

# Smartwatch-Based Persuasive Design with Tailored Competition and Cooperation Strategies for Promoting Physical Activity

Xinrui Guo, Jie Yao, and Shumeng Hou

School of Humanities and Social Sciences, Harbin Institute of Technology (Shenzhen), Shenzhen, China

## ABSTRACT

Persuasive technology has gained popularity in mobile sports applications as a design approach aiming to change healthy-related attitudes and behaviors among users. While researchers have proposed persuasion principles for designing and evaluating Persuasive System Development (PSD), mixed results have been found regarding their effects. One important reason for the discrepancies is related to the “one-size-fits-all” approaches adopted in most of such persuasive applications, which did not consider individual differences and therefore yielded ineffective results. Meanwhile, smartwatch, as a wearable device with health monitoring functions, offers a unique opportunity for persuasive design in the area of promoting physical activity. The current study examined social support, one of the major persuasive strategies that can be implemented on smartwatches, with a focus on social features of competition and cooperation. Our results showed that only the perceived persuasiveness of intergroup competition, which combines competition and cooperation, was significantly higher than that of the individual strategy, whereas competition or cooperation alone was not necessarily more effective. On the other hand, the competitive personality tendency significantly affected participants’ perceived persuasiveness of competition. In other words, the more competitive as people, the more likely they were to be persuaded by the competition strategy. Therefore, tailored strategies were needed for suiting needs of different users when developing persuasive technology in the physical activity domain.

**Keywords:** Persuasive design, Smartwatches, Competition, Cooperation, Physical activity

## INTRODUCTION

In recent years, smart wearable devices have come into our lives, including smartwatches that can conveniently monitor health and exercise data, for which new sports and health applications have been developed. At the same time, persuasive design has gained popularity in mobile sports applications as a design approach to change user attitudes and behaviors, yet most of such persuasive applications have taken a “one-size-fits-all” design approach, regarding all users as the same rather than tailoring contents to individual user characteristics. Inappropriate persuasive strategies may lead to negative reactions and even increase the unhealthy behaviours that the intervention

was intended to reduce (Orji et al., 2014), since persuasive techniques working for one person may reduce the motivation of others. Therefore, it is necessary to find effective persuasive design approaches that are suitable for different groups of people to enhance their exercising motivations and develop sustainable habits.

## LITERATURE REVIEW

### Persuasive Technology and Design

The idea of using technology to motivate desirable behaviors has become a popular topic in the design community in recent years. Originating from the concept of “captology” (Fogg, 2009), interactive information technology designed for changing users’ attitudes or behaviors is known as persuasive technology. Related theories have been refined for more than 20 years, as models and guidelines for persuasive technology were developed. In particular, based on Fogg’s behaviour model (Fogg, 2002), Oinas-Kukkonen & Harjumaa (2008) proposed a framework for designing and evaluating Persuasive System Development (PSD), with specific persuasion principles displayed in Figure 1.

### Promoting Physical Activity Through Social Support Strategies

Regarding the design principles in Figure 1, some studies have been conducted related to social factors and physical activity, as Vallerand & Losier (1999) proposed a motivational sequence in line with the Self-Determination Theory (SDT), i.e., “Social Factors-Psychological Mediators-Types of Motivations-Consequences”. In particular, competition and cooperation as persuasive social factors might affect intrinsic motivation in physical activity. A special type of social strategy has also been found, i.e., intergroup competition, which involves both inter-group competition and intra-group

Primary Task Support	Dialogue Support	System Credibility Support	Social Support
(1) reduction	(8) Praise	(15) Trustworthiness	(22) Social learning
(2) Tunneling	(9) Rewards	(16) Expertise	(23) Social comparison
(3) Tailoring	(10) Reminders	(17) Surface credibility	(24) Normative influence
(4) Personalization	(11) Suggestion	(18) Real-world feel	(25) Social facilitation
(5) Self-monitoring	(12) Similarity	(19) Authority	(26) Cooperation
(6) Simulation	(13) Liking	(20) Third-party endorsements	(27) Competition
(7) Rehearsal	(14) Social Role	(21) Verifiability	(28) Recognition

**Figure 1:** Persuasive design principles in persuasive system development. (Adapted from Oinas-Kukkonen & Harjumaa, 2008).

cooperation, and can combine the advantages of cooperative and competitive strategies for stimulating desired health behavior change. Tauer & Harackiewicz (2004) examined the effects of intergroup competition versus pure cooperation and pure competition on motor tasks, showing that intergroup competition resulted in a higher level of task enjoyment on all measures and led to comparable or higher levels of performance as compared to pure cooperation or pure competition.

