Comparing Competition versus Cooperation Based Gamification Systems in Promoting Moderate Physical activity

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Abstract

Often, moderate physical activity tasks such as daily walks are not highly arousing. At the same time, they provide many health benefits for individuals such as maintaining an ideal bodyweight and improving energy levels during the day that allow people to concentrate. It also lowers the chances for health problems such as strokes, type-2-diabtes and vitamin D deficiency. To make daily walks more arousing and engaging the current study aims to develop a paper prototype application that promotes gamification. From an application designer perspective, it is important to create a game that caters to the intended audience and the feedback provided by the game needs to motivate people to walk. At the same time, it is important to account for individual differences by using a personality measure since motivation varies based on the person. To examine feedback while controlling for individual differences, the current study also aims to compare how gamified competitive and cooperative feedback structures are affected by social value orientation levels. The gamification prototype was developed by setting various capture points within the TU/e campus and providing each participant with a manual that contained instructions and a map with the capture locations. To measure social value orientation, participants were asked to perform a theoretical resource allocation task before the start of the study. The study lasted for 9 days; 4 days of control and 5 days of intervention. During the study, participants had to capture the locations on the map by taking pictures and sending these locations via email. In the intervention participants were randomly assigned to receive competitive or cooperative feedback while playing the capture game. The results indicated that although participants generally found the experience enjoyable, there were no statistical differences between the competition and cooperation conditions and there was no statistically significant interaction effect between social value orientation and participants' assigned condition. Reasons for lack of effect could be because of daily variations in weather, participants combining their walks in groups and the restriction for performing the daily walks on campus and the nature of the social value orientation task. Future research could implement a mobile version of the prototype and perform an iterative design cycle based on user feedback.

Keywords: gamification, social value orientation, step count, competition and cooperation, daily walks, physical activity

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In recent years, there has been an increase in the number of people who use digital devices to receive physical activity feedback through user-interfaces such as smartphone applications (Paul Hover, 2017). Physical activity tasks such as walking at a moderate pace might not contain any interesting objectives so gamifying the smartphone application can provide an immersive interactive user experience to help people maintain active. The concept of gamification is defined as the use of game design elements in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011). If designed properly, gamification can improve motivation and engagement towards performing regular daily activities (Schoech et al., 2013). Gamification has impacted many subject areas including e-commerce, education and health (Hamari, Koivisto, & Sarsa, 2014). Over recent years, more gamification research is being done in the context of health and wellbeing (Johnson et al., 2016). Many smartphone applications, such as Zombies Run!, and Fitocracy have also started incorporating game design elements to promote healthy lifestyle.

Pokémon GO is another particularly successful application that provides users with in-game rewards if they physically walk to certain locations. Although the primary goal of Pokémon GO is not to promote physical activity, the popularity indicates that location-based games are able to indirectly motivate some users to stay active. A recent study tested a similar effect by digitizing the concept of a stamp rally in Japan to motivate elderly people to take regular walks (Takahashi, Kawasaki, Maeda, & Nakamura, 2016). In a stamp rally, a person reaches a target location and is consequently rewarded with a stamp unique to the target location. Although the study was received positively and showed evidence of increasing motivation, it takes a more quantitative approach by measuring step count and performing statistical tests. It is also well established that if a physical activity is goal-oriented, performance can be greatly improved (Munson & Consolvo, 2012). In terms of goal-setting, a well-known study states that it helps to set a realistic goal that is important to the particular individual and easily allows the individual to monitor progress (Locke & Latham, 2002). In games, one study concluded that progress in the form of points provided the largest improvement in individual performance given that the points provided feedback relevant to the individual's goal (Lopez & Tucker, 2017). A recent literature review reported that gamification can have a positive impact on health and wellbeing (Johnson et al., 2016). Most of the studies in the literature analysis also contained points and rewards elements, with a particular focus on improving individual progress, or progress in a multiplayer competitive context but a cooperative context could also be interesting. As an example, looking at the gaming industry League of Legends, a game with a 100 million monthly player base also incorporates cooperative elements to achieve goals. League of Legends is a 5v5 battle arena game where a team of five closely cooperate to defeat the opposing teams throne. With such success in the gaming industry, it is interesting to compare how a cooperative gamification system compares to a competitive system in a non-game context to help people stay active. Many meta-analyses suggest that cooperation is favored over competition in a general context (Beersma et al., 2003) but strictly comparing which one promotes more physical activity could help fitness application developers make design choices. The current study focuses on how competition and cooperation influences physical activity through a location based paper prototype game. While competition and cooperation could influence physical activity, their influences could be moderated by the individuals that play the game. For instance, if a person is prosocial and placed into a competitive setting, the person might not be motivated by the game design to perform more physical activities. Therefore, it is important to measure how *social value orientation*, or the individual levels of prosocial, individualistic and competitive orientations moderates the effectiveness competitive and cooperative gamification systems. The current study monitors how individual social value orientation moderates step count while performing daily walks. If social value orientation is indeed a moderating factor, measuring it for each user could also provide developers with valuable information on balancing the cooperative and competitive elements to optimize user experience.

Competition and Cooperation in Gamification

In gamification, a number of studies investigate how competition and cooperation are influential in different contexts. One fourteen-week study looked at how game features influenced physical activity (Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006). In the study, participants were divided into groups of four and each group was given a virtual fish tank which increased or decreased in activity based on respective increase or decrease in group step count encouraging competition between teams. To encourage cooperation within the team each participant was assigned a given number of fish in the tank which affected the fish tank based on individual step count. The study used a qualitative approach of analysis, by applying Prochaska's Transtheoritical Model. The Transtheoritical Model attempts to explain individual readiness to act on a new behavior as individuals advance through six discrete stages ranging from no intent for behavior change, to never returning back to the old behavior (Prochaska & Velicer, 1997). The study applied this model by initially classifying participants into the six stages based on initial opinions towards behavior change. The participants were subsequently interviewed after the intervention to see if they changed stages. The results suggested that the added responsibility of caring for the fish presented a stimulating challenge and promoted competition. Although this was the case, it is not possible to distinguish the specific cooperative and competitive conditions that instigated this stimulation since no clear separation was made. Another study tested a game where step count goals were geographically mapped onto a virtual route which allowed participants to visualize step counts (Ali-Hasan, Gavales, Peterson, & Raw, 2006). The game also presented the option to set an individual step count goal or a group goal, in order to satisfy both individualistic and team-oriented participants. The study used an iterative user-centered design where participants were interviewed on their opinion about the game. Similar to the previous study, although participants mentioned that the added options invoke competition and cooperation, the conditions were not separated. Furthermore, the results did not compare changes in physical activity between the baseline and intervention. It could be argued that the design was focused more on application development but the researchers tested a paper-prototype that was not ready for application development.

In addition to the previous two qualitative studies, there are also three studies that provide quantitative analyses with similar conditions to the current study, which allow to draw causal conclusions. The first study tested how goal structure (competition vs cooperation) and participant relationship type (friends or strangers) influenced performance in a hand-eye coordination game (Peng & Hsieh, 2012). Participants were presented with the challenge to pop virtual balloons on a computer using a mouse within a specified time limit. The conditions consisted of three game modes: individual mode for baseline measurements, multiplayer cooperative where the group score and individual participant score were shown and a multiplayer competitive mode where participants competed against each other and the individual participant score and game handicap (used to match individual skill levels while competing) were shown. The participant's performance was measured by the total number of balloons popped in the given time and an ANCOVA was used to compare the independent modes. No direct effects on performance were found but the study concluded that more effort was put into the game in the cooperative condition. The experiment was only performed once in a lab setting which makes it hard to inform any daily life interventions. A second 11-week study tried to see how a competitive and collaborative problem-based learning approach influenced coursework marks (Arnab et al., 2016). Participants were assigned to the competitive, cooperative or control condition and their final marks, posts, likes and visits were monitored. A series of one-way ANOVAs concluded that people in the competition setting outperformed those in the collaborative setting. According to the authors, the participants were sport psychology students who were naturally more competitive than other students and they stated that the subject area being studied could influence competitiveness but no further investigations were performed on this prediction. The final study tested competitive, cooperative and hybrid conditions to understand changes in physical activity and shared the closest resemblance to the current study (Chen & Pu, 2014). An activity tracker recorded the step count and floor count (number of stairs walked) of a pair of participants (called dyads), and dyads earned badges differently for each condition. In the competitive condition, participants earned badges if they walked more than their partner whereas in the cooperative system, both participants in the dyad needed to walk an equal amount to progress. In the hybrid system, one participant needed to contribute more than the partner. A set of paired-sample t-tests were conducted and the results indicated that the cooperation (23% increase in physical activity level) and hybrid (18% increase) conditions outperformed competition (8% increase). The study can be improved in three aspects. Firstly, the study used dyads which cannot be directly applied to a group situation. Secondly, the study does not look at individual social value orientation toward competition and cooperation. Thirdly, the outperformance is in relation to the baseline condition, the study does not test whether the difference between the competition and cooperation conditions was statistically significant.

Table 1

Past Literature on Gamified Competition and Cooperation Structures

Title	Type of Study	Results on Competition and Cooperation	Design and Results Analysis
Fish'n'Steps: Encouraging physical activity with an Interactive Computer Game	Qualitative: Prochaska's Transtheoritical Model	"For a majority of the participants, having other fish presented a stimulating challenge and a benchmarking mechanism. Many of them compared their own virtual character's states, moods and sizes to those of their team members and were aware of their comparative performance." (Lin et al., 2006)	The study does not separate the competition and cooperation conditions
Fitster: Social Fitness Information Visualizer	Qualitative: Iterative user-centered	"By enlisting teams, these games facilitate both teamwork and competition, which were mentioned by our users as missing social aspects from their current fitness activities" (Ali-Hasan et al., 2006)	No comparison of physical activity and competition and cooperation conditions are not separated
The influence of competition, cooperation, and player relationship in a motor performance centered computer game.	Quantitative: ANCOVA	"The cooperative goal structure was found to lead to greater effort put into the game than the competitive goal structure." (Peng & Hsieh, 2012)	No direct effects on performance were found and used a single time observation in a lab setting was used.
HealthyTogether: Exploring Social Incentives for Mobile Fitness Applications	Quantitative: Paired sample t-test	"Among the group settings, cooperation (21% increase) and hybrid (18% increase) outperformed competition (8% increase)." (Chen & Pu, 2014)	Uses dyads, does not look at individual social value orientation, physical activity only compared to baseline.
Competition and cooperation using a social and gamified online learning	Quantitative: Series on one-way ANOVAs	"It is clear that for those in the Collaborative condition were significantly lower when compared to those in the Control	Sport psychology students demographic influenced the

Title	Type of Study	Results on Competition and Cooperation	Design and Results Analysis
platform		and Competitive conditions and consequently further investigation into the reasons for this anomaly are required.” (Arnab et al., 2016)	results.

