Perceived Persuasiveness Towards Social Support Features aimed to Stimulate Physical Activity in the General Population

Applying the Principles of Social Comparison, Recognition, Cooperation, and Competition

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Abstract

Background

Physical activity is a crucial part of human's health. Each year there are up to 5 million deaths due to inactivity (World Health Organization, 2020), thus the need to find ways to motivate people to change their behavior is urgent. Social support has shown to play a crucial part in motivating behavior change. Similarly, technology including applications and smartwatches has the potential to influence and stimulate behavior of individuals when behavior change techniques (BCTs) and Persuasive Systems Design (PSD) are integrated. Hence, combining social support and technology could persuade people to be more physical active. However, it is unclear whether there are differences between users in terms of age and their perception of the features. Therefore, in this study, the perceived persuasiveness of four features of the social support category (social comparison, recognition, cooperation, and competition) as part of the PSD model integrated into an application were compared. Furthermore, differences between age groups were assessed.

Methods

A cross-sectional online survey design was chosen. Participants were recruited using convenience sampling and snowball sampling. Using storyboards, the principles of social support design principles were displayed, and the participants' perception of these storyboards was assessed using the Perceived Persuasiveness Questionnaire (PPQ). The PPQ showed excellent reliability (a = .94). Using the Wilcoxon signed rank test, differences between features were tested. Next, the Mann-Whitney U test was conducted assessing the perceived persuasiveness of the features by different age groups.

Results

A sample of N = 134 participants ranging from 18 to 81 years completed the survey. The mean age (sd) was 31 (16) and 72% of the sample were female. Overall, the median (IQR) scores for all of the features were around 4 (1.5) out of 7, which means that the participants neither felt persuaded nor not persuaded. However, there were no significant differences found between the features. Moreover, perceived persuasiveness scores did not differ significantly between the young and old age groups.

Conclusion

Concluding, developers of future applications aiming to stimulate physical activity do not need to consider using specific features of the four social support principles. Furthermore, there is no need to distinguish designs for different age groups based on the current study's results. As a next step future research should adopt a mixed-methods approach including all seven of the social support features demonstrated in a clickable prototype, a perceived persuasiveness questionnaire and an interview with the participants. A mixed-method would result in findings from different perspectives and give more insight into the persuasiveness of the social support features and why they are effective or not. This could be useful in finding a way to persuade people to be more physically active and thus potentially reducing the mortality rate caused by physical inactivity.

Keywords: eHealth, physical activity, perceived persuasiveness, Persuasive Systems Design (PSD) Model, age differences

Table of content

Introduction

The year 2020, specifically the outbreak of Coronavirus disease-19, has brought many changes and challenges with it. One such challenge is having to work from home and being restricted in outdoor activities due to safety regulations. Research shows that after 30 days of the pandemic declaration, there was a worldwide decrease of 27.3% in mean steps, with a reported maximum decrease of 48.7% in Italy (Tison et al., 2020). But even before the pandemic the World Health Organization (2020) declared that worldwide over 25% of individuals above 18 are not sufficiently active. Adults aged between 18 and 64 are suggested to do a minimum amount of 150 minutes of moderate-intensity physical activity a week, such as riding the bike at a regular speed (World Health Organization, 2020). Alternatively, at least 75 minutes of vigorously intense physical activity a week, which includes exercises that demand harder effort, are recommended. As a consequence of physical inactivity, diseases such as type 2 diabetes, cardiovascular disease, and different types of cancer can be reinforced (Gaetano, 2016). According to the WHO, inactivity results in approximately 5 million deaths per year (2020).

Considering the problem of inactivity, the question of how behavior is determined and why there is a lack of physical activity becomes apparent. Morrison and Bennett (2017) stated that determinants for exercise can be, for example, the desire for physical fitness or changing body appearance and exercising as a social activity. While barriers for physical activity can be, for instance, a lack of time, money or social support. Difficulties for changing behavior can have complex reasons laying within and outside of the individual. Accordingly, reasons such as lack of motivation or an understanding of how to change behavior can play a role (Morrison and Bennett, 2017). Hence, it can be said that there can be diverse facilitators and barriers for engaging in physical activity. This diversity makes it difficult to clearly identify the problem which in turn makes it difficult to change behavior.

In the context of the complexity of physical behavior, understanding how to motivate behavior is an important issue. The self-determination theory explains how behavior can be motivated (Deci and Ryan, 1985). The theory was later explained in the context of physical activity (Ryan and Patrick, 2009). According to the authors, physical activity can be motivated by intrinsic and extrinsic motivation. Intrinsic motivation facilitates activity due to internal pleasures. Autonomy and competence are key factors in enhancing internal motivation, which are affected by conditions in the social environment, such as receiving meaningful positive feedback by people around an individual (Ryan and Patrick, 2009). While extrinsic motivation is elicited by external factors leading to an outcome independent

from the activity such as reward or receiving recognition. Hence, intrinsic and extrinsic motivation can be encouraged by the social environment.

Understanding how the social environment influences individuals helps to understand how the motivation for physical activity is elicited. Researchers describe a direct relation between social contacts and health (Heaney and Israel, 2008). Firstly, there is a direct influence of social relationships on health by fulfilling underlying human needs such as the need for physical contact to another individual (Berkman and Glass, 2000, as cited in Heaney and Israel, 2008). Moreover, social support influences health by offering individual and community resources including assets such as new information or contacts to learn how to deal with problems. These resources also act as a buffer for stressors as they have been associated with an increased probability of being resolved faster and thereby alleviating the impact of stressors on an individual. Furthermore, the recurrence and extent of dealing with these stressors are affected by social influences (Heaney and Israel, 2008). Concerning physical activity, an example could be a coach helping an individual to monitor the intensity of a workout, thereby, reducing the risk of injury. Finally, social support can have an impact on the incidence and recovery of disease or injuries by influencing behavior (for instance supporting health prevention and illness behavior). Overall, the social environment contributes to a person's motivation in many ways which makes it valuable in targeting physical inactivity.

The social environment can influence everyone, however, there are differences between age groups (Chierchia et al., 2020). Research shows that early adolescents are most influenced by their social surroundings. The potential of being influenced by peers decreases as early adolescents become adults. Adolescents between 10 and 24 years often show "an increased need for social connection and peer acceptance, and a heightened sensitivity to peer influence", as Andrews et al. (2020, p. 585) explained. This makes them more likely to be influenced by their social environment. As the social environment has a greater impact on adolescent's behavior, it can be suggested that this would also be observed in adolescent's physical activity behavior.

In the context of stimulating physical activity and creating interventions for that cause, different kinds of behavior change techniques (BCTs) are used to tackle the problem. Behavior change interventions can integrate social support within BCTs in different ways. Namely, there are three ways: an unspecified, a practical and an emotional way (Michie et al., 2013). The support can be provided by individuals, such as friends, family members or coworkers. Social support in an unspecified way can be, for instance, an advice or

arrangement for a target behavior. Practical social support can be provided, for instance, by asking a person to place an object in their immediate physical environment to remember a certain behavior. Lastly, an individual can provide emotional support by comforting a person in difficult situations to execute a behavior, for instance, by being present (Michie et al., 2013). Altogether, there are different possibilities to integrate social support that could help to motivate physical activity in behavior change interventions.