### **Tailored Persuasive Design**

Persuasive strategies aiming to promote physical activity may lead to positive, neutral, or even negative results, and therefore understanding individual differences is important. Fogg and colleagues (2002) conducted a study to examine the persuasive effects of similarity between people and computers, and found that people were more readily persuaded by technological products similar to themselves in some way (i.e., principle of similarity). Therefore, compared with traditional user characteristics such as Big Five personality types (Altmeyer et al., 2021), cooperative and competitive personality tendencies were more relevant to the social support design strategies (Xie et al., 2006), and could influence the persuasiveness of cooperative and competitive features on smartwatch-based applications.

## **METHODS**

For this study, we chose to focus on three types of social persuasive strategies implemented on smartwatches for promoting physical activity, the first two common ones plus the third as a new strategy: (1) Cooperation: Users and friends exercise as a team, cooperating by combining the efforts of both; (2) Competition: Users and friends exercise as opponents, and the one with higher scores wins. (3) Intergroup competition: Users form teams and compete with one another.

### **Participants**

This study was conducted in the form of an online survey experiment in China, and each eligible participant was offered a cash incentive. A screening question was set at the very beginning of the questionnaire, asking about their attitude towards exercise: “Are you willing to share exercise data with others online or offline?” Users who selected “no” to this question were excluded, since competition, cooperation, and intergroup competition all require exercising with others. After data cleaning, a total of 168 participants provided valid responses to the experiment, with ages ranging from 17 to 50 years old and 41% being male. In terms of smartwatch usage, over 65% of the participants had a smart watch or band before.

### **Study Design**

The first part of the questionnaire collected background information from the participants, including demographics, smartwatch usage, physical activity, and related attitudes. Then a between-group design was applied in

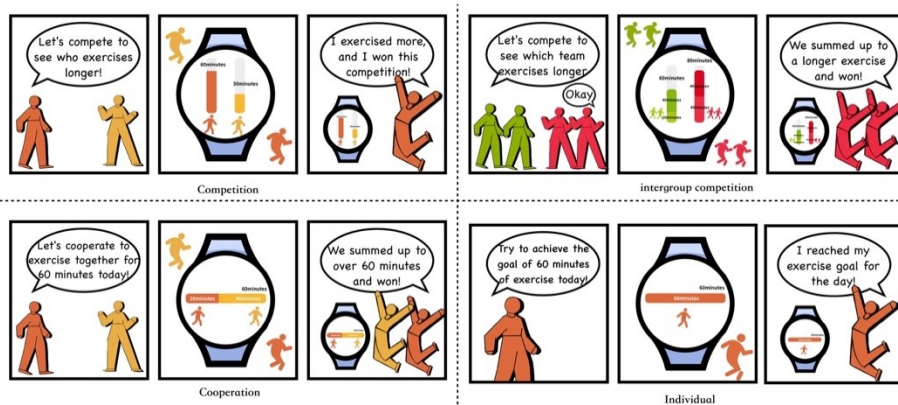
the experiment regarding the perceived persuasiveness of persuasion strategies, as participants were randomly assigned to one of the four groups for evaluating persuasiveness of different strategies, i.e., three social strategies with competitive, cooperative, and intergroup competitive features, and a control group with an individual strategy. Since storyboards have been proved effective at depicting strategies, we followed the approach by Halko & Kientz (2010) to illustrate the persuasive strategies with a common language, by creating storyboards with characters and interactions between them that allowed people from diverse backgrounds to read and understand (see Figure 2).

To elicit feedback on the persuasiveness of the strategies, a validated scale measuring perceived persuasiveness was presented to the participant after each storyboard. The scale was adapted from Drozd et al. (2012) and consisted of four, 7-point Likert-scale questions: “This way of exercising would influence me”, “This way of exercising would be convincing”, “This way of exercising is important to me”, and “This way of exercising make me rethink my exercise habits”. An open-ended question followed to allow participants to give reasons for why they liked or disliked each strategy.