Social Value Orientation

Since we are interested in social value orientation as a moderating factor, it is important to understand the concept and how we measured social value orientation. Broadly speaking, social value orientation is defined as how a particular individual prefers to distribute a finite resource in a group. Individuals are typically categorized into three social value orientations namely; individualistic, competitive and prosocial. If a person is individualistic, he wants to maximize his own resources whereas if a person is competitive, he wants to maximize his own resources while minimizing group resources. If a person is prosocial, he wants the resources to be allocated equally amongst the group. In 1968, a study formalized the notion of social value orientation by observing individual resource allocation behavior in a set of decomposed games related to game theory (Messick & McClintock, 1968). In the original experiment 180 participants were placed into dyads where the members were either given a partner condition or an opponent condition. Participants were further split up into three separate conditions to receive one of the following feedback systems: their own total score (individualistic), the joint total score (cooperative) or the difference between each other’s total scores (competitive). Although the results did not find any differences between the partner and opponent condition, the feedback system had a significant impact on individual points scored.

Social value orientation can be measured by replicating this experiment but more time efficient measures have been developed. Some previous measures introduced lacked sensitivity due to low resolution output (Van Lange, Otten, De Bruin, & Joireman, 1997) whereas other previous measures were inefficient in measuring exact individual differences (Liebrand & McClintock, 1988). One study created a continuous social value orientation measure that consisted of six primary and nine secondary (optional) measurement items (Murphy, Ackermann, & Handgraaf, 2011). Participants were provided with a score that classified them into a competitive (low score), individualistic or prosocial (high score) value orientation. The slider score is also used in the current study for two main reasons. Firstly, the slider measure is continuous whereas discrete measures produce categorical data that could potentially discard valuable information. Secondly, the authors obtained solid psychometric properties while comparing the slider to other social value orientation measures making this a viable option.

Although there are no studies that directly incorporate social value orientation research in gamification, there is one study that revealed that motives that underlie a particular choice rating, increased the most when they corresponded with the raters social value orientation (Joireman, Kuhlman, Van Lange, Doi, & Shelley, 2003). In this study each participant was initially assigned a social value orientation based on the decomposed games task similar to the study that originally formalized social value orientation (Messick & McClintock, 1968). Subsequently, the participants had to rate a set of choices on rationality, power and morality. The choices varied in degrees of altruism, cooperation, competition and aggression. The results suggested that participants chose options that closely represented their social value orientation, especially while rating rationality. Although the current study does not present the individuals with choices, it still suggests that social value motives influence the condition. In particular, participants with a prosocial orientation would prefer the cooperative condition while those who are competitively oriented would prefer the competition condition. People with individualistic orientation would prefer the no game option.

Current Study

The current study aims to compare the effectiveness of using competitive versus cooperative gamification in promoting moderate physical activity and how individual social value orientation moderates the effect. Based on the literature review we derived the following hypotheses:

Hypothesis 1: When participants are placed in the cooperative condition they will walk more on average than when placed in the competitive condition, resulting in a relative increase in moderate physical activity.

Hypothesis 2: Participants who scored either low (competitive) or high (prosocial orientation) in the social value orientation survey will be likely to walk more steps on average in the competitive or cooperative conditions respectively (condition by SVO interaction effect).

Gamification Prototype

The gamification prototype was developed in order to answer our research topics and hypotheses. At the introductory meeting, participants were provided with a manual explaining the entire procedure. The participants have the objective to capture as many locations as possible to compete against fellow participants in a capture-the-flag style game. Participants are provided with a map of the university campus with indicated target locations. Participants can capture as many locations as possible but if they capture more locations and walk a further distance their total score increases. In the cooperative condition, this translates to a higher overall contribution whereas in the competitive condition, it translates to a higher individual rank. The prototype and the maps can be seen at the end of Appendix A.

Method

Experimental Design

At the start of the study participants had to fill in a short survey to measure baseline social value orientation levels. The survey indicated if participants were oriented towards prosocial, competitive or individualistic behavior. The social value orientation levels are particularly important to help validate hypotheses 2 since it provides an estimate of participant compatibility with their assigned condition. The study uses a mixed design consisting of two periods taking a total of nine days. During the control period participants were asked to play the location capturing game but they were not provided with feedback. This period lasted for four days after which participants were randomly assigned into the competition condition or the cooperative condition and entered the intervention period. During the intervention period, participants were provided with feedback on the distance walked after each session. After the intervention period individual, physical activity was compared between the competition, cooperation and control conditions along with the moderating social value orientation to validate hypothesis 1 and 2. Figure 1 provides an overview of the experimental stages.

Experimental stages

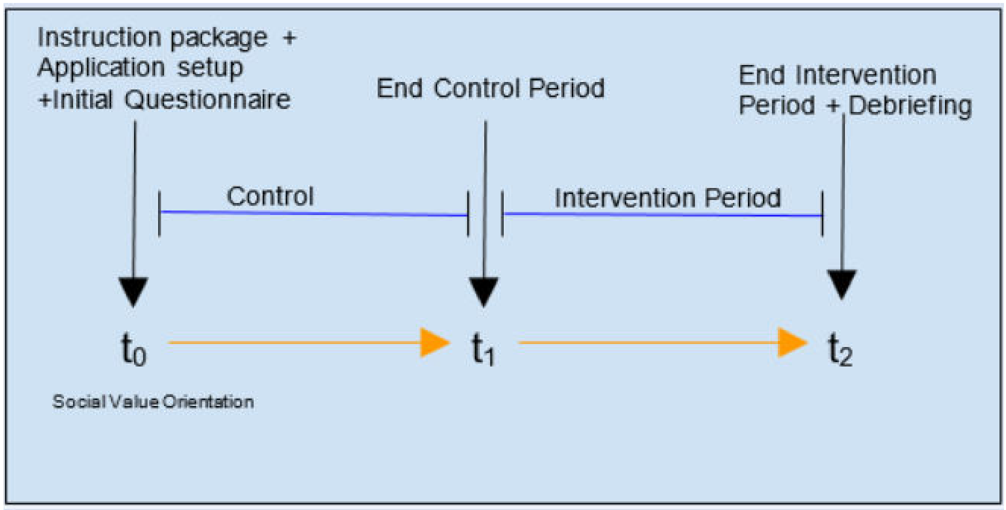

Figure 1. Experimental period with stages and times

Participants

We required regular healthy individuals to participate in our experiment. Participants must not have problems that inhibit them from doing moderate exercise such as handicaps or heart problems. To estimate the sample size for our study, an effect size had to be estimated.

A simulation based on available information and a minimum effect size of interest was used for the power analysis. First of all, based on existing data of SVO measure, we simulated samples of participants with the same distribution of SVO (see Figure 2). Next, each participant's step count was calculated with the linear regression equation: $step = \beta_0 + \beta_1 * condition + \beta_2 * SVO + \beta_3 * condition * SVO + N(0, \sigma^2)$. The parameter values were selected so that a partial eta^2 of 0.16 (minimum effect size of interest) could be obtained and the means and SDs of step counts were reasonable based on available information (see Figure 3 & 4). It should be noted that as step counts are to be measured only in the game context, the SDs should be much smaller than the SDs of total daily steps. Based on the assumptions, results of 1000 simulations indicated that a sample size of 50 participants is needed for achieving 90% power at the alpha level of 0.05. The R code for the simulation is attached in the Appendix D.