Behavior change can not only be targeted in nontechnical interventions but also in eHealth interventions. As defined by Van Gemert-Pijnen et al. (2018) "eHealth is the use of technology to improve health, well-being and healthcare" (p. 29). Using technology, eHealth interventions target a specific context, such as physical activity, and intervene by changing behavior and cognition. There are different types of eHealth technology such as websites, applications, or wearable devices. Wearables, as explained by Van Gemert-Pijnen et al. (2018), could be, for example, "smartwatches that track, trace, and trigger behaviors and moods to support healthier lifestyles" (p. 44). Mobile technologies such as applications and wearable devices connected to an application are distinguished as 'mHealth' (Van Gemert-Pijnen et al., 2018). As of 2018, there were approximately 100,000 mHealth applications available (AppBrain, 2018, as cited in Bol et al., 2018), of which the users were predominantly younger, highly educated, and knowledgeable in eHealth (Bol et al., 2018). In sum, eHealth interventions use different types of technology to improve health by changing behavior of the user.

To understand the added value of eHealth in creating interventions targeting physical activity, the benefits need to be discussed. In general, eHealth can provide a high degree of anonymity, which might be important for those who value protecting personal data such as their weight (Fogg, 2002, as cited in Van Gemert-Pijnen et al., 2018). Moreover, eHealth has the advantage of being able to store huge amounts of data, which is important as messages can become more convincing when being supported with relevant information. Next to these benefits, mHealth offers additional advantages in the context of physical activity. One benefit is the possibility to access health data at any given location and time (Van Gemert-Pijnen et al., 2018). Contrarily, a person, like a fitness coach, cannot always be physically present when it would be important to be motivated such as when deciding to take the stairs or an elevator at work. Moreover, applications offer the possibility to provide a personalized output based on a user's background, demands or context of use (Van Gemert-Pijnen, 2013). This includes personalized features, messages, and the design of the application. All these benefits make an mHealth application in the context of eliciting physical activity valuable. In sum,

mHealth can motivate individuals to change their behavior in an anonymous, personalized, and always accessible way.

As described mHealth has several benefits that help to convince the user, but it needs to be further explained how the mechanisms behind persuasion work and why this is of added value in motivating physical activity. MHealth implements persuasive technology, which is "a computerized software or information system designed to reinforce, change or shape attitudes or behaviors or both without using coercion or deception" (p. 202) as defined by Oinas-Kukkonen and Harjumaa (2008). Persuasive technology is affective in changing user's behavior because it integrated theories of persuasive communication, health promotion, social marketing and human-media interaction (Van Gemert-Pijnen et al., 2018). Persuasive communication aims to encourage and motivate people and contributes to the behavior change by integrating theory about processes of attention when progressing information (McGuire, 1985, as cited in Van Gemert-Pijnen et al., 2018). Health promotion is based on the Theory of Planned Behavior and the Elaboration Likelihood Model theories, which both assume that persuasion is dependent on the social context and the information procedures by the receiver. Furthermore, social marketing integrated strategies including social concepts to influence a user to respond to a behavior (Kotler et al., 2002, as cited in Van Gemert-Pijnen et al., 2018). Therefore, social aspects are already integrated into the technology, which makes it a good fit in motivating physical activity. Lastly, human-media interaction is included, for example, by influencing the design of technology to enhance the interaction between the user and the device. All in all, persuasive technology is based on different theories and studies that all contribute to influencing the behavior of users which makes it effective in motivating physical activity.

The design of persuasive technology is important to improve the effectiveness of applications. The Persuasive Systems Design (PSD) Model is an approach for designing and evaluating persuasive systems aiming to change the user's behavior (Oinas-Kukkonen and Harjumaa, 2009). The model consists of four categories consisting of different principles all contributing to a technology's persuasiveness. The four categories are 'primary task', 'dialogue', 'system credibility', and 'social support'. As established above, studies have shown that social aspects play an important role in motivating behavior change in the context of physical activity (Ryan and Patrick, 2009). Thus, the category of social support will be discussed in depth.

The category of social support includes seven principles, namely 'social learning', 'social comparison', 'normative influence', 'social facilitation', 'cooperation', 'competition'

and ‘recognition’. The principle of social learning suggests that “a person will be more motivated to perform a target behavior if (s)he can use a system to observe others performing the behavior” (p. 495) as stated by Oinas-Kukkonen and Harjumaa (2009). Social comparison demonstrates that it is motivating for a person to make comparisons with other people’s behavior. Normative influence implies that the system itself can influence the facilitation of a target behavior. Social facilitation as described by Oinas-Kukkonen and Harjumaa (2009) implies that “users are more likely to perform target behavior if they discern via the system that others are performing along with them” (p. 495). Cooperation and competition take advantage of peoples’ natural drive to challenge each other to motivate a behavior (Oinas-Kukkonen and Harjumaa, 2009). Lastly, receiving public recognition elicits motivation to perform a target behavior. Thus, in the context of stimulating physical activity, social support principles can be an advantage because they help stimulating social interactions, which has been shown to motivate behavior.

To date, to the authors knowledge, there is no study that evaluated the perceived persuasiveness of the features of the social support category simultaneously in the context of motivating physical activity. Perceived persuasiveness has been connected to users’ intentions and usage of eHealth technology (Drozd, Lehto, & Oinas-Kukkonen, 2012; Oinas-Kukkonen, 2013, as cited in Van Gemert-Pijnen et al., 2018). There was no direct comparison between the features in the context of physical activity, however, researchers constructed a model for fitness applications stimulating physical activity (Yoganathan and Kajanan, 2015). The researchers empirically studied the features of different fitness applications and assessed which persuasive features influenced the design of successful apps. Regarding the social category, Yoganathan and Kajanan (2015) combined five of the social support features concluding that the “Social facilitation techniques such as normative influence, social comparison, competition, co-operation, and social recognition can enhance the physical activity behavior of fitness app users” (p. 7). Thus, it could be of value to further analyze these features regarding the perceived persuasiveness. Due to the limited scope of this research only four features have been chosen for a more in-depth evaluation. The principle of normative influence is regarded to the whole system of an application. As it would be necessary to include many different facets to test this principle without the opportunity to use a functioning application normative influence will not be considered within this study.

Overall, as mentioned in previous studies, another aspect that seems to be important is how different age groups respond to social influences. As mentioned before, mHealth users

are mostly younger (Bol et al., 2018). Additionally, as adolescents are most influenced by their social environment (Chierchia et al., 2020), it would be important to know what social support features are the most persuasive for this age group to create an effective application. Comparing young adults to older age groups can help to develop applications as it is important to know whether different features are needed for specific target groups. Furthermore, studying what features are of relevance for younger age groups could help to tackle the problem of physical inactivity at early stages and reduce the problem in the long-term.

Concluding, social support plays an important role in facilitating physical activity. Additionally, technology can play a vital role because of its accessibility and ability to track and personalize individuals' needs. However, to date no study identified what social support principles using the PSD model are the most persuasive in eliciting physical activity while making a direct comparison between different age groups. Therefore, the primary aim of this study is to explore the perceived persuasiveness of the social support principles (1) social comparison, (2) recognition, (3) cooperation, and (4) competition of the PSD model, as integrated into an application to stimulate physical activity in adults. Secondary, this study aims to investigate whether the perceived persuasiveness of the different social support features varies between age groups.

The following hypothesis will be tested:

> *H1:* Compared to older age groups, young adults feel more persuaded to engage in physical activity elicited by different social support features from the PSD model (social comparison, recognition, cooperation, and competition) when integrated into an mHealth application.

Methods

Design

The study was conducted in November 2020 using a cross-sectional online survey investigating the perceived persuasiveness for physical activity among different age groups elicited by social support principles (social comparison, recognition, cooperation, and competition) displayed in an application. Storyboards demonstrated the different principles of the social support category within the application. To ensure that the survey was ethically acceptable, it was previously submitted to the Faculty of Behavioral Sciences Ethics Committee of the University of Twente, which approved the study (file number 201318).

