencing physical activity, but mostly offered virtually. While virtually-offered social support is efficient, we believe that person-to-person communication, based on personal coaching, might open a new way of influencing the inactive users and their motivation. Responding to this, we developed an Android application that facilitates physically inactive users to connect with a real life coach to receive person-to-person social support. This paper explains the motivation behind the system's design decisions and discusses the potential of social support in mHeatlh apps. In addition, we present the design of the evaluation study in which the hypotheses and research questions will be evaluated.

1 INTRODUCTION

Physical inactivity is identified as one of the major hazards related to many health problems including cancer, diabetes and heart diseases. Consequently, physical inactivity is the 4th global risk for mortality in the world, being responsible for over 3 million deaths annually, as reported by the World Health Organization [WHO] (2009). WHO recommends at least 150 minutes of moderate-intensity aerobic physical activity throughout the week for adults between 16-64 years. Alternatively, this age group should do at least 75 minutes of weekly vigorous-intensity exercises, or a combination between the two (WHO, 2017). Unfortunately, these guidances are not met by a significant proportion of the population (Hallal et al., 2012), resulting in a common interest of designing efficient health programs and interventions.

Meanwhile by 2018, over a one third of the world population is projected to own a smartphone, bringing the estimated total of users to almost 2.53 billion (Statista, 2017). As of June 2017, there were more than 3 million available smartphone applications (apps) at Google Play Store, almost 100000 of them were categorized as health & fitness apps (AppBrain, 2017). Apps are undoubtedly popular, easy to reach and offer cost-effective interventions, therefore they could be considered as promising tool for influencing human health.

van den Dool et al. (2017) have shown that 31% of the Dutch population uses electronic tools for sports and moving activities, out of which the apps were the most popular tool with 61% of total electronic tools usage. However, there is a remarkable contrast in tools usage between the sufficiently physically active users and the insufficiently physically active users, that we will refer to as inactives in the remaining part of the paper. The usage of tools among active people varies from 32% to 55%, depending on the type of active person, compared with just 12% of inactives, that have used any electronic tool for their sport activities. In order to indulge inactives to use health & fitness apps, there is a necessity to better understand their needs. van den Dool (2015) has investigated the behaviour of this population group, and proposed several guidances that inactives might find useful related to goal setting, skills, social support and personal coaching, as detailedly explained in Section 3.

Following these guidances, we have created an Android app that targets inactives and promotes physical activity intervention predominantly via real-life social support and having a personal motivator (coach). Social support is proven as a powerful tool for influencing people's behavior change and is al-

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ready applied in some health & fitness apps, but mostly offered virtually: via forums, online social networks or chat messages. While virtually-offered social support is efficient and was already linked with increasing physical activity among users, we believe that person-to-person communication, based on social support and personal coaching, could bring additional benefit for the inactives and their motivation. Therefore, in this work the virtually-offered social support was joined by an additional layer, one of real-life social support - our app promotes group exercises and support where dyad, a group of two people, can do joint exercises, indulge in real life communication and motivation. In the dyad, one individual being sufficiently physically active, is a personal motivator for the other individual, namely the insufficiently physically active person. The dyad members should have strong mutual social ties, being either friends, colleagues, family members or partners.

The goal in the first phase of this long term project, is to investigate the effectiveness and acceptance of applying (real-life) social support in mobile health (mHealth) interventions for increasing the physical activity among inactives. In addition, we will obtain the physical activity level (PAL) trendlines, and determine if there is an increase of physical activity for our participants over the experimental period. Finally, we would like to investigate the correlations between the PAL trendlines and the perceived social support via our app.

The remainder of the paper is organized as follows: Section 2 discusses the potential of using social support for physical activity interventions, especially in physical activity apps. In Section 3 we explain the motivation behind the Social Coaching app design choices, and give an extensive description of the app's modules. The evaluation plan is presented in Section 4, where we describe the planned experimental setup, the data nature and collection, followed by the analysis plan where we define our hypotheses. Finally, Section 5 ends the paper with a discussion.

2 BACKGROUND

This section starts by giving overview of previous research studies that explored the implementation of social support in physical activity apps. As real-life social support is often omitted when designing the apps features, we continue by explaining the influence that the social environment and real life contact might have on people's physical activity behavior. Finally, we present one way in which person-to-person communication could be integrated in apps, by explaining the concept of social accountability.