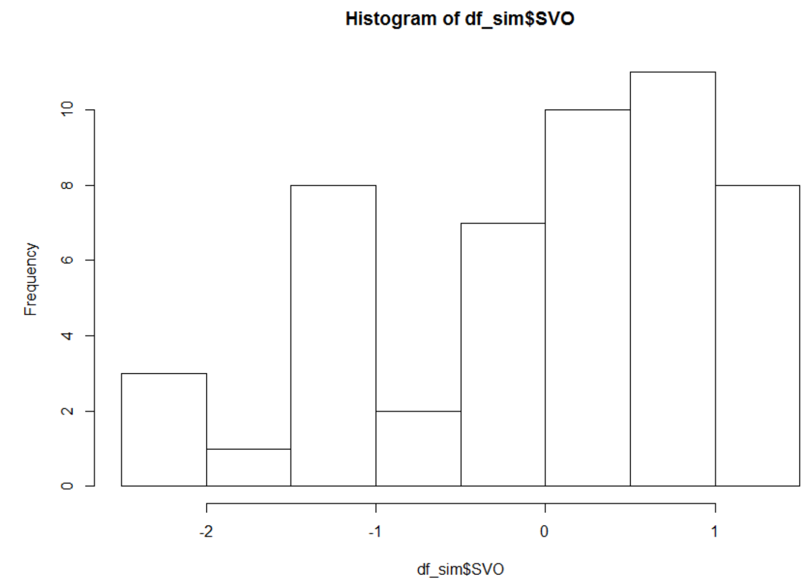

Figure 2. Simulated distribution of SVO based on existing data

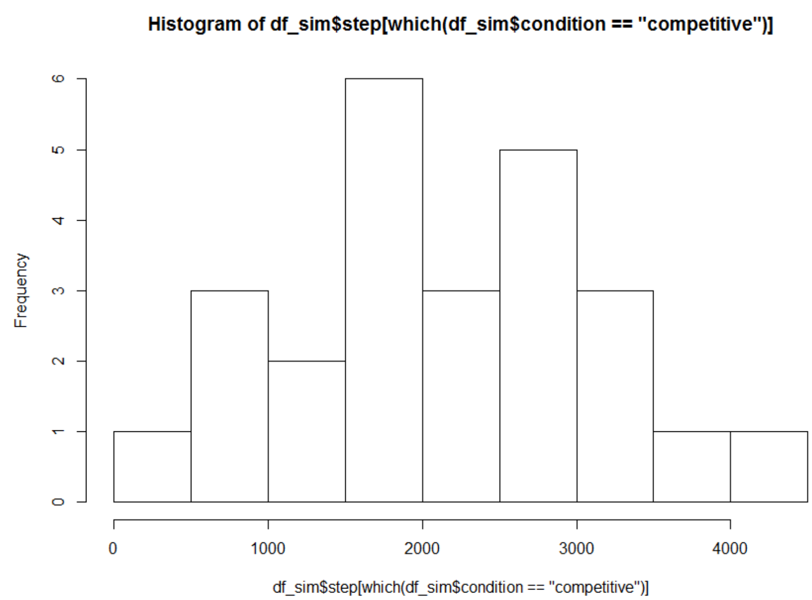

Figure 3. Histogram of step counts in the competitive condition

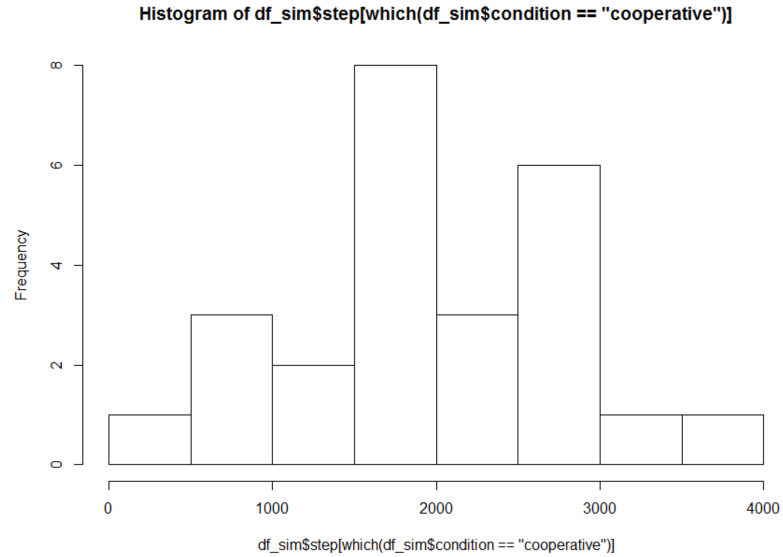

Figure 4. Histogram of step counts in the cooperative condition

Measurements

To measure social value orientation levels the six-item continuous scoring system was used (Murphy et al., 2011). During the control and intervention periods, players had to capture nearby target locations and send daily feedback on capture locations. In the competition condition players received a rank and could compare their score to the player who ranked first during the day. In the cooperative condition, each individual received the total group score and individual score along with an indicator displaying individual contribution to the group in percentage. The exact feedback format can be seen in Appendix C. For the competitive and cooperative conditions, physical activity was tracked using step count while playing the game and capturing the objectives. Step count was primarily measured by comparing the capture locations and timestamps and subsequently calculating a trajectory based on the shortest walking distance between locations. During the intervention week, the same method was used. This was measured based on photographs that participants took through Timestamp Camera and submitted at the end of each day. The photographs consisted of the starting/ending location of each walking session and the capture locations with an associated time stamp. Based on the time that the participant visited a location, the shortest walking route was calculated using google maps. An example of this trajectory is shown in Appendix E. Based on the distance walked, the step count was calculated by using an online conversion tool that takes 1 meter to be equivalent to 1.3123 steps (“meters-to-steps” n.d.). We decided to use this measure because compliancy in capturing a location is a less noisy estimate than step count and more specific than distance walked since it only includes distance walked in the game context. If there were difficulties in measuring step count using the trajectory method, a backup commercial application called Runtastic measured daily step count. Players only enable the step counter while playing the game so it works similar to compliancy.

Procedure

When participants were digitally invited to participate in the experiment we also provided them with a small monetary incentive. Participants were then invited to the lab to sign an informed consent and receive a general introduction to the study procedure. During this procedure participants were asked to download the Runtastic Pedometer application and Timestamp camera for ios and android. Participants were also provided with a user manual that contained a map with target locations and photos depicting each target location (see Appendix A). At the introductory meeting, participants were also asked to fill in the social value orientation survey after which control period started. At the start of each session, participants launched the Runtastic application, start a workout session and open up timestamp camera to take a picture of the starting location. After this, participants walked around campus and capture any of the specified locations on a map provided in the participant manual. At the end of each session participants took a picture of the final location and ended the workout an took a screenshot of the

Runtastic pedometer application with total step count. Participants could choose to complete as many sessions as they wished with the condition that each day, at least one session must be logged. At the end of the day, participants submit all the Timestamp Camera photos and Runtastic pedometer screenshots via email. Every day, the trajectory walked was calculated but participants did not receive any feedback. The control period lasted for four days after which participants proceeded to the intervention period. At the start of the intervention period participants were randomly assigned to the competitive condition or the cooperative condition. During the intervention period, participants continued to play the game just as they did during the control condition but received daily feedback. Participants that were assigned to the competition condition received a daily email with current rank, score based on distance walked and the score of player who was currently ranked first. Participants that were assigned the cooperation condition were also presented with a daily email containing their group score and individual score based on distance walked and contribution percentage to the group goal. The feedback format of the emails can be seen in Appendix C. The intervention condition concluded after five days. After the study, participants received a debriefing along with their monetary reward.

Data Analysis

Based on the allocation task, the social value orientation was estimated using the formula as proposed by the original paper (Murphy et al., 2011) :

$$SVO^o = arctan\left(\frac{(Ao-50)}{As-50}\right)$$

Where A_o is the mean allocation for other and A_s is the mean allocation for self in the social value orientation task.

Next, the mean steps for each observation were computed for the intervention and control conditions and the intervention condition was separated into the competitive and cooperative conditions.

To test the first hypothesis, an independent sample t-test was performed between the competition and cooperation conditions after checking if each condition was normally distributed. If the distributions were skewed the non-parametric Mann-Whitney U test was performed.

To test the second hypothesis, the following regression model was checked:

$$steps\_intervention = \beta_0 + \beta_1 * condition + \beta_2 * SVO + \beta_3 * condition * SVO + N(0, \sigma^2).$$

Where steps_intervention is the steps walked during the period, condition refers to the competition or cooperation condition, SVO is the social value orientation score and condition*SVO is the interaction effect and $N(0,\sigma^2)$ is noise.

The interaction effect between the intervention conditions and social value orientation was checked for significance in moderating step count assuming that all the noise was distributed equally.

Results

Descriptive Analysis

Initially, a total of 35 participants joined the study. Four participants voluntarily withdrew because they were unable to dedicate time towards the experiment. One participant was unable to install the commercial application and had to withdraw. Three participants were excluded from the study; two did not provide any walking data and one only a single walk. All three participants did not respond to any reminders throughout the study. Out of 35 initial participants, 27 participants completed the entirety of the study. All participants were healthy students ranging from ages 19 to 29 (M = 23.8).

Social Value Orientation

Before the two-week walking period, all participants completed a six-item questionnaire measuring social value orientation by performing a hypothetical resource allocation task (see appendix B). The results of the task are shown in Table 2. As seen in Figure 5, the scores follow a bimodal distribution where a large portion of participants are either prosocial or individualistic. Out of all participants (N=27), six participants are individualistically oriented while the remaining 21 participants are prosocial. Table 2 also shows that there are no competitive and altruistic oriented participants. The second and third column in Table 2 show that both intervention conditions contain roughly the same average scores ($M_{competitive} = 29.4$, $M_{cooperative} = 32.6$) so there is no skewness based on condition.

Table 2

Social Value Orientation Statistics

	Observations	Mean	SD	Min	Max
SVO Total	27	31.05	11.56	7.82	50.40
SVO Competitive Condition	13	32.59	12.46	7.82	50.40
SVO Cooperative Condition	14	29.39	10.74	7.82	39.46

Note: According to the original paper (Murphy et al., 2011), angles greater than 57.15^{o} are altruists, between 22.45^{o} and 57.15^{o} are prosocial, between -12.04^{o} and 22.45^{o} are individualists and less than -12.04^{o} are competitive.

Social Value Orientation Distribution

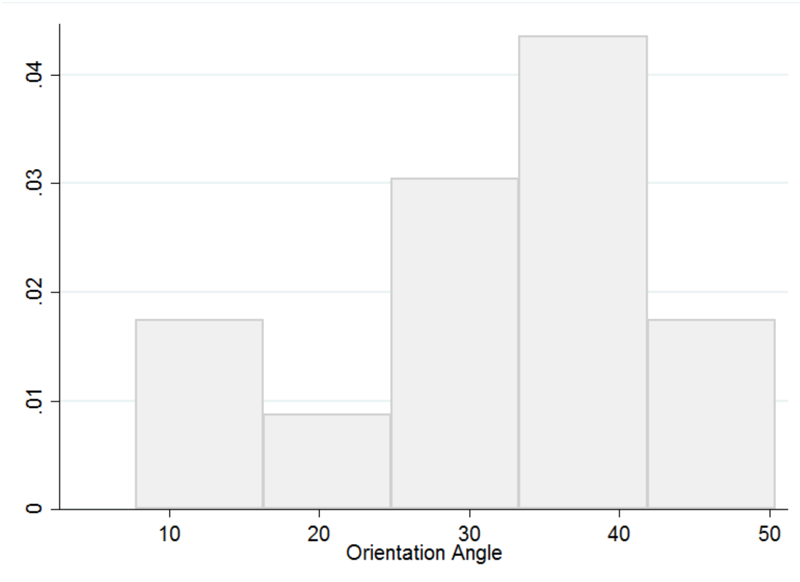

Figure 5. Variation of social value orientation among all participant (N=27).

Step Count

For a period of nine days, daily participant step count was measured. Since the first day of the week was considered a public holiday, it was not possible for participants to come to campus so there was an unequal amount of control and intervention days. During the first four control days, it was decided that the step-count application was not viable. The Runtastic Pedometer application had restrictions on the total number of sessions per day which could potentially demotivate some participants from loggings multiple sessions. Furthermore, the application did not provide accurate results for iPhone users which made it unreliable to use so the main procedure was used to calculate step count (mentioned in the method). There were some participants who were unable to walk during particular days. If participants were unable to walk during a particular day, they were asked to report this just as they would report daily step count and this was counted as no steps walked during the day. Out of 243 total step count observations collected from all participants over the nine-day period, there were 54 observations with zero steps.

For each participant, the steps count during the control and intervention periods were averaged to find any differences between playing the game with and without feedback. The large number of no steps clearly creates a larger variation to these mean values but these values were not removed since walking was a voluntary part of the study and not willing to walk was a viable option if there were unforeseen circumstances. Step count data for the control and intervention periods can be seen in Table 3. The table shows that although participants walked more in the intervention period compared to the control period, both values have a large standard deviation.

Table 3

Participant step count statistics (N=27)

	Mean	*SD*	*Min*	*Max*
Step count control	889.56	781.84	0	2888.25
Step count intervention	1145.83	1074.57	249	4065.4

Note: The values represent daily step count only while playing the game.