Participants

The inclusion criteria of participants included sufficient English skills and being above 18 years old. As a sampling method, non-probability sampling was chosen, more specifically convenience sampling. The questionnaire was shared via private WhatsApp messages and publicly via the social media accounts (Facebook and Instagram) of the researcher. After that, snowball sampling took place by participants sharing the link for the survey with their closer environment. A G*Power (version 3.1.9.6) analysis for a Wilcoxon-Mann-Whitney test with an anticipated medium effect size of Cohen's d 0.5, the desired power level of 0.95, and a probability level of $a = 0.05$ was conducted to calculate the a-priori sample size. This resulted in a minimum of $N = 184$ participants, meaning $n = 92$ for the young age group and $n = 92$ for the older age group to reach significant findings.

Materials

Demographics

The first questions of the survey were about the participant's demographics including age, gender, nationality, and educational level.

General questions

The current use of eHealth technology was collected to assess the participants' familiarity with technology, which could account for biases in their responses. To get an idea of what technology the participants used daily, 'Yes' or 'No' questions were used for assessing if they were using a smartphone application or wearable device. Questions such as "I am using a smartphone application for keeping track of my physical activity" were asked.

Physical Activity

Physical activity levels were assessed to get an understanding of participants' responses to the features. To measure the current physical activity of the participants the International Physical Activity Questionnaire-Short Version (IPAQ-SV) created by Craig et al. (2003) was used. The test had a Cronbach's alpha of < 0.8 and a Spearman's reliability of 0.85. The participants were asked to answer seven questions regarding their weekly physical activity. Before calculations, data was organized by excluding outliers, which were, for example, a higher number of minutes there is a day, or an unrealistic number like over 720 minutes of vigorous activity a day. Using descriptive statistics, the median scores (IQR) of the days and minutes of physical activity were calculated. These were used to calculate the MET-min/week based on the guidelines of the IPAQ Research Committee (2005). According to the authors MET minutes represent the energy a person requires to perform physical activity. For each activity there is a certain MET level defined as follows, walking = 3.3, moderate-intensity = 4.0, and vigorous-intensity = 8.0. Using the MET levels of each

physical activity MET-min/week were calculated by multiplying the MET level by the minutes per day and number of days a week a person was performing a type of physical activity. After calculating the scores of each physical activity, total scores were calculated by summing the MET-min/week of walking, moderate-intensity, and vigorous-intensity (IPAQ Research Committee, 2005). MET-min/week scores would be categorized as 'insufficiently active' if there was no activity reported or not enough to meet the criteria of the other categories. 'Sufficiently active' would be anyone who performed at least five days of any activity combination resulting in at least 600 MET-min/week. Lastly, 'health-enhancing physical activity' (HEPA) would be at least seven days of any activity combination resulting in at least 3000 MET-min/week. The scores of the participants sitting behavior were calculated using descriptive statistics, documenting the median and interquartile range (IPAQ Research Committee, 2005).

Storyboards

Four storyboards were used to illustrate the four features. Storyboards were chosen because they are easily comprehensible, and they offered the opportunity to show how the features would appear in an application in isolation. The storyboards each visualized one principle (social comparison, recognition, cooperation, and competition) of the social support category. The first two features were based on the storyboards by Beerlage-de Jong et al. (2017), and the last two were based on Halko and Kientz (2010) storyboards. Storyboards of two different researchers were chosen as there were no storyboards for all four principles available created by one researcher.