Social support is a complex term and has be conceptualized and defined from multiple perspectives. From the mHealth perspective, a valid social support interpretation is specified in the taxonomy constructed by Abraham and Michie (2008), that proposed a set of standardized definitions of the techniques most commonly used in behaviour change interventions. Social support, one of the 26 techniques described, is defined as ”prompting consideration of how others could change their behaviour to offer the person help or (instrumental) social support, including buddy systems and/or providing social support” (Abraham and Michie, 2008, p.4). The presence and effectiveness of social support as a behaviour change technique in physical activity apps has already been investigated. Matthews et al. (2016) investigated the pervasive technologies used in physical activity apps, concluding that social support is moderately represented, mostly via social comparison, social learning and competition. These techniques refer to comparing behavior and results between users, observing and learning from behavior of other users, and finally competing with other users. Another study (Bort-Roig et al., 2014) has identified social support networking as one of the most effective behavior change strategies for encouraging physical activity. King et al. (2013) tested the effectiveness of different motivational apps (analytic, social and affective) for increasing physical activity at users, and found the social app, being based on social comparison and social normative feedback, as most effective.

A common approach for the above examined apps is that they offer social support virtually, mostly via online social networks like Twitter, Facebook, or by creating online support communities. While applying virtual social support has already been shown to be effective, the potential of adapting the real-life social support via the social environment in mHealth interventions is usually left out. The social environment could offer social interactions that are missed in virtual social support, for example, observational learning. Observational learning for physical activity can be achieved by exercising with others and observing their behavior, that was shown useful to build positive social norms for physical activity (Ståhl et al., 2001).

People having low social support from the personal environment are more than twice as likely to exhibit sedentary behavior than those whose personal environment was highly supportive and motivational (Ståhl et al., 2001). Connecting with the nearest surroundings matter: having supportive partner, family and/or friends all contribute to increased physical activity (Eyler et al., 1999; Sternfeld et al., 1999). Social support interventions based on ”buddy” systems, having a ”contract” with others to achieve a certain level of physical activity, initiating walking or other types of sport groups, showing confidence in one’s ability, were all associated with increasing levels of physical activity (Kahn et al., 2002; Sternfeld et al., 1999).

Social accountability refers to ”a person’s awareness of another person’s goal and rendering himself/herself responsible to the goal’s successful fulfillment” (Chen et al., 2014, p.1). Personal coaching, where the coach observes and supervises the goal progress set by another person (coachee), could be one way of applying social accountability in mHealth interventions. This type of coach-coachee relationship could be used to integrate person-to-person communication in physical activity apps. Commercial applications are already using social accountability to help users achieve goals. CommitTo3 (2015) is an app in which users build social accountability groups, and try to motivate themselves in fulfilling three daily goals, by sharing their own progress and looking at other team members progress. In the GoalSponsor (2012) app, users appoint their own ”accountability buddy” to monitor and share their progress with. The HealthyTogether project explores mutual accountability in a gamification mobile app, their results showing that users improved their physical activity by 15% when using the app compared with when they were exercising alone (Chen and Pu, 2014).

3 THE SOCIAL COACHING APP

We present a ’Social Coaching’ app that offers a personalized social support experience for inactives. As mentioned in Section 1, our app design is inspired by the set of requirements introduced by van den Dool (2015), that suggested several approaches that might attract inactives to be more physically active, the most relevant for our app being paraphrased as follows:

1. Include skills that the inactives already possess or introduce them with less complicated new skills.
2. Define goals that are individual and where any progress is good enough.
3. Apply social support in interventions as this technique can keep users motivated for longer time and comfortable during the exercise.
4. Have a personal coach as this can be helpful to overcome the initial obstacles.

The following subsections discusses the app functionalities, and the technology behind the app.

3.1 Social Aspects between Dyad Members

The dyad is composed by two individuals having strong mutual social ties: family members, partners, friends or colleagues. The dyad members are:

- Coachee - user that does not meet the minimum 150 minutes/week WHO requirement. Supported by the motivator and using the app, the coachee wants to improve its physical activity.
- Motivator - user that does meet the minimum 150 minutes/week WHO requirement. The motivator should help the coachee in the process of becoming more physically active.

As shown in Section 2, the social environment and having supportive partners, family or friends were all associated with increasing physical activity, therefore socially tied dyads are preferred. The dyad is teamed before participants are joining the experiment, it is a responsibility of the coachee to decide whom to team up with - preferably the coachee will choose a supportive person as the motivator.