During the second week (intervention period), participants walked for five days while receiving competitive or cooperative feedback (see Appendix C). Table 4 shows the participant step count between the competitive and cooperative conditions. Table 4 indicates there was not a large difference between the two conditions and the standard deviations were also large. Table 4 also indicates that there was a large difference between the minimum and maximum step count so it is possible that some participants caused a larger variance in step count. To investigate if this is the case the distribution curves of the control and the intervention conditions are plotted on Figure 6 and Figure 7 respectively. Both the figures show a skewed distribution so most of the observations have a step count lesser than 1000. Figure 7 shows that there are only a few observations close to the maximum step count but these observations are kept in the results because it is natural for some individuals to walk more than others. It is also the case that lower sample sizes produce more extreme results. The intervention period contains less participants per condition and it can already be seen that there is more irregularity compared to Figure 6 where the number of steps has a gradual decrease.

It is also important to note that during the control period, there were multiple rainy days that could have affected participant motivation to take daily walks. The rainy days might have contributed to the lower mean during the control period compared to the intervention period as seen in Table 3. This will be discussed further by examining daily variations in step count.

Table 4

Participant step count during the intervention

	Observations	Mean	SD	Min	Max
Step count competitive	13	1169.55	863.05	311.6	3097.8
Step count cooperative	14	1123.8	1273.09	249	4065.4

Step count distribution control condition

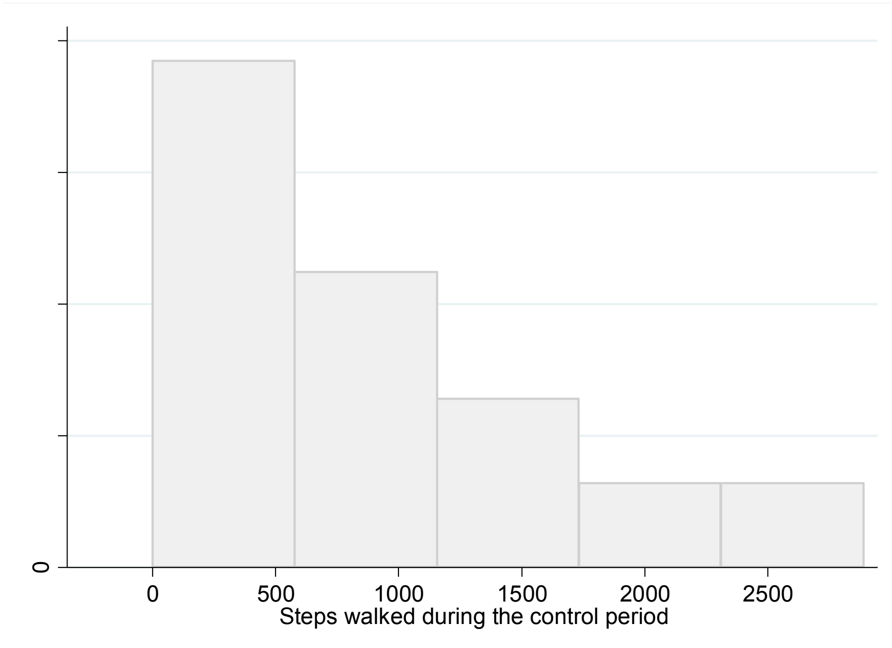

Figure 6. Histograms depicting cooperative and competition conditions

Step count distribution per condition

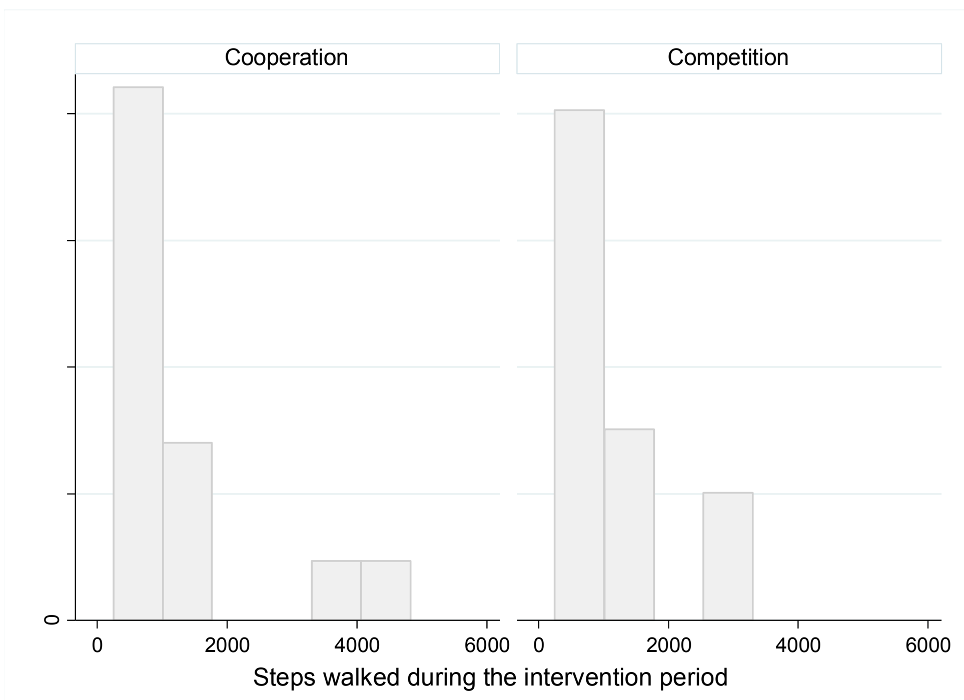

Figure 7. Histograms depicting cooperative and competition conditions

Daily variations in mean step count

Since there might be daily variations due to factors such as events, construction, and weather, it is interesting to see how the average step count varies every day. Figure 8 shows the daily variation line-plot for the period of the nine days.

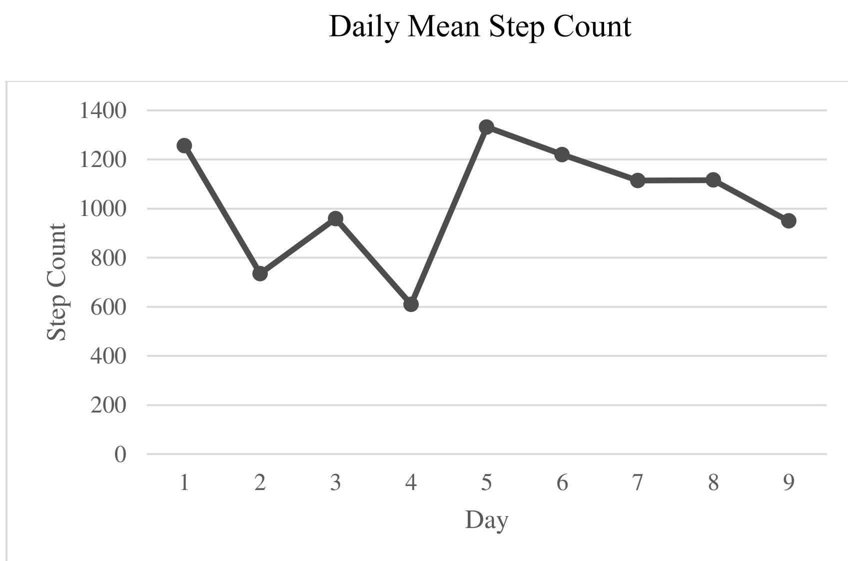

Figure 8. Line plot showing how step count varied throughout the study

As observed in Figure 8, there was a larger daily variation during the control periods. This could potentially be because of the weather conditions during this week. On day 4 there was rain and thunderstorm in the area and this point showed the lowest step count. During the intervention week, there was a steady downward trend in steps count. The downward sloping trend is not very reliable since the sample size is low and no systematic analysis can be performed to investigate this further. To examine if there were any notable differences between the two intervention conditions, Figure 9 shows the daily variation in average step count between the competitive and cooperative condition. Figure 9 does not show any notable differences in the daily mean step count between the competitive and cooperative conditions as both tend to fluctuate around the 1200 step mark.

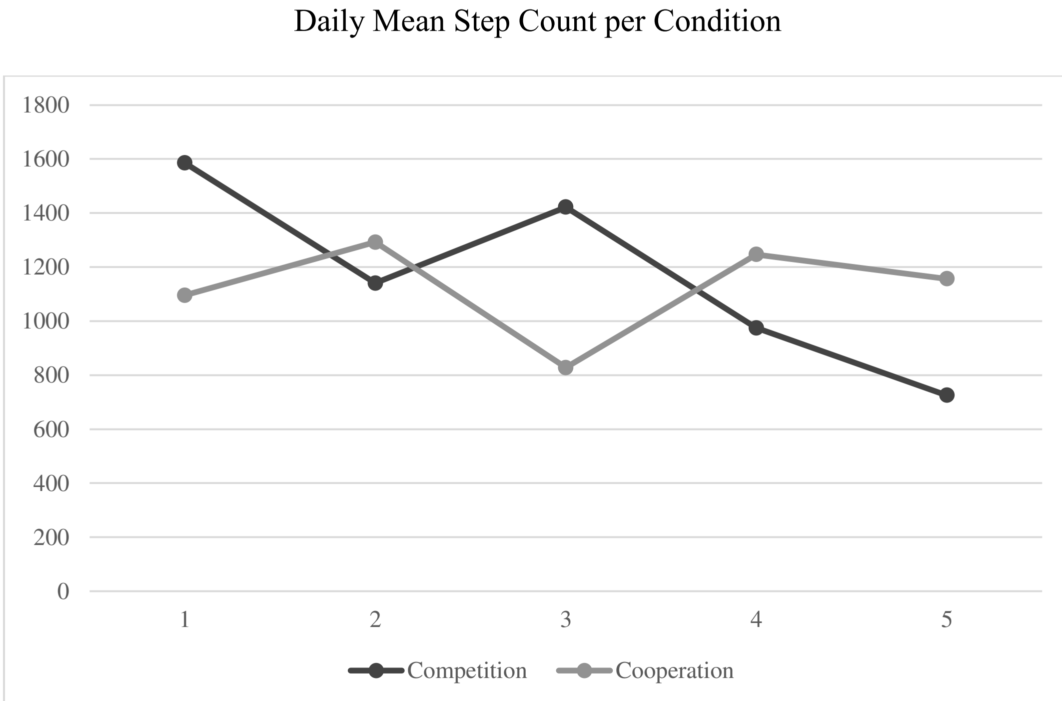

Figure 9. Line plot comparing daily variations in step count between competition and cooperation.