Figure 1

Social comparison

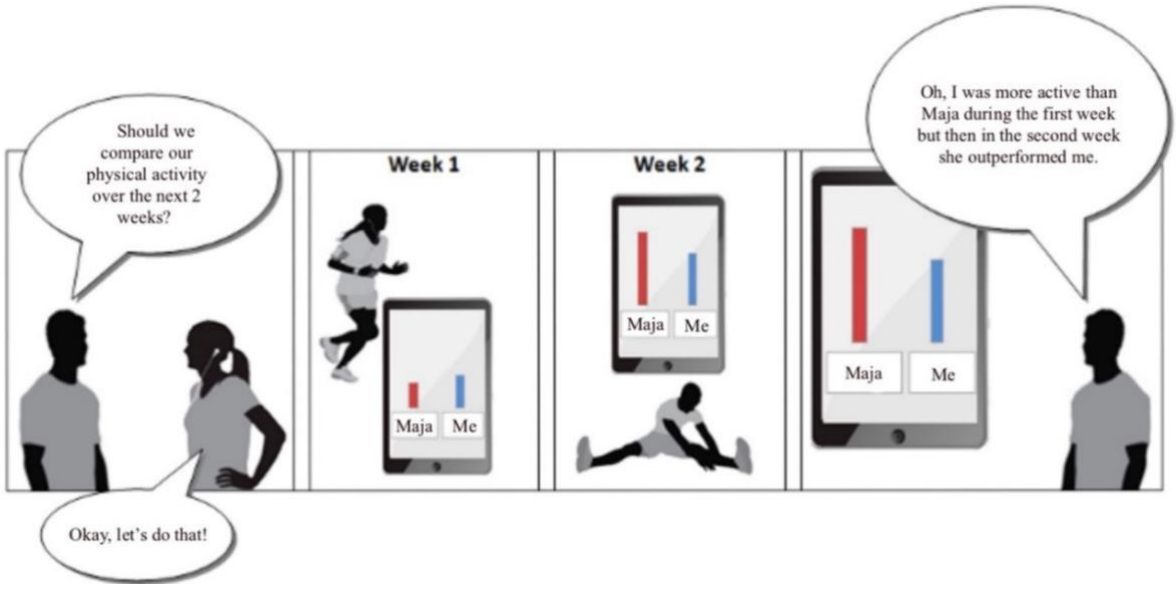


Figure 2

Recognition

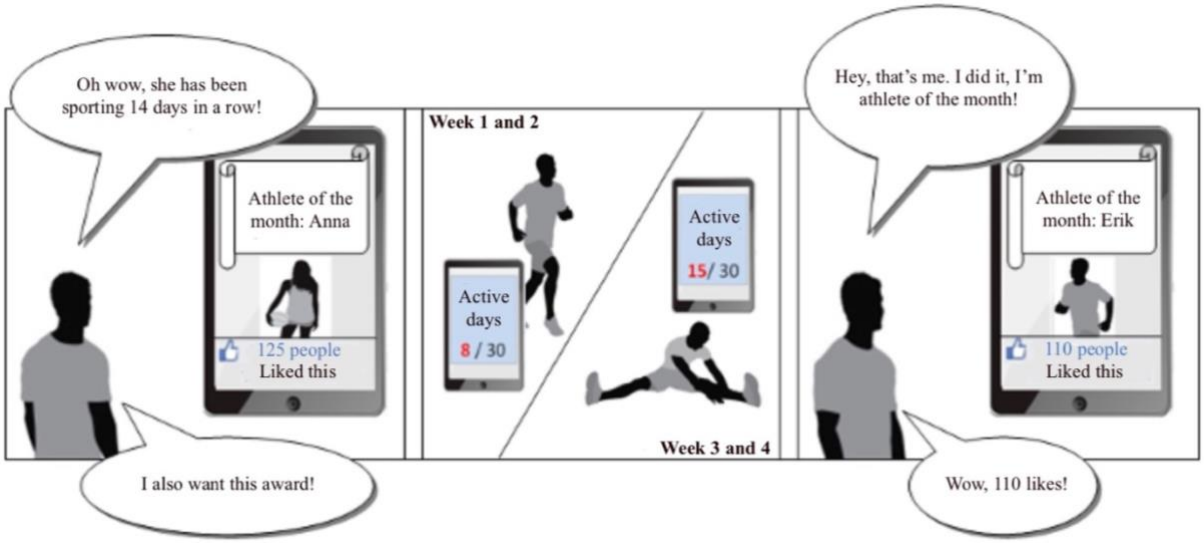


Figure 3

Cooperation

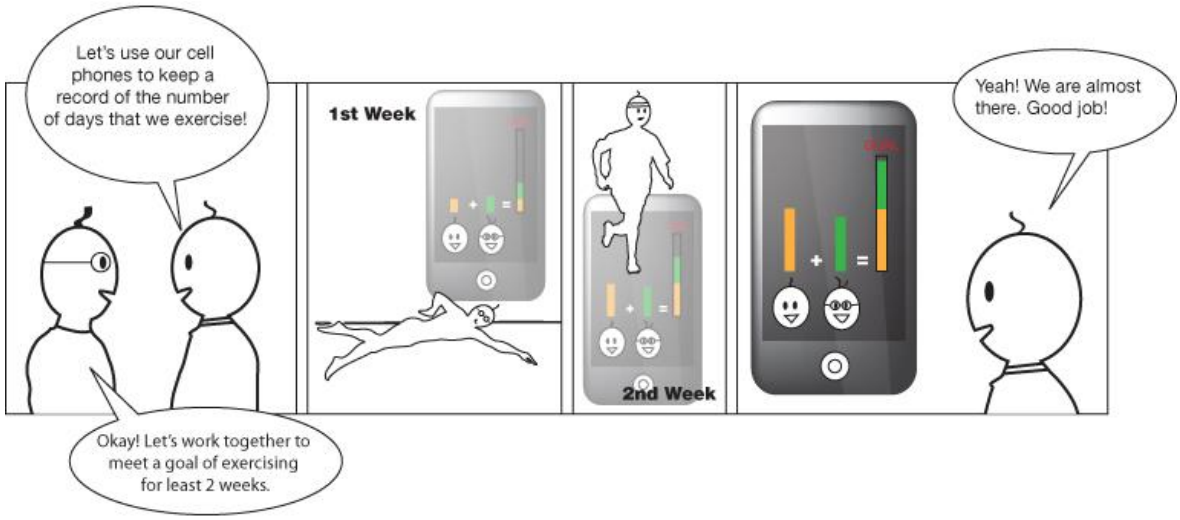
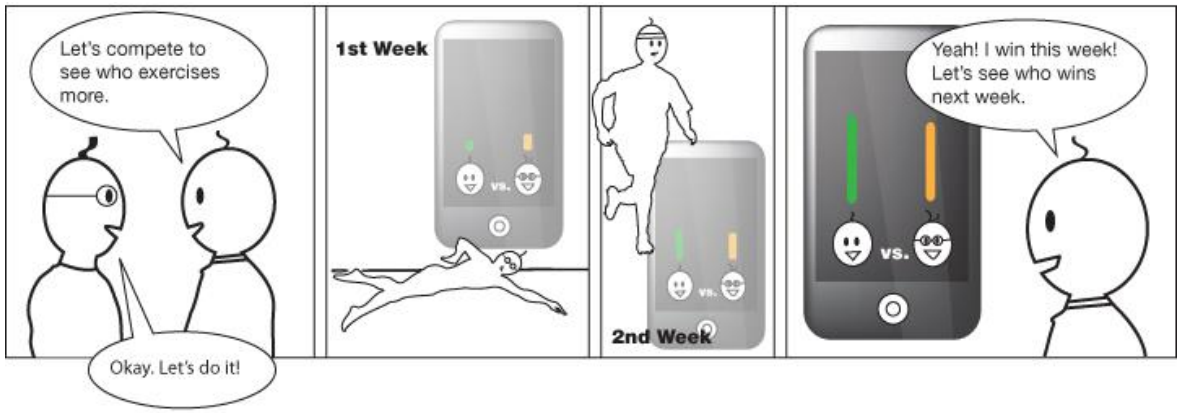


Figure 4

Competition



Perceived Persuasiveness

To measure the participants' perception, items based on Beerlage-de Jong et al. (2020) version of the Perceived Persuasiveness Questionnaire (PPQ) were used. The PPQ includes the four categories of the PSD model and four additional dimensions related to perceived persuasiveness, namely unobtrusiveness, effort, effectiveness and perceived persuasiveness (Drozd et al., 2012, as cited in Beerlage-de Jong et al., 2020). Six of the categories and dimensions of the PPQ were included in the current study due to a limited scope. Accordingly, for each storyboard, six questions were asked covering the primary task support (TASK), perceived social support (SOCI), perceived persuasiveness (PERS), perceived unobtrusiveness (UNOB), perceived effectiveness (EFFE), and use continuance (CONT). The items were answered on a 7-point Likert Scale (1 = Strongly disagree; 2 = Disagree; 3 = somewhat disagree; 4 = Neither agree nor disagree; 5 = Somewhat agree a; 6 = Agree; 7 = Strongly agree). The higher the score of an item the higher the perceived persuasiveness. To measure the internal consistency of the questionnaire, Cronbach's alpha was used. Here, A value of < .5 would indicate unacceptable internal consistency, > .5 and > .6 imply poor and questionable values, > .7 would be acceptable, > .8 would be good and > .9 would be excellent internal consistency (George and Mallery, 2003, as cited in Gliem & Gliem, 2003). The scales of the perceived persuasiveness showed excellent reliability (a = .94).

Table 1

Overview of Perceived Persuasiveness Questionnaire Constructs and Items

PPQ construct	Short description	Items
Primary task support (TASK)	Weather the technology helps to achieve the goal	I think this application helps me to achieve my personal fitness goals
Perceived social support (SOCI)	Weather the technology allows the user to share with and learn from peers	I think this application would help me to receive support from my peer
Perceived persuasiveness (PERS)	Weather the user thinks that the technology is valuable and has an influence on them	I believe this application would help me to improve my physical activity
Perceived unobtrusiveness (UNOB)	How disturbing the technology is to daily life	I think the application would not be obtrusive or disturb my activities of daily life
Perceives effectiveness (EFFE)	The efficacy of the technology	I believe this application would help me to start being physically active
Use continuance (CONT)	Willingness of users to adopt the technology in the future	I would use this feature in the future in order to improve my physical activity

Note. This table demonstrates the elements of the Perceived Persuasiveness Questionnaire along with the correlating items that were used.

Procedure

The survey was pretested with two voluntary participants from two different age groups to evaluate reliability and validity. Next, necessary changes were adopted to avoid misinterpretation. The survey was available on Qualtrics between the dates of November 19th and November 30th. Participation was voluntary; thus, the participants did not receive any rewards for their participation. After receiving ethical approval from the Ethics Committee of the University of Twente, the data collection started.

The survey started by asking every participant to sign the informed consent, which provided an overview of the study, its purpose, and the option to stop participation at any given time without providing a reason (see Appendix A). After declaring their consent and understanding of the information, participants were forwarded to the next page where the questionnaire started (see Appendix A). First questions regarding the participant's demographics were asked. If a participant fulfilled the inclusion criteria, the weekly physical activity of the participants was assessed. After that, they were asked to evaluate the perceived persuasiveness of each storyboard. In the end, the participants were thanked for participating and provided with an email in case they had further questions or comments for the researcher.

Data Analysis

The collected data was transferred to the SPSS software (version 26). Participants who did not fulfill the inclusion criteria or did not complete the questionnaire were excluded from the dataset. Descriptive statistics were used to summarize the social demographic characteristics (age, gender, etc.) of the study sample. Secondly, a preliminary test to check normality for the perceived persuasiveness scale was conducted using the Kolmogorov Smirnov test. Next, in accordance with the first research question scores of the perceived persuasiveness of the whole sample were calculated to explore the results of the features of social comparison, recognition, cooperation, and competition. As the data has not met the assumptions for conducting an ANOVA, the Wilcoxon signed-rank test was used as this is a non-parametric test. The Wilcoxon signed rank test was appropriate for testing the first research question because it can be used to assess whether there are significant differences between two or more variables, which was the case for the four storyboards.

