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# Wearable Device Users' Behavior Change: Does Persuasive Design Matter？

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***Abstract***

***Purpose***
*Wearable devices are widely used in our daily life. The purpose of this study is to investigate the relationship between persuasive designs of fitness trackers and users' physical activity behavior.*
***Methods***
*To test the research model, data was collected from a web-based survey in China, resulting in an effective sample of 166 usable questionnaires. The survey was restricted only to respondents who wear a fitness tracker.*
***Results***
*The sample surveyed in this study indicated that half of the respondents had been wearing a smart fitness tracker shorter than one year, and only 27% were long-time users (longer than two years). Dialogue support and social support strategies were both proved to be effective in increasing users' workout behavior intention. Social support strategies had a greater effect on behavior change than dialogue support strategies.*
***Conclusion***
*The findings from this study make several contributions to the practice. Wearable devices developers can employ the result from this study to help them design devices, which can persuade people to do more exercises and preserve a healthier life.*

***Keywords:*** *Wearable Device, Fitness Tracker, Persuasive Technology, Physical Activity*

## 1. INTRODUCTION

As Google Glass and Apple Watch gain popularity, wearable devices attract considerable attention of the public. Wearable devices with state-of-the-art features and affordable prices penetrate our daily life quickly. According to a Gartner survey of 9,600 online consumers, for fitness trackers, U.S. consumers lead market adoption rate at 23%, followed by Australia at 19% and the U.K. at 15%. The leading smartwatch country is the U.S. at 12%, while the U.K. is at 9% and Australia at 7%. The overall adoption rate is 19% and 10% for fitness trackers and smartwatches, respectively, which means one every five people wears a fitness tracker and one every ten people wears a smartwatch [1].

Wearable devices are electronic technologies and systems imbedded into daily items, such as wristbands, headphones, clothes, etc., which can be comfortably worn on a body. Wearable devices not only assist our daily life and work, such as making phone calls, sending messages, but also affect our health. Sensors are attached to wearable devices to allow them to take the snapshot of users' everyday activity and synchronize data with mobile devices or computers, like tracking motion, brain activity, heart activity, and muscle activity. The main benefits of wearable technology are to track users' steps along with monitor their heart rate to encourage self-monitoring, create awareness about fitness levels, and improve personal health. By tracking workout and health data, wearable devices make users clearly know their workout and health status.

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To change users' behavior and form healthier behavior habits, persuasive technology is widely devised into wearable devices. In academia, there is a growing body of literature that recognizes the importance of persuasive technology in information system design [2, 3]. Although extensive research has been carried out on persuasive technology, there have been few empirical investigations into the persuasive design of wearable devices. How the persuasive design of wearable devices is related to health behavior is not clear. Besides basic self-monitoring, complementary persuasive features are also implemented into wearable devices, such as sedentary reminder, steps ranking, etc. Are these persuasive designs really meaningful to promote healthier behavior, or just an apple of sodom, is something deserving investigation.

This study aims to investigate the relationship between the persuasive design of fitness trackers and workout behavior. It is hoped that this research will contribute to a deeper understanding of the effect that the persuasive design of wearable devices plays on users' workout behavior and provide good guidance to redesign a persuasive wearable smart device by technical researchers and developers. It is beyond the scope of this study to examine other behaviors, like calling or texting behavior, only workout behavior is examined. The remaining part of the paper proceeds as follows: The next part begins by laying out the theoretical foundation of the research and research model; the third section is concerned with the methodology used for this study and the results; the fourth section discusses the findings of the research; The last two sections present the implication and limitation of the research and make conclusions.

## 2. THEORY AND RESEARCH MODEL

Some scholars and researchers focus their research on identifying distinct persuasive software features in order to confirm and evaluate the significance of persuasive systems and behavior change support systems [4, 5]. Persuasive System Design Model (PSD Model) was conceptualized by Harri Oinas-Kukkonen and Marja Harjumaa in 2009 [6]. It discusses the process of designing and evaluating persuasive systems and describes what kind of content and software functionality may be found in the final product. PSD model, presented in Table 1, provides 28 detailed persuasive system design principles with four categories – primary task support, dialogue support, credibility support, and social support. Primary task support means design principles that support the carrying out of a primary task by the user. Dialogue support refers to principles related to the implementation of human-computer dialogue in a way that helps users move toward their goal or target behavior. System credibility support is described as principles that describe how to design a credible system, which will be more likely to persuade its users. Lastly, social support is principles that describe how to design a system so that it motivates its users by leveraging social influence [6].