The relation between our dyad members is implicitly based on the social accountability factor introduced in the previous section - even though the exercise results are team based, there is one dyad member, the coachee, that wants to accomplish a goal, and another dyad member, the motivator, that is aware of this goal and tracks the goal progress.

The motivator should be a person who is already physically active, therefore has awareness of the benefits of being fit. Driven by the positive effects of observational learning for physical activity as discussed in Section 2, we assume that having a ”role model” motivator type can be helpful for the inactives.

3.2 Exercise Types

Following the first requirement (related to skills), the app promotes and records dyad’s walking and / or running exercise sessions. Walking and running are chosen as physical activities because they do not require any specific equipment, are budget friendly and have significant health effects if performed regularly.

The users could obviously do other types of physical activity during their day. In order to have this information, the app supports manual logging of any other physical activity types, as we want to take in consideration all the activities that might influence user’s PAL.

3.3 Goal Setting

The dyad sets weekly goals expressed in number of meters of weekly walk and/or run. Before confirming the goal, the app gives a pop-up message showing the approximate total time in minutes for achieving that weekly goal. Considering the second requirement (related to goals), explicit goal recommendation is inappropriate. The goals are set by the coachee, according to the ambition for the upcoming week, and possibly, upon consulting the motivator. The app implicitly influences the coachee's goal setting strategy by showing the WHO recommendation of 150 minutes of moderate-intensity physical activity per week as a reference point for the user. We have used this particular reference point, as the app promotes walking and running, that are both considered moderate-intensity exercise types, making them a suitable choice for the inactives. Users can track their goals on the app's home screen where we visualize pie charts of the current weekly progress, presenting the percentage of the remaining/accomplished goal. Moreover, in order to support a timeline of the physical activity progress, the app has a history screen that provides the dyad members with a retrospective view of their weekly walking / running goals accomplishments and their individual exercise session records over the weeks.

3.4 Contract Agreement

Before they are allowed to exercise, the dyad members needs to 'sign' an exercise contract. This virtual contract is imagined as defining the available free slots by both team members, during the week, that would ideally be dedicated for performing team exercise. The time slots should bring more responsibility at both the motivator and the coachee "to stick to the plan", as having a behavioural contract for a certain amount of exercise was already related to increase of physical activity (Kahn et al., 2002). The dyad members can initiate exercise at any time, regardless the time slots that are defined in the contract agreement.

3.5 The Exercise Session

The exercise session is imagined as team activity, where the motivator and coachee walk or run together. The exercises can be initiated by both the motivator and the coachee, upon mutual agreement. These exercises are an opportunity for the motivator to support and teach the coachee. During the exercise session, the app shows the progress made by the coachee in time and meters passed, to both members of the dyad. Therefore, the motivator is able to real-time track the progress that the coachee is making and give instant feedback, while the latter can simply "forget" about the phone and relax on actually performing the exercise. After each exercise, the app displays a short questionnaire to the coachee, related to satisfaction with the exercise and the team communication during the exercise. When exercising together is not possible, the coachee can individually perform the exercise session, and the motivator will be notified about the end result.

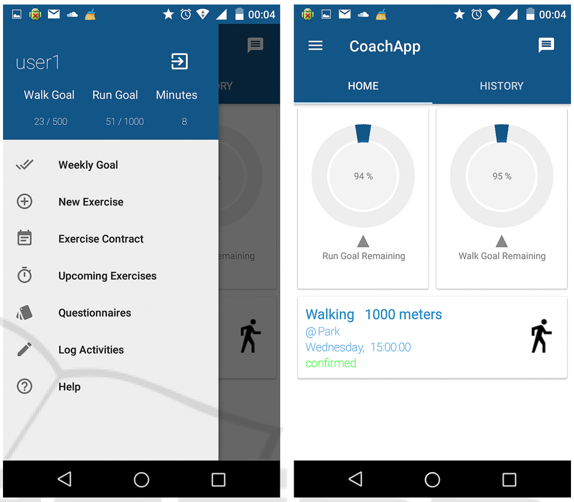

Figure 1: Social Coaching app screenshots. Left screenshot shows the different menu options, related to weekly goal setting, initiating new exercises or logging extra exercises. The right screenshot displays the home screen, where the user can reflect on his weekly goal progress and see information about upcoming exercises.