To test for differences between the age groups for the four features, the age groups were defined as young adults = 18-24 years and older adults > 25 years. Regarding the second research question, it was investigated whether the perceived persuasiveness of the different social support features varied between different age groups. As the dataset did not meet all the assumptions for performing a t-test, a non-parametric test had to be used. The Mann-Whitney U test was appropriate for the second research question as it can be used to calculate differences between two independent groups, which was the case for the two age groups.

Results

In total N = 184 participants were enrolled of which n = 50 (25%) participants were excluded because they did not complete the survey. The young age group consisted of n = 80 participants, while the old age group included n = 54 participants. This resulted in a final sample size of N = 134. As displayed in Table 2, the final sample included 96 female (72%) and 37 male (27.6%) participants. The mean (*sd*) age among the participants was 31 (15.6) years with a range of 19 to 81 years. The majority of the respondents had German nationality (n = 95) representing 71% of the sample. The most frequent educational level of the participants was an HBO/Bachelor's degree (51%), which is a relatively high educational level. Regarding the current use of eHealth, $n = 63$ participants indicated that they are using a smartphone application, and n = 34 indicated that they are using a wearable device. Additionally, it was asked which of the following features 'number of steps', 'distance', 'running/walking speed', 'heart rate', 'stress level', and 'sleep pattern' they were using. The

most used feature was number of steps (*n* = 76), followed by distance (*n* = 64), running/walking speed (*n* = 37), heart rate (*n* = 35), sleeping patter (*n* = 22) and stress level (*n = 8*).

The total weekly physical activity level of the whole sample was *Mdn* = 2270 MET-min/week, as can be seen in Table 3. According to the guidelines of the IPAQ Research Committee (2005), the sample was 'sufficiently active'. Overall, the medians of the different physical activities of the younger age group were higher than of the older group. The sitting behavior of the sample had a median (IQR) of 360 minutes per week (230), whereas the median of the older age group (*Mdn* = 300, IWR = 305) was lower than the median of the younger age group (*Mdn* = 360, IWR = 200).

Table 2

Socio-Demographic Characteristics of the Sample per Age Group

Characteristics	Total	Age 18-24	Age 25+
	N = 134	*n = 80*	*n* = 54
Gender, N(%)			
Female	96 (72)	62 (77)	34 (63)
Male	37 (28)	18 (22)	19 (35)
Mean age in years *(Sd)*	31 (16)	22 (1)	45 (17)
Nationality, N(%)			
German	95 (71)	59 (74)	36 (67)
Dutch	11 (8)	8 (10)	3 (5)
Other	28 (21)	13 (16)	15 (28)
Education, N(%)			
Primary school	-	-	-
Secondary school	25 (19)	11 (14)	14 (26)
MBO/post-secondary vocational education	25 (19)	11 (14)	14 (26)
HBO/Bachelor	68 (51)	52 (65)	16 (30)
Academic/Master	15 (11)	5 (6)	10 (18)
PhD	1 (1)	1 (1)	-
Current eHealth usage, N(%)			
Smartphone application	63 (47)	37 (46)	26 (48)
Wearable eHealth technology	34 (25)	18 (22)	16 (30)

Table 3

Physical activity of the Sample per Age Group

Physical activity MET-min/week	Total	Age 18-24	Age 25+
	Mdn (IQR)	*Mdn* (IQR)	*Mdn* (IQR)
Walking	693 (1072)	693 (1044)	511 (1250)
Moderate-intensity	360 (480)	400 (615)	380 (480)
Vigorous-intensity	800 (1100)	960 (960)	540 (1620)
Total	2270 (1988)	2270 (1911)	2233 (2932)
Sitting	360 (230)	360 (200)	300 (305)

Perceived Persuasiveness

Regarding the first research question, it was assessed if there is a difference in perceived persuasiveness scores among the social support principles. The scores of the four principles of the PSD model are displayed in Table 3. Overall, the median (IQR) scores of all the features were around 4 (1.5), which means that the participants neither felt persuaded nor not persuaded. As for research question 2, it was assessed whether there were differences between the age groups. No significant differences between the age groups were found for any of the features. The social comparison scores of the young age group (*Mdn* = 4.0, IQR = 1.3) did not differ significantly from the scores in the older age group (*Mdn* = 4.1, IQR = 1.3), U = 2125, *p* = .874. The scores of recognition showed no significant difference between the young age group (*Mdn* = 3.7, IQR = 1.8) and the old age group (*Mdn* = 3.9, IQR = 2.0) *U* = 2142, *p* = .935. The scores of cooperation did also not differ significantly between the age groups. The participants of the younger group showed a median (IQR) of 4.4 (1.0), while the older participants showed a median (IQR) of 4.3 (1.6), *U* = 1960, *p* = .363. Lastly, competition showed no significant difference between the younger (*Mdn* = 3.9, IQR = 1.3), and older participants as well (*Mdn* = 4.3, IQR = 1.8), *U* = 1957, *p* = .357.

Table 4

Perceived Persuasiveness Scores towards different persuasive features (social comparison, recognition, cooperation and competition) between young and old age groups

Persuasive features	Total Sample	Age 18-24	Age 25+	P
	Median (IQR)	*Median* (IQR)	*Median* (IQR)	
Social comparison	4.0 (1.3)	4.0 (1.3)	4.1 (1.3)	.874
Recognition	3.7 (1.8)	3.7 (1.8)	3.9 (2.0)	.935
Cooperation	4.4 (1.2)	4.4 (1.0)	4.3 (1.6)	.363
Competition	4.0 (1.5)	3.9 (1.3)	4.3 (1.8)	.357

Discussion

This study aimed to explore the perceived persuasiveness of four principles of the social support category of the Persuasive Systems Design Model (social comparison, recognition, cooperation, and competition) in the context of eHealth interventions aimed at increasing physical activity. Furthermore, it explored whether there are differences between age groups in the perceived persuasiveness of the four principles. The results showed no significant differences in perceived persuasiveness of the features. Moreover, there were no significant differences found between the age groups in their perception of persuasiveness. Hence, the

first hypothesis which assumed that young adults would feel more persuaded by social support features to engage in physical activity compared to the older age group was rejected.

Regarding the differences in persuasion between the features that were tested, the results of the current study are not in line with previous studies. Matthews et al. (2016) conducted a systematic review aimed at establishing the current influences of applications integrating the PSD model to target behavior change of physical activity. In the review, each of the social support features except recognition were discussed. It was revealed that among the different article's researchers the findings were inconsistent. Some articles found results promoting social support features such as that the principle of cooperation motivated users to adopt the target behavior (Matthews et al., 2016). However, other researchers showed that the features did not influence the motivation to perform a physical activity such as that the principle of competition can result in demotivation when individuals were unsuccessful. Hence, across the studies, there were differences in the effectiveness of the features.

As found by other researchers, results of the current study are similar in regard to the persuasiveness of the features of one category of the PSD model. Based on their literature review, Matthews et al. (2016) concluded that "persuasive categories are dependent on each other for motivating physical activity". Consequently, applications integrating features of different categories would be more motivating than applications with features of just one category. This might serve as an explanation of why the current study could not identify persuasiveness elicited by the features as this study focused on features of one category only.