Hypothesis Testing

To test the first hypothesis, the difference between the means of the competition and cooperative conditions have to be tested by performing an independent sample t-test. To test for the normality condition, a Shapiro-Wilks test was conducted. For both cooperative and competitive conditions, normality was rejected ($p=0.00020$ and $p=0.00573$ respectively) thus it was not possible to perform a t-test. The two histograms in Figure 7 show the distributions of the cooperative and competitive conditions respective. Both histograms in Figure 7 show a left-skewed distribution. The skew was possibly caused by the 54 observations of participants who did not walk on particular days. Since the data does not follow normal distribution, a Mann-Whitney U test was performed. The results of this test indicated that the steps walked in the cooperative condition were not significantly higher ($M_{cooperative} = 1123.8$, $M_{competitive} = 1169.55$) than the steps walked in the competitive condition ($Z = -1.262$, $p = 0.2071$). From this result, it can be stated that hypothesis 1 is not supported.

To test the second hypothesis a regression model was built to test the interaction effect between social value orientation and the condition of each participant. A regression model was built with step count during the intervention period as the dependent variable that was compared with participant condition, social value orientation and the interaction between social value orientation and participant condition as the three independent variables. The interaction effect did not yield any significant effects ($\beta=6.4$, SE $\beta = 38.53$, $p=0.869$). This implies that hypothesis 2 is not supported from these results.

It is important to note here that the initial sample size (N=50) to obtain a minimum effect size of interest ($\text{partial-eta}^2 = 0.16$) was not met (N=27). This implies that even if an interaction effect was present, it was not possible to observe this since the experiment was underpowered.

User Experience Feedback

Throughout the duration of the study, participants were free to provide feedback on the gamification prototype. After the introductory meeting, three participants stated that they would feel much more motivated if participants received a small reward above the personal feedback. "Participant 22: *I would feel more motivated if the winner got a small reward, like a badge or a chocolate bar.*" During the control period, some participants reported difficulties using the commercial applications; Runtastic Pedometer and Timestamp Camera. The Runtastic application had multiple issues. During the first day of the control period, there were two participants who had difficulty installing the Runtastic Pedometer application. On the second day of the control, one participant noticed a bug that only allows a fixed number of sessions to be recorded. “Participant 40: *The step counting app only can make 3 sessions per day for the free app. Otherwise, a paid version is required.*” During the first three days of the control period, multiple participants were also concerned about the accuracy of the pedometer application. “Participant 10*: Runtastic was acting weird today. All three Runtastic Screenshots were namely from a single run.*” Since there were concerns with the pedometer application, it was discarded after day 3 of the experiment. The Timestamp Camera application did not receive many complaints. Two participants had an odd bug that flipped the saved image “Participant 10: *When I photograph using the Timestamp Camera, the photos are always upside down*”. This did not cause any changes with the concerned data so this app was kept to track the trajectory walked. During the first day, one participant had difficulties with posting all the timestamp camera images and felt the emailing part was cumbersome. “Participant 36: *It took too much time because first I have to transfer the pictures to my laptop and then send you all the pictures.*” To improve convenience, from day 2 onwards, participants were also given the additional options to send the captured locations via a cloud transfer or multiple emails. For the entirety of the study, many participants reported that they enjoyed to walk in groups while performing the capturing assignment. One participant also indicated that he bumped into multiple other participants while performing the experiment. “Participant 20: *Today while I was walking, I bumped into two other participants who were taking photos on campus.*” Some participants also provided feedback after the study and debriefing. One participant did report that taking photos of location did feel awkward at times but he enjoyed the exploration aspect. “Participant 36: *Honestly, I felt the taking-pictures part is a bit embarrassing, I felt myself like a spy. The rest is fine! I explored the campus, and now I know so many names of the buildings!*”. During the intervention period, there were multiple participants in the cooperative condition who wanted feedback on the total number of participants in the team to have a relative understanding of their standing “Participant 49: *How much is contribution of 5%. A lot or few*?” “Participant 44: *Honestly I was not sure what the contribution percentage was measuring because I did not know how many people were in my team.*” One participant also reported that the cooperative condition would have benefited with a group goal “Participant 23: *Honestly I felt after a few days that if I do not contribute a lot, someone else would do it for me. The whole experience would have benefited if there was some goal we had to achieve.*” One participant was not entirely motivated by the walking process. “Participant 13: *Honestly I don’t understand why people would go out of their way to capture locations. I just did the minimum to log one session per day.*” There was also one participant who felt it constraining to walk on campus “Participant 30: *I felt very constrained in my walking since it was only limited to the tue campus.*” In contrast, there were multiple participants who found the prototype enjoyable. “Participant 43: *I found it very fun to take part in your experiment.*” “Participant 20: *I found the game quite fun.*” One participant who was placed in the also felt healthier and enjoyed the walks. “Participant 36: *I have so much fun walking with my colleague together last few days. It is very healthy, and the feedback is very motivating*.”

Discussion

The current study investigated how gamifying daily walks influenced step count by providing daily competitive and cooperative feedback. Furthermore, the study looked at how individual social value orientation moderated the effectiveness of the two types of feedback by examining the interaction effect between social value orientation and the randomly assigned intervention condition. For a period of 9 days, participants walked around the university campus and captured location by taking photographs. Every day, participants sent the photos and step count was calculated based on walking trajectory. During the final five days participants were randomly assigned into the cooperative/competitive condition and received respective feedback. The first hypothesis stated that when participants are placed in the cooperative condition they will walk more on average than when placed in the competitive condition, resulting in a relative increase in moderate physical activity. The results indicate that there are no significant differences between the competitive and cooperative condition. The second hypothesis stated that participants who scored either low (competitive) or high (prosocial orientation) in the social value orientation survey will be likely to walk more steps on average in the competitive or cooperative conditions respectively. The results indicated that there was no significant interaction effect between the participant condition and social value orientation while testing for a change in step count. Thus, there is no statistical support for both the hypotheses of this study.

Effects of condition on step count

The current study closely resembles a previous study where an activity tracker recorded step count and determined that the cooperation condition outperformed the competition condition (Chen & Pu, 2014). This previous study is in line with two other studies where the results state that participants in cooperative circumstances put more effort on game related tasks than those in the competitive circumstances (Lin et al., 2006; Peng & Hsieh, 2012). Although the first hypothesis resembles the results of these studies, the current study does not have the statistical power to conclude this result so it is not possible to state whether the study is in line with existing literature.

Looking at Table 3 and Table 4, it is noticeable that standard deviations are almost as large as the mean step count values during the control and intervention periods. Comparable studies (Croteau, 2004; Koulouri, Tigbe, & Lean, 2006) provided a baseline standard deviation of 2000-3000 steps for every 8000 – 9000 steps walked. This indicates that the standard deviation to mean ratio is proportionally smaller in past studies compared to the current study. Unlike the current study where participant step count was measured during the game setting, the studies measured step count while performing regular daily activities. It would be reasonable to assume that a daily step count measure would be subjected to larger standard deviations since the step count might vary depending on activity.

In the current study, one reason for large standard deviation in step count could be related to a feature of the study that constrained the capture location. Originally, the study was constrained to the university campus since the capture locations were placed in this area. Although there was a requirement to log at least one session per day, many participants were unable to do so. According to the emails from the participants who did not completed the walking tasks, there were in general two recurrent justifications for not walking. Some participants mentioned unforeseen circumstances such as urgent meetings outside campus or travelling delay. In other situations, participants did not do the walks during days when they were not required to be on campus. Based on these justification trends, the campus constraint could have caused the 54 zero step observations that skewed the step count results towards zero.

A more basic problem that could have influenced the independence of observations during the current study was that there were a number of participants who enjoyed walking with each other whilst playing the game. When participants were randomly split up into two intervention conditions during the second week, it was possible that participants between conditions were discussing daily feedback results. This could have potentially attenuated the difference between the competition and cooperation conditions. It was not possible to restrict participant interaction since some participants reported that they coincidentally bumped into others while playing the game. Restricting their interaction might demotivate participants from performing daily walks.

Other than the unusually large standard deviation and attenuation effect, it is possible that other things could have influenced the daily step count such as weather. As shown in Figure 8 and Figure 9, during the control period, there were more rainy days than during the intervention period. Outside weather influences participants step count since it might demotivate participants to perform outdoor activity but to confirm this effect, a systematic study that controls for daily variations needs to be performed.

In conclusion, there were two main issues with the current study. Firstly, the campus constraint could have resulted towards an unusually large standard deviation. Secondly participants could have possibly been discussing feedback that could have attenuated the results meaning that the difference in step count between conditions was not as large as expected. Both these issues lead toward a small effect size of interest meaning that it is difficult to observe an effect in this study. Daily variation might have a moderating effect but a more systematic study controlling for these effects needs to confirm this.

Effects of social value orientation and participant condition

The social value orientation follows a bimodal distribution that is similar to the original study in which the continuous measure was developed. The observations are mainly concentrated around the prosocial and individualistic orientations and taper off as the they approach competitive and altruistic orientation angles. While the current study uses 27 people to obtain this distribution, the original study used 56 participants (Murphy et al., 2011). An additional study with a sample size of 256 participants also found a similar bimodal distribution (Gamba, Regner, Bicocca, Gamba, & Regner, 2015). In all three studies, university student samples were used so the distribution might be different for other populations. Since the current study has the lowest sample size, there were no participants oriented towards a competitive and altruistic orientation. Based on the other two studies however, this might increase with larger sample sizes. Similarly, the current study shows more prosocial oriented participants but the proportion of individualistic oriented students might increase with larger samples.

One problem with the social value orientation task posed is that the allocative task provides a hypothetical situation where resources must be split between two individuals; yourself and another. The current study divides multiple participants into each intervention condition. A dual allocation task might thus not translate into a task that compared relative points earned among multiple participants. This might have influenced the interaction effect between social value orientation and the participant condition. To minimize the differences, one can take two approaches. The first approach is to ask the participants to perform a social value orientation task that involves more people. Currently there is no continuous measure that involves hypothetical tasks with multiple people so a measure must be created from scratch. The second approach is to design an experiment where participants have to walk in dyads (pairs) where the conditions are compared between the dyads. One study did perform a test using dyads (Chen & Pu, 2014) but it did not measure individual social value orientation.

Another problem with translating the social value orientation task to the current study is that the task involved the allocation of a limited resource. In the current study, each participant was awarded with points based on total distance walked and participants could decide how much they walked. Essentially, the point system was not finite so the resources were not limited as opposed to the social value orientation task. To translate the current study to the limited resource requirement, the distance travelled must also be limited.