3.6 Chat Feature

The dyad can communicate to each other using the chat feature. Having the messaging feature can be beneficial for the dyad to ease and enrich their communication. The frequency of messages exchanged was already linked to increase of physical activity (Chen and Pu, 2014).

3.7 App Communication with End-users

The app has a rather passive communication with the users. This is a conscious design decision, since we aimed at keeping the app interaction with the users at minimum, as our goal is to investigate how the real-life social support works for the coachee. However, the app does communicate using notifications, and there are several of them, mostly directed toward the motivator. Sending these notifications, the app can be

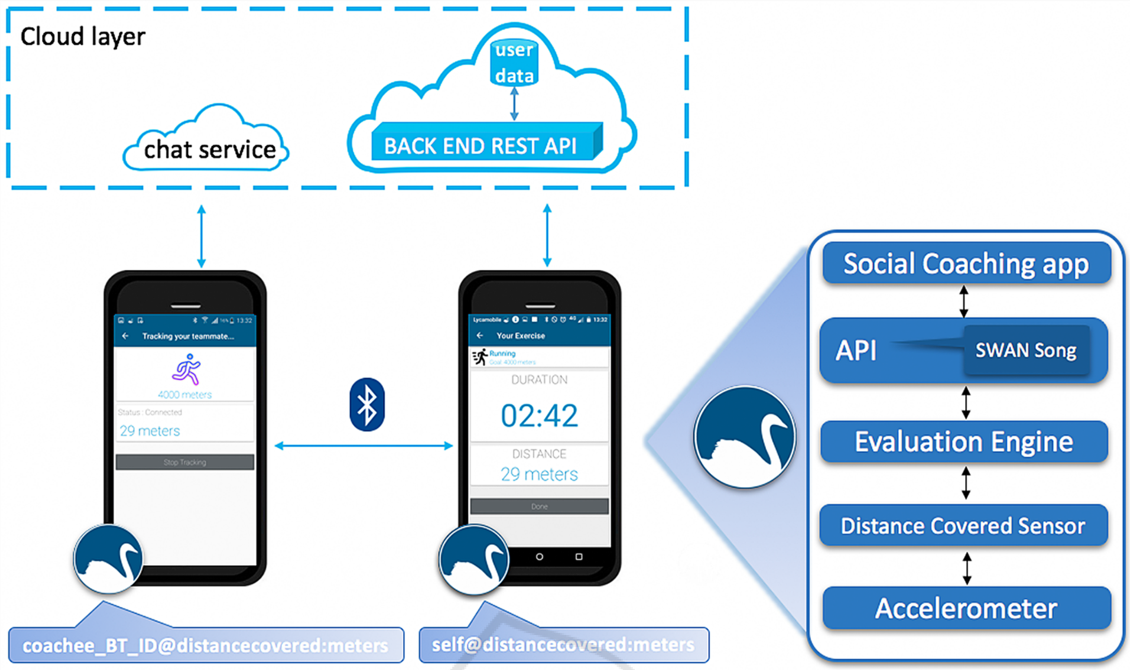

Figure 2: Architecture of the Social Coaching app. The app is supported by SWAN, an open source framework for building context aware Android apps. SWAN enables offline real-time sensor data sharing between smartphones via Bluetooth, a feature used for the exercise sessions of the app. In addition, the cloud layer is used to store and retrieve the app's data.

considered as a rudimental virtual coach for the motivator: it reminds the motivator to send motivational messages to the coachee in case this was not done yet during the day, it reminds to initiate new exercise in case when the dyad has a free slot assigned for that particular day, and finally it notifies if the dyad did not do the planned exercise.

3.8 Technologies and Tools

The Social Coaching app is an Android based app. We chose the Android platform due to its big market share and wide acceptance among smartphone users. The app is supported by a back-end API system, built using the Play Framework and deployed as a Heroku cloud application. The REST API calls are used to store and retrieve information to/from the cloud database (Heroku Postgres database), that contains all the app related data, except the chat messages. To deploy the chat we used Google Firebase and stored the chat messages in the Firebase Realtime Database.

One of the biggest challenges we faced during the app development was how to build an exercise tracking system, that can work in offline mode, has low battery consumption and enables real-time sharing of exercise progress between the coachee and the motivator. We have used the open-source SWAN project (SWAN, 2010), a framework for developing context-aware Android apps, in order to manage the smartphone's sensor data processing during the exercises.