Although the current study did not achieve significant results in the persuasiveness of the features, there are research findings that did. Foster et al. (2010) found a difference in daily steps between individuals using applications that integrated a social comparison feature and individuals using an application that did not include this feature. The research focused on activity during nurses' work hours, which includes a very specific target group and context. The researchers tested the influence of the social comparison feature on the user's physical activity behavior. Participants using the application with social comparison were able to see other user's data and could compare it with their data. The results showed a significant increase in daily steps of the participants using the application with the social comparison feature. However, the study's aim and context of the research conducted by Foster et al. (2010) might be difficult to compare with this study. Foster et al. (2010) explored the effects of social comparison integrated into an application on the participants' actual behavior, while the current study compared the perception of a prototype on the participants' behavior. Furthermore, the researchers included a specific target group and context, while the current

study targeted the general population. As explained by Oinas-Kukkonen and Harjumaa (2009) considering the context of the behaviour is relevant in creating interventions. The context between the work environment and a general environment might elicit different kinds of motivations and, consequently, could result in differences in persuasion between the conditions.

The results of the current study regarding differences between the age groups are not in line with previous research. Oyibo and Vassileva (2020) conducted an empirical study regarding predictors of the intention to adopt a fitness application integrated with six persuasive features. The researchers included six storyboards each representing a persuasive feature combined with the perceived persuasiveness scale, including amongst others the features of social comparison, competition, and cooperation. To increase the reliability of the storyboards of Oyibo and Vassileva's study (2020), the participants were asked to study and identify the features of the storyboards prior to answering questions about persuasiveness. After answering the questions to each storyboard, the researchers asked the participants for their opinion about the features, thereby collecting qualitative and quantitative data (Oyibo and Vassileva, 2020). Evaluating their qualitative and quantitative data, the researchers found a significant difference between the age groups for the feature of social comparison. Their findings showed a positive relationship ($\beta = 0.19$, $p < 0.05$) between social comparison and the younger age group of 18-34 years, while there was a negative relationship ($\beta = -0.19$, $p < 0.05$) for the older age group above 35 years (Oyibo and Vassileva, 2020). In sum, an explanation of why their study results differed compared to this study might be that they used a different study design. Oyibo and Vassileva (2020) measured qualitative and quantitative data, while the current research assessed quantitative statistics alone. Hence, they collected more data from different perspectives, which could explain why they found different results between the age group.

Concerning participants' background of the current study, inferences about the study's results can be made. Approximately 50% of both groups' participants indicated that they were already using a fitness application and a quarter of the participants indicated using wearable devices. Recent research shows that prior experience with technology has a direct influence on the attitude towards an application (Rivera et al., 2015). Along similar lines, former research of Wu and Shaffer (1987) explained that participants with prior experience tend to keep their attitudes and are harder to persuade of the opposite opinion. If the participants already had a neutral attitude towards health applications, the effect of the principles represented in the storyboards might not have stood out to leave a greater

impression on them. Thus, the participants prior experience could explain why the features neither seemed persuasive nor not persuasive to the participants.

Another aspect of the participants' characteristics that has possible relevance was that the participants were already significantly physical active. As the participants were already significantly active, their perception on the features might differ from individuals who are not sufficiently active. The participants' activity level might explain why the responses showed that they did not seem to feel persuaded by an application.

Strengths and limitations

A strength of this research is that it investigated four specific features of the social support category in isolation, while other studies mostly evaluated the different features of all categories as a whole. Therefore, this study filled a literature gap by focusing on specific features of mHealth applications to learn more about these.

Furthermore, the use of storyboards can be considered a strength as well. Previous studies made use of a vignette or the participants' imagination of a feature which could lack validity as it might not represent an application realistically. While other researchers based their studies on specific applications those might not exclusively focus on physical activity. Therefore, storyboards specifically illustrating different social support features targeting physical activity is of advantage.

Next to the strengths, this study has some limitations. Firstly, the use of a lo-fi prototype in form of storyboards also has its disadvantages. As mentioned, there are advantages of using storyboards, however, this method could still have made it difficult for participants to see it as features integrated into an application. In a hi-fi prototype which could be, for example, a functioning application, the features might have felt different as there would have been more stimuli to it such as the interaction between the system and the user when clicking buttons. Furthermore, perhaps the storyboards did not represent the features clear enough, which was not tested as the reliability and validity of the storyboards were not measured. Lack of validity testing could have influenced the results by not clearly representing the features and thereby not receiving participants' true opinion about it because they could have interpreted the features in a different way than intended by the researcher.

Furthermore, this study is based on self-report. Several issues can arise when using self-report as a method, which could lead to results that do not represent the actual persuasion of the participants (Ainsworth et al., 2012). There are two types of errors that can occur in self-report measures. The first error that can happen is a 'random error'. A random error occurs due to false reporting and innate alterations of behavior as time passes (Ainsworth et

al., 2012). The second error that can occur in a self-report measure is a 'systematic error'. A "systematic error may be caused by reporting biases or a mismatch between the scope of a questionnaire relative to a reference measure chosen to estimate the true score" as explained by Ainsworth et al. (2012). A systematic error can cause inaccuracy in the mean scores of the dataset. All in all, using self-report as a measurement tool can result in an error occurring in the data and therefore reporting inaccurate results.

Lastly, the age groups were very similar to each other concerning their demographic characteristics such as their educational level or nationality. This could be due to snowball sampling, which can have the disadvantage of including a specific group of people in the sample (Etikan and Bala, 2017). Including similar participants makes the sample less generalizable and the probability of finding differences between groups smaller. Thus, this could have affected the results of this study by not showing differences between the groups' perceived persuasiveness.

Practical implications for future research

In the context of this study, several findings can be useful for future research. Based on the findings of this research it can be said that there were no differences in persuasiveness between the four features. This means that in the future the design of technology does not rely on specific features to have an effective application. Instead, it could be based on, for example, existing material which would save costs for the developers.

Furthermore, there were no differences found in the persuasiveness between the age groups. Therefore, there is no need to apply different strategies for users of different ages when designing an application. This means that developers of applications do not need to narrow their target group to a specific age. This would result in having a greater target group and the potential to reach more users to motivate physical activity.

As this research concluded the features of the social support category do not seem to be persuasive when integrated in an application on its own. Therefore, future applications should include features of different categories. However, in order to know whether there are features within the social support category that are more persuasive than the others, further research is needed. As the scope of this research was too small to include all of the social support features, future studies should include the seven principles of the social support category. This would help to make inferences about the features that were not included in this current study. This will help to explore differences between the all the features of the category and understand the persuasiveness. Hence, more insight would be established and conclusions about the whole category of social support can be made.

The current research showed, using storyboards has advantages but also some constraints to it. In future research, the features of social support should be investigated in a high functioning prototype. When designing the features illustrated in a prototype, different elements should be considered. The prototype should be clickable and interactive, which would be more representable of an application. Also, the features should all look the same graphically and visually which could help to avoid biases as no feature would look more appealing than the others. Using a high functioning prototype, the participants would experience the features in a more practical way, which could account for more valid results. Additionally, the influence of the features on the participants' behavior could be assessed instead of just their perception.

Furthermore, it was found that almost 50% of the sample of both groups were already using a fitness application. As this was not yet considered in the current study due to restrictions in the scope of the research, future studies could consider this finding and focus on the differences between the participants already using an application compared to unexperienced participants. This way it could be assessed what features seem to be persuasive for starting to use an application and what features are important when using it.

Moreover, overall, the participants of the current study were already sufficiently physical active. However, future research could consider the activity level of the participants as a moderating variable of persuasiveness. This way it could be assessed if there is a difference in persuasiveness between active and inactive participants. As the aim is to improve physical inactivity this could be an important addition to the current research.

Considering that this study was based on self-report measures alone, future research should apply a mixed-methods approach to investigate the features of the PSD model in more depth. Mixed-methods offer the opportunity to receive quantitative and qualitative information (Bulsara, 2015). This leads to the advantage of investigating a topic from various perspectives, which leads to higher validity and avoidance of missing information. This would be an important addition to the current study as it could provide more insight into the persuasiveness of the features by helping to find out what elements make the features persuasive or not and why the participants feel that way. The design could include a survey measuring the perceived persuasiveness and interviews with the participants assessing the reasons for their responses. This way more insight into why participants feel persuaded to perform physical activity and what elements of social support have an impact on persuasiveness would be acquired.