Since the second hypothesis of this study is trying to test how social value orientation interacts with the intervention conditions, it is important that social value orientation is properly translated in the task. In the original study that formalized the notion of social value orientation, a decision maker chose how the resources were allocated which was an essential characteristic for measuring social value orientation (Messick & McClintock, 1968). While controlling for competition and cooperation, the current study provides points based on performance. Unlike the social value orientation task, it does not ask a participant to allocate distance walked, and it does not limit how much distance each participant is allowed to walk. This means that the cooperation and competition conditions measured in this study do not have the same defining characteristics as the pro-social and competitive social value orientations so the interaction effect measured by the second hypothesis might not be valid. The comparable study that measured competition and cooperation in dyads also measures the performance relative to other member in the dyad so that study would also not have successfully found an interaction effect since resources were not limited or allocated (Chen & Pu, 2014). It must be noted that limiting resources and allocating distances might not translate properly into promoting physical activity since a participant will be constrained in daily steps.

Limitation and Future Research

In this study, the two major constraints had to do with the limited time and the fixed location. Due to a lack of time it was not possible to recruit a sufficient number of participants and the final sample size was only half of the required sample size from the power analysis. As a consequence, there is a high type 2 error in this study meaning that if there is an effect, it is not easy to observe the effect. Furthermore, the time constraint made it unable test for potential problems such as complying to the one session per day rule mentioned in the user manual. Thus, for future studies with lesser time restrictions, it would be beneficial to perform a preliminary user test with a small sample so that unforeseen circumstances during the procedure can be eliminated. There were multiple problems such as the cooperative condition not having the total team number, the Runtastic app having a session limitation, the emails having a size cap limit. All of these problems could have been eliminated by interviewing participants about product usage. Secondly, for future studies with less time restrictions, a pilot test could be performed to identify unaccounted independent variables such as weather conditions and participants who walk together. The large standard deviations in Table 3 shows that these limitations can't be easily removed and must be considered in the final regression model. The location constraint was a physical constraint that decreased the overall compliance. For many participants who were unable to walk on campus, they could also not walk in their free time outside the campus. If participants were provided with the option to walk in any location, it is more likely that they will log daily walks since participants have more freedom. It will also increase ecological validity since participants don't have to capture locations in one particular area since they can do it in their daily environment. For future studies, a good way to account for these limitations is to use this prototype and develop a mobile application that generates random capture points around the current participant location (See Figure 10). Each location could contain a geofence that detects when the participants enters the capture point. This location capturing mechanism also eliminates the awkwardness of taking a photo that one of the participants mentioned. The application could be improved by setting up a remote server with the ability to send and receive data. If this implementation is done using sockets it could be possible for participants to receive real-time dynamics feedback of their progress. This makes it far less cumbersome for participants since it eliminates submitting daily walking data. This is also less cumbersome for the researcher since the feedback mechanism can be automated by the server.

One participant in the cooperative condition also mentioned that he lacked motivation to continue in the cooperative condition and a group goal might be beneficial. Observe that theoretical mobile application in Figure 10 provides a cooperative condition with a goal to reach 10,000 steps. This means that the cooperative condition is moderated by a particular group goal. It is our prediction that cooperative feedback without team objective might not generate the same level of steps walked as a cooperative condition with a goal. To verify this predication, a future study can test how step count is influenced by cooperation with group goal as a moderating factor.

Finally, it is also notable that many participants found it enjoyable to walk together. An alternative future study could develop a mobile application where dyads of participants are asked to perform competitive/cooperative walking tasks against each other. The discussion on social value orientation says that such a measure might not translate well to a game aiming to promote physical activity since it might constrain the distance walked. In future gamification studies involving physical activity, it might be more beneficial to see how a different personality measure, that translates better towards competition and cooperation feedback in games moderates step count.

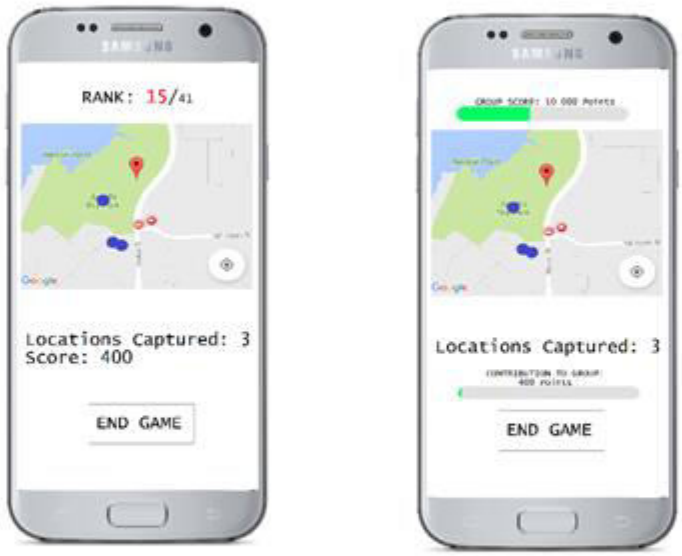

Figure 10 FLTR: Competition and cooperation conditions

Conclusion

The goal of the current study was to see how competition and cooperation influence the daily physical activity through gamification. After providing participants with competitive and cooperative feedback, the study also aimed to examine if individual differences in social value orientation correspond to participant performance in these conditions. The results do not provide any statistical evidence for these two effects. From participant feedback, there was valuable information regarding how the app could be improved. For future studies, a mobile application that tests this game using geolocations will most likely provide a solution for most of these problems if it is carefully designed to address the problems faced by users. If social value orientation needs to be measured, it might be more beneficial to go for an alternative experiment design that looks at the difference between competition and cooperation in dyads. The current research provides the important insight that properly designing a prototype or mobile application by performing an iterative design cycle that includes user experience tests is not only important for application developers, but also for researchers who want to quantitatively examine gamification effects under controlled conditions. The current research also shows that in order to provide a realistic model that looks at all the factors that influence step count, researchers must take an extra step by performing a pilot study that looks at how variables such as location constraints, participants collaboration and daily variations influence step count so that these can be moderated while playing the game as these might strongly influence the step count, particularly if the experiment is underpowered.

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Appendices

Appendix A: Participant Instruction Manual

Introduction

First of all, thank you very much for taking part in this experiment. We hope it will be a fun experience! For many of us, walking is an uninteresting activity that can easily get monotonous. This is unfortunate since an easy exercise such as a daily 30-minute walk provides many health benefits including:

1) Maintaining an ideal bodyweight

2) Better moods and energy levels during the day

3) Lower chances of health problems such as strokes, type-2-diabetes and vitamin D deficiency

To make walking more enjoyable we decided to add some interactivity by gamifying the experience. If the game is designed properly, gamification has been shown to improve motivation and engagement towards performing daily activities. In this experiment, we are trying to find out how a prototype gamification system will influence your daily walking behavior. Based on the success of this prototype, our idea has potential to be used in commercial applications to help promote a healthy habit.

Setup

Please start off by downloading the “Runtastic Pedometer” application and “Timestamp Camera” application.

- Runtastic Pedometer:
    - Android: https://goo.gl/sK6IFk

   - IOS: https://goo.gl/23S8js
- Timestamp Camera:
   - Android: https://goo.gl/RCXiCQ
   - IOS: https://goo.gl/bCTwXF

In Appendix A you will find a map with all the capture locations and the model picture for each location. Example of usage: If you want to capture location C7 on the map, look for the model photo of C7 and take a picture **resembling the model**. You have now captured the location!

The complete experiment will take a total of two weeks. You are only required to play the game during weekdays. This means that you must take daily walks while playing the game in the Tu/e campus between 6^{th} – 9^{th} June and 12^{th} – 16^{th} June.

It is entirely up to you how long you wish to walk per day but you must log at least **one walking session every day**. During the second week, you will receive daily feedback on how you compared with fellow participants. This will be calculated by taking the shortest distance between capture locations. This implies: **The more you walk the higher your score**!

After the introductory meeting, the first week and the end of the study, you will also receive a survey via email. More details will be provided in the email.

On the next page, you will find more information on the game procedure for one walking session.

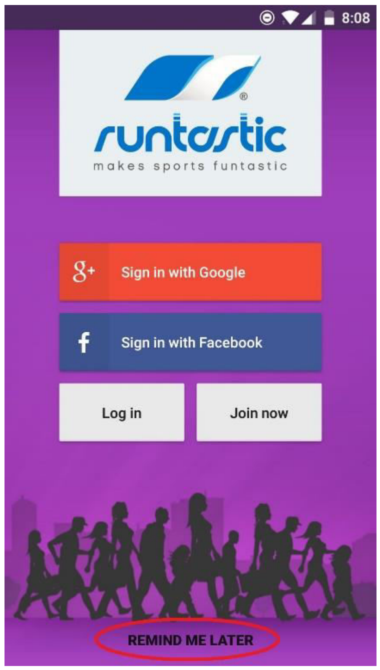
Walking Session

You can have multiple walking session during the day. For each walking session, the procedure is as follows:

1. Start the "Runtastic Pedometer" application:

Android

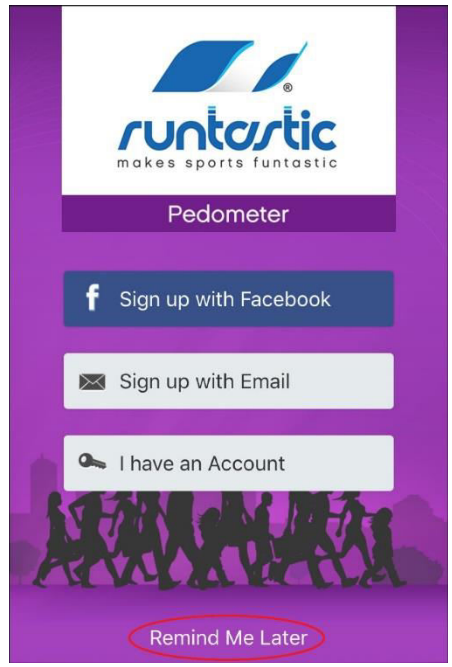
1. Open the application and press "REMIND ME LATER"



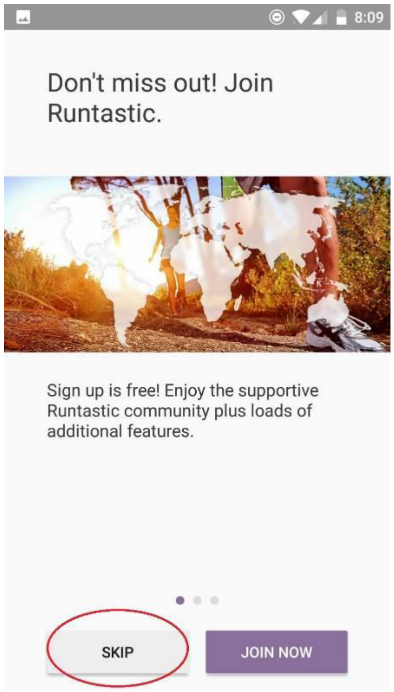
2. Press "SKIP"