SWAN runs as a background service and can be simultaneously accessed by multiple Android apps on the phone. SWAN creates powerful abstractions for managing the otherwise complex (Android) sensor APIs: it supports smartphone sensors, software sensors (e.g. open-source weather API data) or external sensors connected to the smartphone (e.g. wearables data via Bluetooth). SWAN offers more than 20 predefined sensors, moreover the developer can easily plug-in any new sensor to the framework according to the application needs. As example, in order to satisfy our application requirements, we have manually created the Distance Covered sensor that uses the smartphone's accelerometer sensor data obtained during the exercise and translates it to number of steps, using the Pedometer (2013) app's open source step counter algorithm. The number of steps are then represented in meters depending on the walk/run stride length of the coachee.

Context-aware apps communicate with SWAN using the SWAN API to register and unregister sensor expressions. These expressions are build using the domain specific language of SWAN: the SWAN-Song. In our app we use the following sensor expression for calculating the distance covered during the exercise session, at the coachee phone:

```
self@distancecovered:meters
```

where the first component indicates the source of the sensor - *self* means that we get the data locally from the smartphone. The second component defines the sensor, which is the Distance Covered sensor in our case. Finally, the third component specifies the value of interest within the chosen sensor, in our case we are interested in the number of meters, obtained from the Distance Covered sensor.

On the motivator side, during the joint exercises, we want to show the real-time progress of the coachee. SWAN supports Bluetooth-enabled data sharing between phones, as simple as registering a sensor expression in the following manner:

```
coachee_BT_ID@distancecovered:meters
```

here the source of the sensor is the coachee's Bluetooth MAC address, meaning that we are interested in getting the meters of the Distance Covered sensor from the coachee's smartphone. After the Bluetooth connection is established, the motivator will be able to see the coachee's real-time progress on the screen.

Once the expressions are registered, they are evaluated on every new sensor event, using the Evaluation Engine. The Evaluation Engine sends broadcast messages to the app, whenever it needs to notify sensor data changes. The sensor data is read until an unregister event is called, for example, when our users finish an exercise session.

4 EVALUATION PLAN

4.1 Experimental Setup

The proposed app in this paper will be evaluated in a user experiment, to test if promoting real-life social support via mHealth apps can be considered as an useful tool for physical activity interventions. There is no control group (i.e. dyads without the app), as the aim of the experiment is broader than comparing the effectiveness of using such a system with face-to-face coaching.

The goal of our experiment is to investigate the feasibility of real-life social support via an app. We will do this in a small user study of approximately 50 participants, i.e. at least 25 dyads, in which we both look at the user experiences and the change in physical activiity. At the time of writing this paper, we have three dyads that have already started the experiment. The ongoing recruitment is done via online tools like websites, forums, social media, and by recruiting at the university campus. The participants should be between 16-64 years old, similar to the age group specified by WHO in Section 1, be healthy enough to perform physical activities and possess an Android smartphone.

In order to get additional step-based physical activity data, each participant will be given an activity tracker, a Fitbit One device. This is a sufficiently reliable activity tracker for continuous measurement of physical activity (Takacs et al., 2014; Paul et al., 2015), and will be used during the whole experiment duration, as a support tool besides the apps.

Before the experiment, the participants will answer online questionnaires regarding team relationship; personality traits; and current physical activity status, motivation and goals. The overall participation will take 5 weeks, with one week of assessment period and four weeks of intervention period.

For the assessment week, the participants will install the ActivityLogger app, a simple physical activity diary app, where they will log their individual exercises over the period of 7 days. We will use the data obtained from this app, combined with the activity tracker data, to determine the pre-intervention PAL for each participant. This approach will give us more reliable and accurate baseline for determining the initial PALs of the participants, compared to using physical activity self-assessment questionnaires like IPAQ (Lee et al., 2011). Using the initial PAL values of our participants, we can test if the dyad indeed consists of one sufficiently active person and one insufficiently active person.

After the dyads are confirmed, the participants will enter the four weeks of intervention period, during which they will use the Social Coaching app, supported by the activity tracker. At the end of the intervention period, the participants will be asked to fill another set of questionnaires, regarding their satisfaction of using the app as a tool for increasing their physical activities, focusing on the social support context of the app.