Altogether, in the future, the next step to acquire more results regarding persuasiveness and additional insight into why individuals think certain social support features are persuasive or not would be a mixed-methods design. This design should include a high functioning prototype and a survey measuring the perceived persuasiveness, as well as qualitative measures by asking the participants for their opinion in an interview. Consequently, qualitative and quantitative methods can be combined to receive a variety of information from the participants. Simultaneously, using a mixed-method approach might account for significant results.

Final comments

Concluding, although this research has certain limitations, it adds to the field of mobile applications aiming to motivate users of different age groups to engage in physical activity. It helps to direct future research by providing suggestions about a possible study design. The next step would be to adopt a mixed-methods design which could lead to significant, more reliable, and valid findings. The study emphasizes the need to further investigate the integration of features from the PSD model into a mobile application. This might help to tackle the problem of too little physical activity among the population, especially during the current pandemic.

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Appendix A

Full Questionnaire

Dear participant,

Thank you for taking part in this study as part of my bachelor thesis at the University of Twente. The study will investigate which persuasive features that are integrated in an app to stimulate physical activity will be more persuasive. The survey will take about 20 minutes to be completed. Please answer each question carefully and honestly; there are no right or wrong answers.

Feel free to stop the survey at any point in time if you wish to. Only completed surveys will be used for this research. All data will be treated with anonymity and only for the purpose of the study.

If you have any questions or comments, you can contact me at any time via this email address: v.j.zobel@student.utwente.nl

Thank you in advance!

Vivien Zobel

Q1: I read and understood the above-mentioned information and agree to participate in the study. I'm taking part out of my own free will and I understand that I can withdraw from this study at any time without providing a reason.

- Yes (1)
- No (2)

The first questions are regarding your demographics.

Q2: What is your age?

_____

Q3: What is your gender?

- Female (1)
- Male (2)
- Other (3)

Q4: What is your nationality?

- German (1)
- Dutch (2)
- Other _____ (3)
- I do not want to say (4)

Q5: What is your educational level?

- Primary school
- Secondary school
- MBO/post-secondary vocational education
- HBO/Bachelor
- Academic/Master
- PhD

The following questions ask about your physical activity and what kind of health technology you already use.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

Q6: During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ days per week

- No vigorous physical activities ***Skip to question 8***

Q7: How much time in minutes did you usually spend doing **vigorous** physical activities on one of those days?

_____ minutes per day

- Don’t know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

Q8: During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ days per week

- No moderate physical activities → ***Skip to question 10***

Q9: How much time in minutes did you usually spend doing **moderate** physical activities on one of those days?

_____ minutes per day

- Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

Q10: During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ days per week

- No walking → ***Skip to question 12***

Q11: How much time in minutes did you usually spend **walking** on one of those days?

_____ minutes per day

- Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This

may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

Q12: During the **last 7 days**, how much time in minutes did you spend **sitting** on a **weekday**?

_____ minutes per day

- Don't know/Not sure

Q13: I am using a smartphone application for keeping track of my physical activity (such as Runtastic)

- Yes (1)
- No (2)

Q14: I am using a smartwatch or wearable which keeps track of my physical activity.

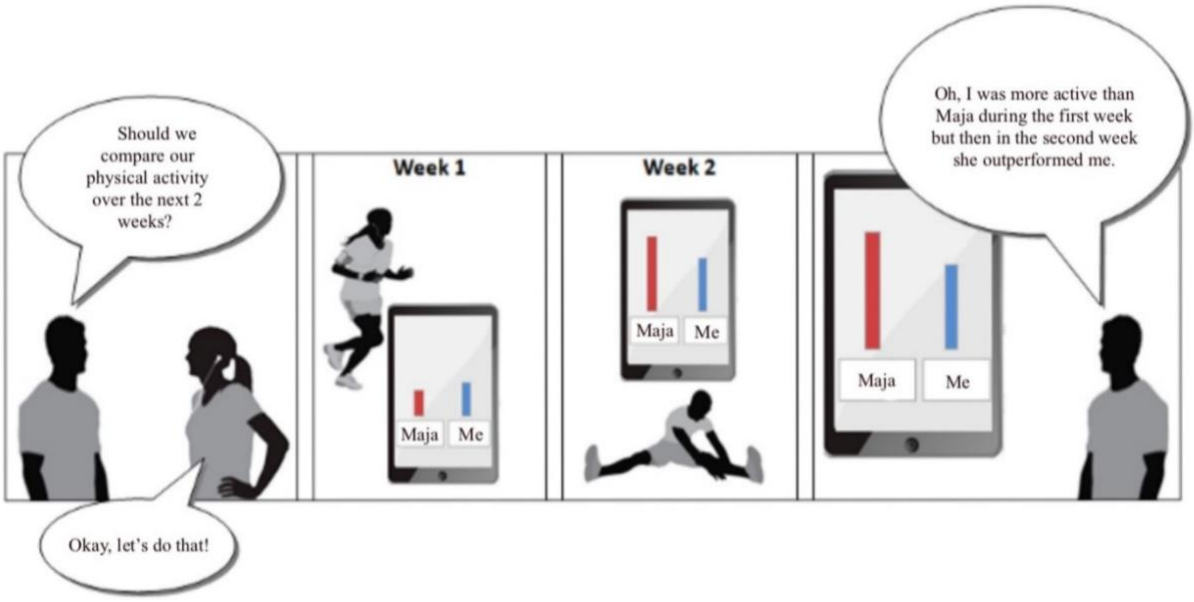
- Yes (1)
- No (2)

Q15: What data are monitored when using your smartphone application, wearable or smartwatch? More than one answer is possible

1) Number of steps
2) Running/walking speed
3) Distance
4) Heart rate
5) Stress level
6) Sleep pattern

Now, we will show you 4 different storyboards. These storyboards present graphic illustrations of a user and his/her interaction with a mobile app aimed to improve your physical activity. After each storyboard, you will be asked to indicate how much you agree or disagree with several statements.

Please read and inspect the storyboards clearly before you rate the statements. Keep in mind that there are no right or wrong answers as we are interested in your personal opinion.

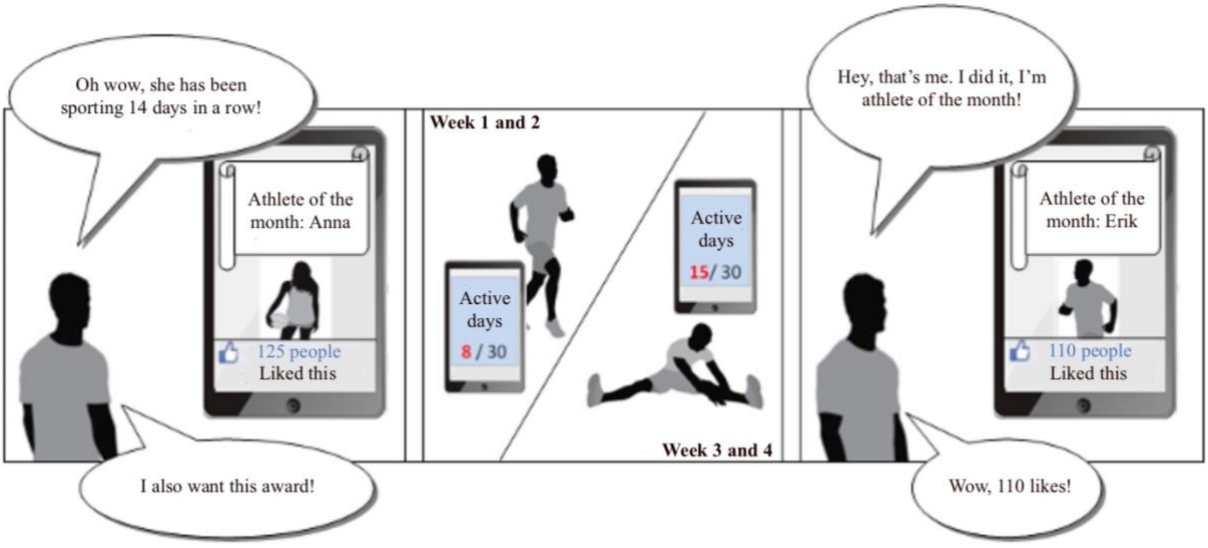


You just saw an example of a feature embedded in an app to stimulate physical activity. Now, we ask you to answer the following questions about your opinion regarding this app. Please answer these questions as honest as possible