IOS

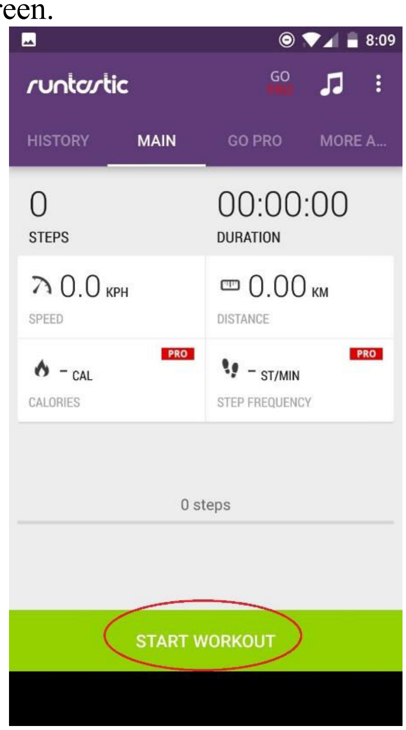
1. Open the application and press "REMIND ME LATER"

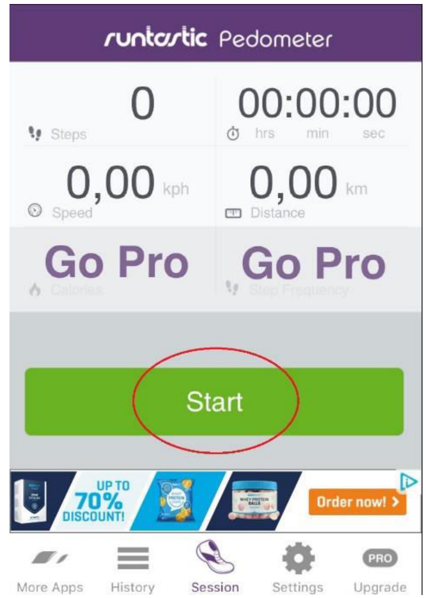


3. Press "Start"
The application will run in the background so you can exit this screen.



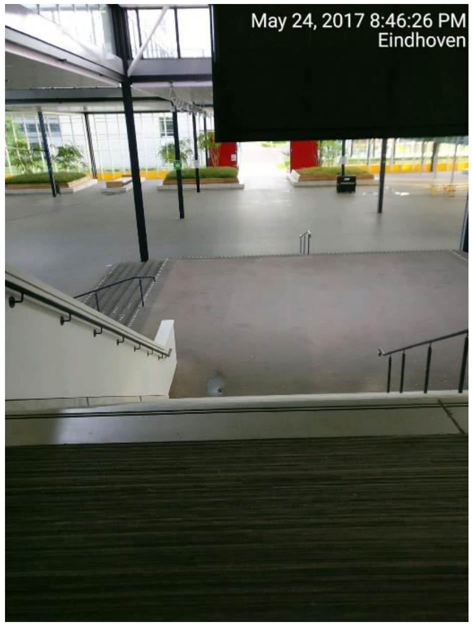
4. Press “START WORKOUT”. The application will run in the background so you can exit this screen.





2. Open “Timestamp Camera” and take a photo clearly indicating the location where you will start your walking session on campus. This application is very similar in IOS and android. If there are questions, please contact r.mohan@student.tue.nl

Example photo. Make sure the location is **outdoor**



3. Walk to your first capture point. Use the capture map (appendix A) to navigate to the location. Once you arrive, capture the location using “Timestamp Camera”. There is also a model photo of all capturable locations (appendix A). **For the capture to count, try to duplicate this picture as much as possible**.

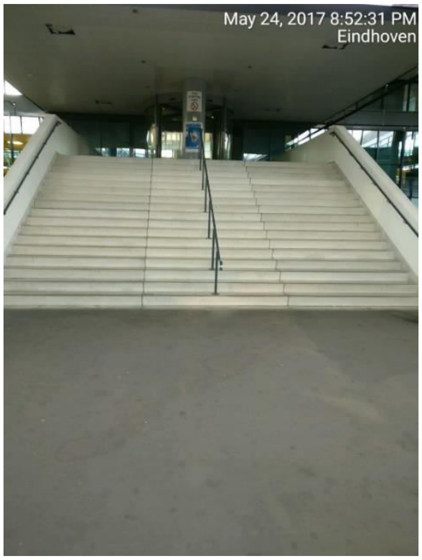
Example Capture C7 (see model photo)

4. Use the map to navigate to your next location and capture the location using timestamp. You are free to capture as many locations as you want. In the second week of the study you will receive daily feedback on your captured locations. **Again, keep in mind the more you walk, the higher your score!**

Example capture C4 (See model photo)

5. Once you have finished your walk, take a photo of the location where you completed your walk on campus.

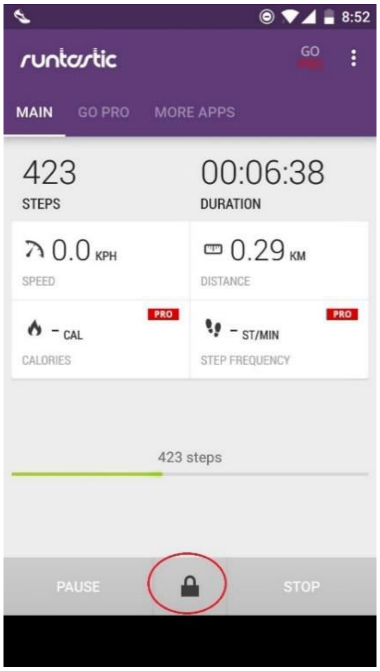
Example photo. Make sure the location is **outdoor**



6. End your workout session in “Runtastic Pedometer” and take a screenshot by following these steps:

Android

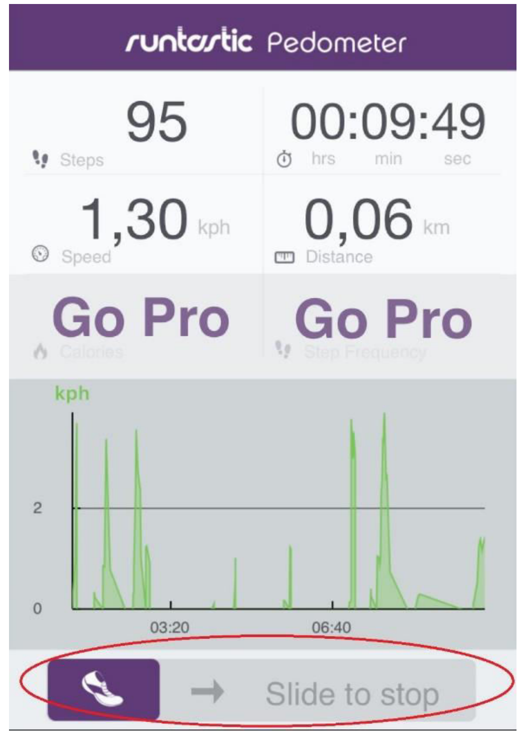
1: Open the running application. It will display the total workout time. Press the lock icon.



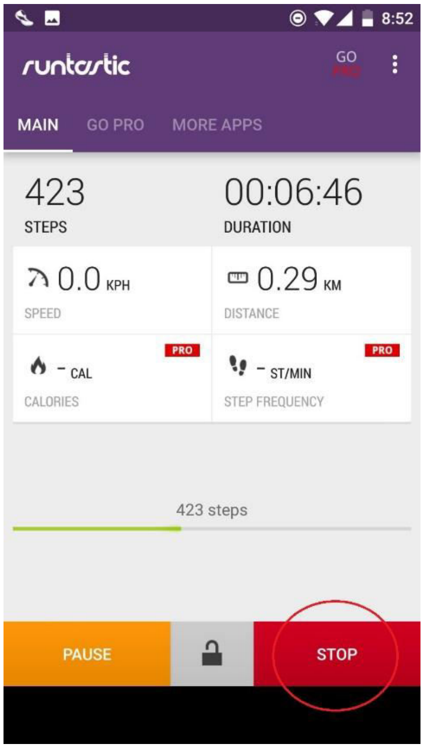
2: Press “STOP”

IOS

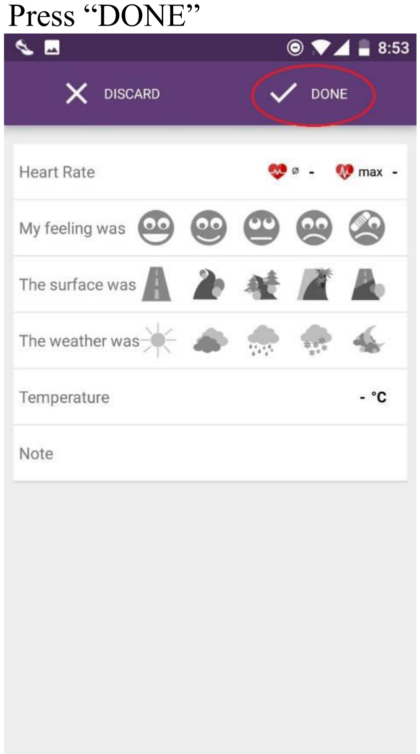
1: Open the application. It will display the total workout time. Swipe the slider to stop.