We also adopted the scales of cooperative and competitive personality tendencies, which were proposed by Xie et al. (2006) based on in-depth interviews and literature review. Cooperative and competitive personality tendencies were measured respectively by 10 items on the competitive dimension and 13 items on the cooperative dimension, all of which were on a 9-point Likert scale. In addition to personality, the study was also concerned with the influence of intrinsic motivation for exercising on the perceived persuasiveness of persuasive strategies. Therefore, the six items measuring the need for relatedness from the Psychological Need Satisfaction in Exercise Scale (PNSE) (Wilson et al., 2006) were also presented to the participants.

## Data Analysis

We used SPSS to validate our hypotheses with regression analyses and analysis of variance. The main aim of this paper was to examine whether



**Figure 2:** Storyboards used in the questionnaire.

participants showed significantly higher perceived persuasiveness for the intergroup competition compared to the control group, which would provide evidence for intergroup competition as a persuasive strategy combining competition and cooperation. We also analyzed whether personality traits affected perceived persuasiveness for different strategies, in order to justify tailored persuasive design on smartwatches.

## RESULTS AND DISCUSSION

We tested the participants' competitive and cooperative personality tendencies with a total score of 90 on the competitive dimension and a total score of 117 on the cooperative dimension. According to Table 1, the mean values of the cooperative personality traits were excessively high, and therefore the low cooperative personality sample was so small that it was difficult to examine the differences. We speculated that the reason for this situation may well be the fact that China is a country where the collectivist culture stands dominant and the participants are influenced by social desirability to gain a high score on the cooperation dimension. Therefore, in this paper, only the competitive personality trait dimension was further evaluated as the base for tailoring, which was divided into the high competitive personality and low competitive personality.

As mentioned in the study design, a four-item scale was selected for the perceived persuasiveness measurement. However, we found that there was a significant difference when comparing the fourth item ("This way of exercising makes me rethink my exercise habits") with the other three, which may be due to the fact that changing habits is a better indicator of being persuaded. Therefore, we used this item alone to measure the perceived persuasiveness of the strategies. Controlling for the influences of age and psychological need for relatedness (see Table 2), the perceived persuasiveness of intergroup competition was significantly higher than that of the individual strategy ( $p < 0.05$ ), whereas the perceived persuasiveness of competition or cooperation was not significantly higher.

Then, we conducted a one-way ANOVA with the competitive personality as a covariate to examine its effect on perceived persuasiveness of the competition strategy versus others. The results showed that the personality tendency of competition affected perceived persuasiveness, with a significant main effect ( $p < 0.05$ ) and a non-significant interaction effect (see Table 3). Further pairwise comparisons in Table 4 revealed that among the four groups, the competitive personality did significantly affect perceived

**Table 1.** Personality of competition and cooperation.

Types of personality	Descriptive Statistics				
	N	Minimum	Maximum	Maximum Mean	Mean Std. Deviation
Personality of Competition	168	19.00	90.00	54.8214	14.71092
Personality of Cooperation	168	47.00	117.00	88.3512	13.60879

**Table 2.** Regression analysis summary for strategies predicting perceived persuasiveness.

Variables	Descriptive Statistics Coefficients				
	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
IV (Constant)	-.233	.868		-.268	.789
Cooperation	.347	.302	.101	1.148	.253
Competition	.345	.301	.101	1.147	.253
Intergroup Competition	.636	.312	.176	2.035	.044
Individual	0				
CV Relatedness	.707	.138	.365	5.140	.000
Age	.055	.022	.181	2.557	.011

Dependent Variable: Perceived Persuasiveness

IV: Independent Variables

CV: Control Variables

**Table 3.** Univariate analysis of variance for personality of competition and strategy group in perceived persuasiveness.