Questions	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Q16: I think this application helps me to achieve my personal	○	○	○	○	○	○	○

fitness goals (1)							
Q17: I think this application will help me to receive support from my peers (2)	○	○	○	○	○	○	○
Q18: I believe this application would help me to improve my physical activity (3)	○	○	○	○	○	○	○
Q19: I think this application would not be obtrusive or disturb my activities of daily life (4)	○	○	○	○	○	○	○

Q20: I believe this application would help me to start being physical active (5)	○	○	○	○	○	○	○
Q21: I would use this application in the future in order to improve my physical activity (6)	○	○	○	○	○	○	○

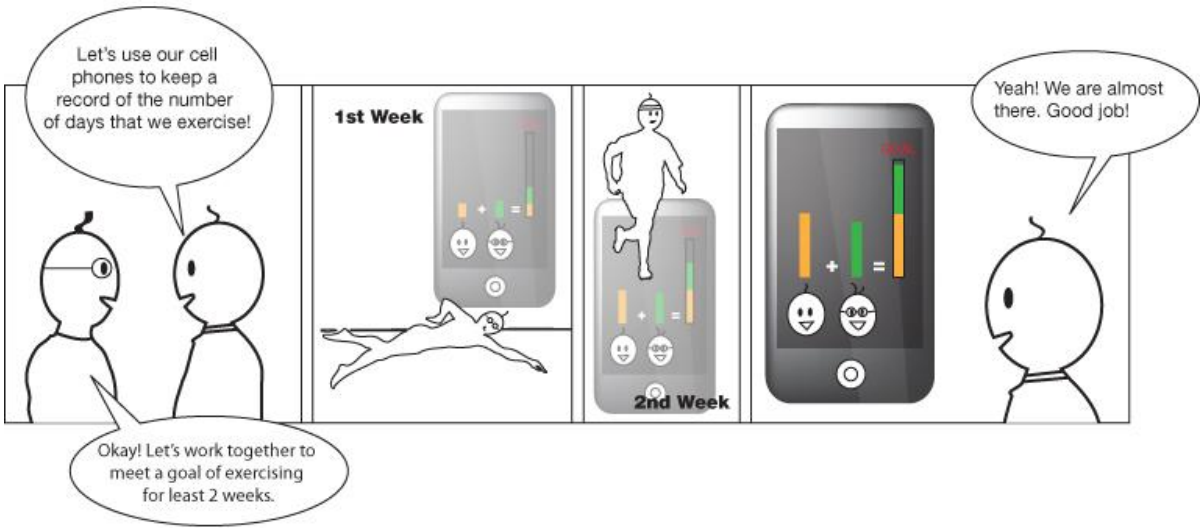


You just saw an example of a feature embedded in an app to stimulate physical activity. Now, we ask you to answer the following questions about your opinion regarding this app. Please answer these questions as honest as possible

Questions	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Q22: I think this application helps me to achieve my personal fitness goals (1)	○	○	○	○	○	○	○
Q23: I think this application will help me to receive support from my peers (2)	○	○	○	○	○	○	○
Q24: I believe this application would	○	○	○	○	○	○	○

help me to improve my physical activity (3)							
Q25: I think this application would not be obtrusive or disturb my activities of daily life (4)	○	○	○	○	○	○	○
Q26: I believe this application would help me to start being physical active (5)	○	○	○	○	○	○	○
Q27: I would use this application in the future in order to improve	○	○	○	○	○	○	○

my physical activity (6)							

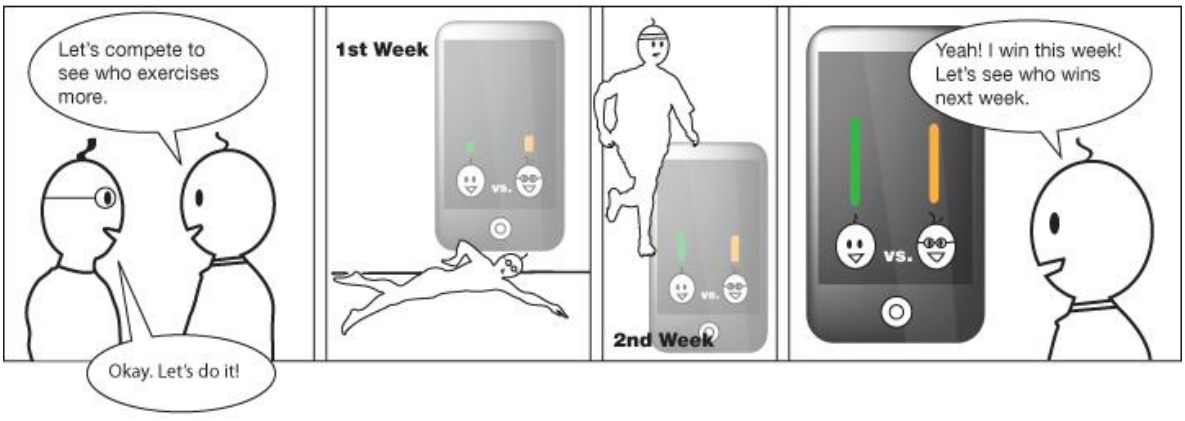


You just saw an example of a feature embedded in an app to stimulate physical activity. Now, we ask you to answer the following questions about your opinion regarding this app. Please answer these questions as honest as possible

Questions	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Q28: I think this application helps me to achieve my personal fitness goals (1)	○	○	○	○	○	○	○

Q29: I think this application will help me to receive support from my peers (2)	○	○	○	○	○	○	○
Q30: I believe this application would help me to improve my physical activity (3)	○	○	○	○	○	○	○
Q31: I think this application would not be obtrusive or disturb my activities of daily life (4)	○	○	○	○	○	○	○
Q32: I believe this	○	○	○	○	○	○	○

application would help me to start being physical active (5)							
Q33: I would use this application in the future in order to improve my physical activity (6)	○	○	○	○	○	○	○



You just saw an example of a feature embedded in an app to stimulate physical activity. Now, we ask you to answer the following questions about your opinion regarding this app. Please answer these questions as honest as possible

Questions	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Q34: I think this application helps me to achieve my personal fitness goals (1)	○	○	○	○	○	○	○
Q35: I think this application will help me to receive support from my peers (2)	○	○	○	○	○	○	○
Q36: I believe this application would help me to improve my	○	○	○	○	○	○	○

physical activity (3)							
Q37: I think this application would not be obtrusive or disturb my activities of daily life (4)	○	○	○	○	○	○	○
Q38: I believe this application would help me to start being physical active (5)	○	○	○	○	○	○	○
Q39: I would use this application in the future in order to improve my physical activity (6)	○	○	○	○	○	○	○

Thank you for your participation! You helped me a lot in gaining data about persuasive features integrated into an app aiming to stimulate physical activity. If you have any questions or concerns, feel free to contact me:

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