4.2 Data Collection

We are interested in gathering relevant data regarding physical activity and perceived social support. The physical activity data is collected via the Android apps, and the activity tracker, and enables us to calculate the PAL of each participant. The pre-intervention PAL value will be calculated combining the data from the ActivityLogger app and the activity tracker. During the intervention period, the PAL will be obtained on weekly basis, by gathering the data from the Social Coaching app and the activity tracker. Using these PAL values we will calculate the PAL trendlines of each participant, which will be then used in the analysis. The activity tracker enables data extraction in spreadsheets, where we will obtain daily information about number of steps, distance in km, floors climbed; and number of lightly, fairly and very active minutes over the day. The ActivityLogger app will provide information about exercise type, duration and date. The Social Coaching app gives data about exercise type, time spent in exercise, number of meters, date for the walking and running sessions. In addition, this app allows the user to log extra exercises (besides walking and running), in a similar way as in the ActivityLogger app, therefore an additional data about exercise type, duration and date, will be obtained for them.

The Social Coaching app, will further give us insights about the perceived social support. The social support factor will be calculated by quantifying the communication patterns between dyad members, and by using the app questionnaire responses. We have identified several suitable data sources for calculating the perceived social support: the frequency of joint exercises; frequency of chat messages and sentiment analysis of the messages; weekly questionnaires about dyad satisfaction sent as notification; after exercise satisfaction questionnaire sent as a notification to the coachee.

Additional data will be collected via online questionnaires both before and after the experiment, as explained in the previous subsection.

4.3 Analysis Plan

The multidimensionality of the collected data will give an opportunity for data analysis from different perspectives. Calculating the individual PAL trendlines, as explained in Section 4.2, will help us determine if there was an increase of physical activity at the participants, during the experimental period. We will test the significance of the PAL trends using Mann-Kendall (MK) trend tests, that can statistically access trend presence in a variable over time. Moreover, we will investigate the correlation between the PAL trends and the perceived social support over time. For this, we have defined several hypotheses:

H1. Inactives that show satisfaction of the perceived social support will show an increase in PAL trends.

H2. Inactives that show dissatisfaction of the perceived social support will not show an increase in PAL trends.

H3. High frequency and positive sentiment of exchanged messages between dyad members, will result with increase in PAL trends at inactives.

H4. Low frequency and negative/neutral sentiment of exchanged messages between dyad members, will not result with increase in PAL trends at inactives.

These conditions will be tested by performing MK non-parametric tests for statistical dependence.

Finally, we would like to investigate the acceptance of applying (real-life) social support in mHealth interventions for increasing the physical activity among inactives. In order to answer this, the participants will be given questionnaires regarding app usability and acceptance, with special emphasis on the (real-life) social support context of the app.

5 DISCUSSION

This paper presents a novel approach in which person-to-person social support is incorporated in mHealth interventions for increasing physical activity. In order to fight the epidemic of physical inactivity, innovative and effective tools which are accepted by end-users are required. Real-life social support via personal coaching has the potential to motivate inactives, but is hardly used in mHealth apps. In this work we focused on explaining the design decisions behind the system and we discussed the potential of social support in mHeatlh apps. Furthermore, we have introduced our evaluation plan in which the hypotheses and research questions will be evaluated.

There are several considerations for future work, inspired by the current limitations of our research, that we would like to discuss. The social context play key role in this research, and we can imagine incorporating different social interactions, in addition to the current dyad relationship, for example:

- create groups of arbitrary number of members, for example enable the coachee to have more than one motivator.
- match with an anonymous person instead of a person from the social circle.
- instead of having a motivator, match inactive persons with each other.

With these combinations, we could test different types of social interactions, which is important in order to find the ideal combinations of motivators and coachees.

One important aspect that could influence the perceived social support by people, is the effect of social comparison. Not all people get motivated by having a role model that performs better then they do. Some individuals gets more motivated by comparing themselves with others performing worse (downward social comparison), and other individuals are motivated by comparing themselves with someone who is better then they are (upward comparison). We would like to consider this theory when thinking about supporting new social ties types.

Finally, the focus of this research is on the inactives, but in order to have an effective intervention that is based on social support, we should consider the satisfaction of the motivators as well. We have build the current app under the assumption that the motivators will use the app in order to help their acquaintances, but the question is what will keep them motivated to use the app for a longer period? One possible approach is to extend the app by implementing gamification elements, i.e having rewards, trophies, challenges, or the possibility to compare their performance with the performance of other motivators.

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