Source	Tests of Between-Subjects Effects				
	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25.307a	7	3.615	1.613	.135
Intercept	3837.485	1	3837.485	1711.793	.000
Personality of Competition	11.739	1	11.739	5.236	.023
Strategy Group	8.814	3	2.938	1.311	.273
Personality of Competition *Strategy Group	3.178	3	1.059	.473	.702

Dependent Variable: Perceived Persuasiveness

persuasiveness of the competitive strategy ( $p < 0.05$ ). Specifically, a higher competitive personality would significantly outperform a lower competitive personality when evaluating the persuasiveness of the competitive strategy.

In addition, the personality tendency of competition also influenced task enjoyment with a significant main effect ( $p = 0.022$ ). As shown in Figure 3, pairwise comparisons indicated that participants with a higher competitive personality would score significantly higher on the task enjoyment of the competitive strategy ( $p < 0.05$ ), suggesting the importance of tailored design for improving task enjoyment as well.

**Table 4.** Pairwise comparisons between personality of competition and strategy group in perceived persuasiveness.

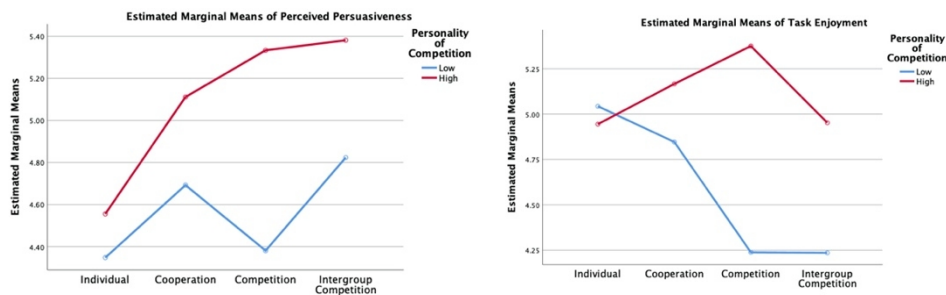
Random	Pairwise Comparisons				
	(I) Personality of Competition	(J) Personality of Competition	Mean Difference (I-J)	td. Error	Sig. <sup>b</sup>
Individual	Low	High	-.208	.471	.660
	High	Low	.208	.471	.660
Cooperation	Low	High	-.419	.459	.363
	High	Low	.419	.459	.363
Competition	Low	High	-.952*	.447	.035
	High	Low	.952*	.447	.035
Intergroup Competition	Low	High	-.557	.488	.256
	High	Low	.557	.488	.256

Dependent Variable: Perceived Persuasiveness

Based on estimated marginal means

\*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Sidak.



**Figure 3:** Estimated marginal means of perceived persuasiveness (left) and task enjoyment (right) with different strategies and personality of competition in different levels.

## CONCLUSION

This study has contributed to tailored persuasive design in the field of physical activity in two aspects. Firstly, we conducted an online experiment to investigate the perceived persuasiveness of individual, cooperative, competitive, and intergroup competition strategies in relation to physical activity. Our results showed that intergroup competition was significantly more persuasive than the individual strategy. Therefore, intergroup competition as a new persuasive strategy can be incorporated into future design approaches for promoting physical activity and health. Secondly, we investigated the effects of the competitive personality tendency on social strategies, as a test of the necessity of tailored persuasive design in the area of physical activity. Both perceived persuasiveness and task enjoyment of the strategies were evaluated, which separately represented the extent to which the strategies are persuasive and enjoyable. As consistent with our hypothesis, the competitive personality tendency significantly affected participants' perceived strategy

persuasiveness. The more competitive as people, the more likely they were to be persuaded by the competition strategy. Given the significance of such individual differences, tailored strategies were required for suiting needs of different users when developing persuasive technology in the physical activity domain.

Limitations of this study were that scores of the cooperative personality were too high among the participants, making subsequent analyses difficult, whereas ideally, we would also tailor persuasive strategies for different levels of the cooperative personality tendency. Nevertheless, this study has laid a foundation for further field research on smartwatch-based social strategies that can promote physical activity in the real world, which is crucial for developing better technological products and advancing the area of tailor persuasive design.

## ACKNOWLEDGMENT

This study was funded by the Guangdong Social Science Fund (Grant No. GD22CJY05), Shenzhen Social Science Fund (Grant No. SZ2022B008), and the Guangdong Education Science Fund (Grant No. 2022GXJK425).

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