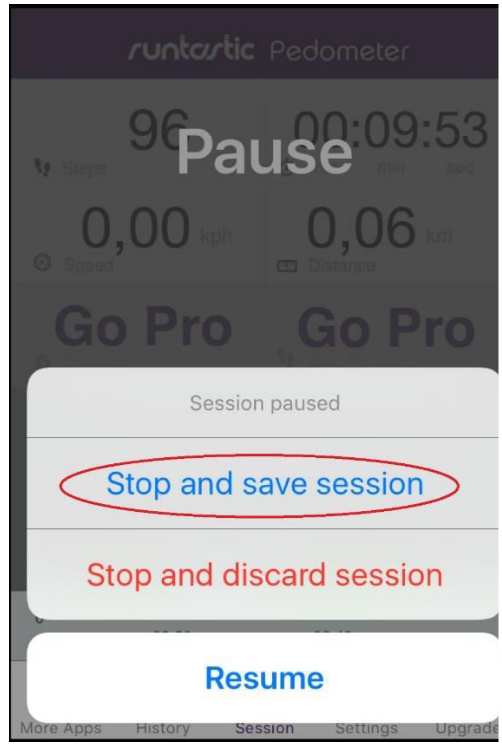
2: Press “Stop and save session”



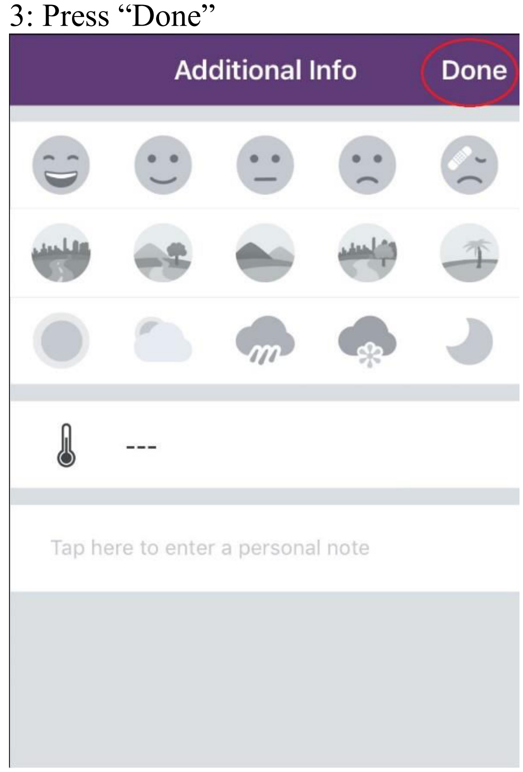
3: Press “DONE”



4: Take a screenshot of your

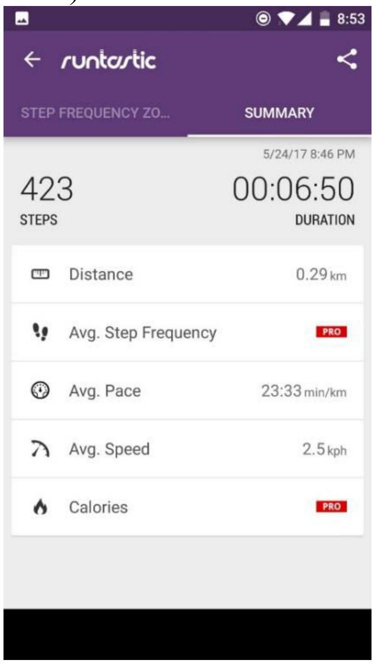


3: Press “Done”

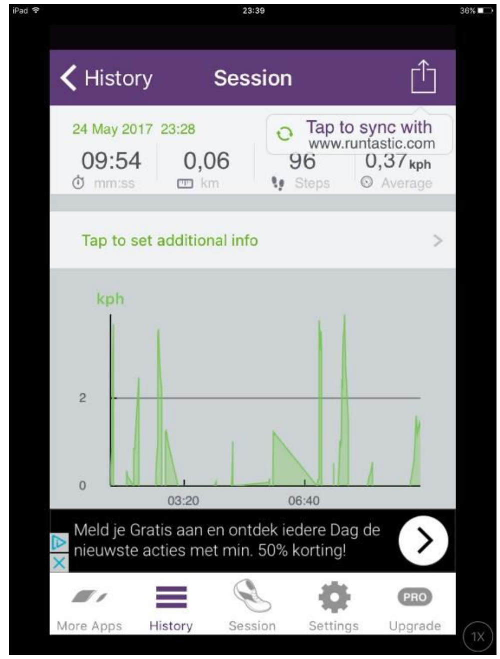


4: Take a screenshot of your workout

workout (This is usually **power + volume down** in android)



(This is usually **power + home button** on IOS)



7. You can now exit both applications. Sometime the pedometer app shows ads. You can disregard these. Be sure to follow this procedure every time you log a session!

Sending the information

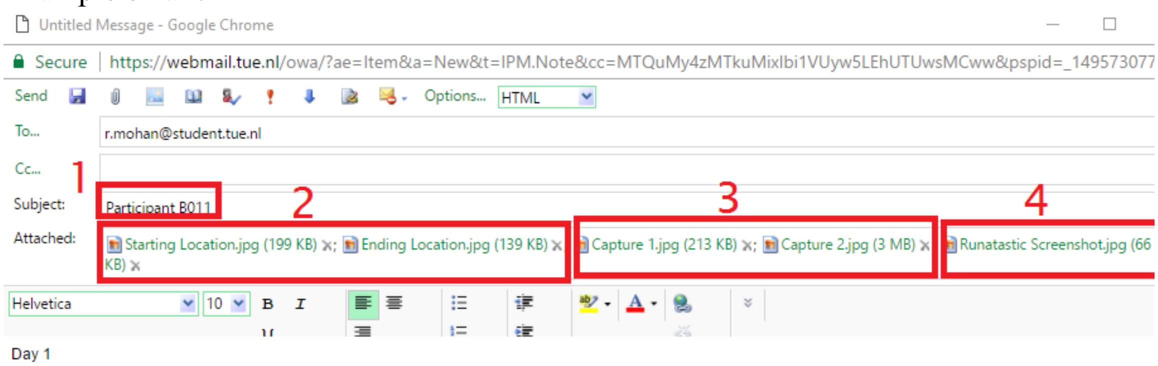
For this experiment, you are required to send daily information via email to the experiment leader. The information must include:

1. Your participants number In the subject header. (Eg. Participant B011). You will receive this during the introduction meeting. In case you forget this please email r.mohan@student.tue.nl

For each walking session:

2. Your start location(s) and end location(s) photos
3. Your capture locations photograph
4. Your Runtastic session screenshot(s)

Example email:



You don’t need to rename the files. If you walked multiple sessions, attach all your sessions to one email. You must send this email **before 9 pm** every work day to the following email address: r.mohan@student.tue.nl. We are aware that it is easy to cheat so please try to be as honest as possible while sending this information as this will help us the most. To be sure, we will be checking if your information is correct.

We hope this instruction manual has informed you sufficiently about the procedure. In case you have further questions, do not hesitate to contact us via email: r.mohan@student.tue.nl. Hope this experiment will be a motivational and enjoyable experience!

Best Regards,

Raghav Mohan & Ismay Cohen

Appendix A: Capture map (model photos next page)

C1

C2

C3

C4

C5

C6

C7

C8

C9

C10

C11

C12

C13

C14

C15

C16

C17

C18

C19

C20

C21

C22

C23

C24

C25

C26

C27

C28

C29

C30

C31

Appendix B: Social Value Orientation Questions

Instructions

In this task you have been randomly paired with another person, whom we will refer to as the **other**. This other person is someone you do not know and will remain mutually anonymous. All of your choices are completely confidential. You will be making a series of decisions about allocating resources between you and this other person. For each of the following questions, please indicate the distribution you prefer most by **marking the respective position along the midline**. You can only make one mark for each question.

Your decisions will yield money for both yourself and the other person. In the example below, a person has chosen to distribute money so that he/she receives 50 dollars, while the anonymous other person receives 40 dollars.

There are no right or wrong answers, this is all about personal preferences. After you have made your decision, **write the resulting distribution of money on the spaces on the right**. As you can see, your choices will influence both the amount of money you receive as well as the amount of money the other receives.

Example:

You receive	30	35	40	45	50	55	60	65	70
Other receives	80	70	60	50	40	30	20	10	0

You 50

Other 40

1

You receive	85	85	85	85	85	85	85	85	85
Other receives	85	76	68	59	50	41	33	24	15

You ______

Other ______

2

You receive	85	87	89	91	93	94	96	98	100
Other receives	15	19	24	28	33	37	41	46	50

You ______

Other ______

3

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	98	96	94	93	91	89	87	85

You ______

Other ______

4

You receive	50	54	59	63	68	72	76	81	85
Other receives	100	89	79	68	58	47	36	26	15

You ______

Other ______

5

You receive	100	94	88	81	75	69	63	56	50
Other receives	50	56	63	69	75	81	88	94	100

You ______

Other ______

6

You receive	100	98	96	94	93	91	89	87	85
Other receives	50	54	59	63	68	72	76	81	85

You ______

Other ______

Appendix C: Participant Feedback Format

Header: Gamification Feedback dd/mm/yy

Dear participant BXXX,

Yesterday the total team scored:
xxxx

You contributed:
xxxx or **xx%**

To the team.

We hope to hear from you today.

Kind regards,
Raghav & Ismay

Dear participant BXXX,

Yesterday you ranked:
xx/xx

with a score of:
xxxx

The current rank one has a score of:

XXXX

We hope to hear from you today.

Kind regards,
Raghav & Ismay

Appendix D: R Code for Power Analysis Simulation

```
n_sim <- 1000
p0 <- rep(NA, n_sim)
p1 <- rep(NA, n_sim)
p_int <- rep(NA, n_sim)

for (k in 1:n_sim) {
	n_ppn <- 50
	SVO_angle <- c(-17, -11, -8, -1, 3, 7, 11, 13, 15, 17, 18, 20, 22, 25, 27, 29, 31, 33, 35,
	37, 39, 41, 43, 45)
	SVO_prop <- c(0.025, 0.015, 0.019, 0.005, 0.005, 0.163, 0.005, 0.042, 0.019, 0.043,
	0.038, 0.038, 0.012, 0.042, 0.058, 0.031, 0.062, 0.093, 0.062, 0.038, 0.005, 0.038,
	0.019, 0.111)

	df_sim <- data.frame(ppn=1:n_ppn, SVO=rep(NA, n_ppn),
	condition=c(rep("competitive", n_ppn/2), rep("cooperative", n_ppn/2)), step=rep(NA,
	n_ppn))

	for (i in 1:n_ppn) {
		df_sim$SVO[i] <- sample(SVO_angle, 1, prob=SVO_prop)
	}
	df_sim$SVO <- (df_sim$SVO - mean(df_sim$SVO)) / sd(df_sim$SVO)

	beta_intercept <- 2000
	beta_condition <- 200
	beta_SVO <- -550
	beta_interaction <- 550
	sigma <- 800

	for (i in 1:n_ppn) {
		if (df_sim$condition[i]=="competitive") {
			condition <- 0
		} else {
			condition <- 1
		}
		df_sim$step[i] <- beta_intercept + beta_condition * condition + beta_SVO *
		df_sim$SVO[i] + beta_interaction * condition * df_sim$SVO[i] + rnorm(1, 0,
		sigma)
	}
	fit <- lm(step~condition*SVO, df_sim)
	p0[k] <- summary(fit)$coefficients[15]
	p1[k] <- summary(fit)$coefficients[16]
}

power0 <- length(which(p0 < 0.05)) / n_sim
power1 <- length(which(p1 < 0.05)) / n_sim
```

Appendix E: Mapping participant trajectory