**Table 1. Persuasive system design principles**

| Primary Task Support | Dialogue Support | System Credibility Support | Social Support |
|---|---|---|---|
| Reduction | Praise | Trustworthiness | Social learning |
| Tunneling | Reward | Expertise | Social comparison |
| Tailoring | Reminder | Surface credibility | Normative influence |
| Personalization | Suggestion | Real-world feel | Social facilitation |
| Self-monitoring | Similarity | Authority | Cooperation |
| Simulation | Liking | Third-party endorsements | Competition |
| Rehearsal | Social role | Verifiability | Recognition |

Based on Persuasive System Design Model, seven persuasive design principles (praise, reminder, reward, suggestion, social comparison, competition, and social facilitation) used in fitness tracker design to promote users' behavior change are identified and tested with an empirical model. As the relatively high correlation and low discriminant validity among the design principles, a second-order model is used.

Dialogue support strategies consist of praise, reminder, reward, and suggestion. When smart band users forget or give up their exercise plan, or do not work out at all, smart bands remind them to exercise. Physical activities are usually hard to start and hard to maintain, by effective reminder strategy, it is easier for the users to adhere to an exercise plan. Moreover, smart bands usually give praise and virtual rewards when everyday step goals are achieved or win a competition game, which makes the exercise requitable and deserves a long-term persistent effort [7]. Additionally, for those who are lack of professional exercise knowledge, an expertized guide from fitness tracker provides a step by step exercise plan, which can motivate a long-term desire and eliminate the risk of withdrawing from the plan [8]. In general, dialogue support strategies build smart band users' self-confidence and self-motivation to adhere to their exercise plan and increase their physical activity level.

H1 Dialogue support design of smart band has a positive effect on users' physical activity behavior change

Social support strategies are composed of social comparison, competition, and social facilitation. With these strategies, smart bands provide users a social environment to do exercise with others together rather than doing exercise themselves alone, in order to arouse their motivation. When being aware that friends are doing exercise with a smart band, and friends can observe their exercise status and performance through the device, it drives smart band users to adhere to or even speed up their exercise schedule [9]. Moreover, competing with friends in a virtual hiking game, and comparing steps ranking among friends, motivate users' desire to win and make the exercise an interesting game rather than a dull routine. All these social support designs of smart bands make a boring routine exercise as an interesting collective workout among friends, encouraging users to engage in more sustained and intensive physical activities.

H2 Social support design of smart band has a positive effect on users' physical activity behavior change.

## 3. METHOD AND RESULT

To test the research model, data was collected from a web-based survey in China, resulting in an effective sample of 166 usable questionnaires. The survey was restricted only to respondents who wear a fitness tracker. Table 2 shows the demographic information of the sample. The final sample consisted of 48.8 percent men and 51.2 percent women. The most popular fitness tracker brands were Xiaomi, Samsung, Huawei, and Fitbit. Half of the respondents (53.0%) were Xiaomi Miband users, and 52.4% had less than one year smart band using experience.

**Table 2. Sample summaries**

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| Gender | | |
| Male | 81 | 48.8 |
| Female | 85 | 51.2 |
| Age (Years) | | |
| Below 20 | 18 | 10.8 |
| 20-29 | 78 | 47.0 |
| 30-39 | 27 | 16.3 |
| 40-49 | 24 | 14.5 |
| 50-59 | 15 | 9.0 |
| 60 and above | 4 | 2.4 |
| Brand (Multiple choices) | | |
| Xiaomi | 88 | 53.0 |
| Samsung | 28 | 16.9 |
| Huawei | 27 | 16.3 |
| Fitbit | 20 | 12.0 |
| Lifesense | 18 | 10.8 |
| Misfit | 17 | 10.2 |
| Garmin | 17 | 10.2 |
| Jawbone | 16 | 9.6 |
| Time | | |
| Less than 6 months | 51 | 30.7 |
| 6 months-1 year | 36 | 21.7 |
| 1 year-2 years | 34 | 20.5 |
| 2 years-3 years | 18 | 10.8 |
| 3 years-4 years | 16 | 9.6 |
| 4 years-5 years | 5 | 3.0 |
| 5 years and above | 6 | 3.6 |

The questionnaire used in the survey was built on existing literature. This study adapted tested and proved multi-item scales from prior studies and developed new measurements for constructs without empirical support. The items and responses appeared on a seven-point Likert scale, ranging from "1: strongly disagree" to "7: strongly agree". Two higher-order constructs were constructed, dialogue support and social support, to overcome discriminant validity problems. Dialogue support is a higher-order construct with praise, reward, reminder, and suggestion at its lower-order construct level. Social support is a second-order construct with social comparison, social facilitation, and competition as its first-order constructs. Moreover, physical activity behavior change intention was measured with four items.

To analyze the research model in this study, partial least squares structural equation modeling (PLS-SEM) was employed. Following Hair et al. (2014) [10], the interpretation of the results comprises two stages: (1) assessment of the measurement model, and (2) evaluation of the structural model.

## 2.1 Measurement Model

We estimated the second-order construct measurement model. The assessment of a reflective second-order factor model should use the same set of criteria and critical values as for the reflective first-order factors to establish reliability and validity of the higher-order level constructs [11]. The results indicated that the reflective measures of the first- and second-order constructs met all the requirements in terms of reliability and validity. Table 3 demonstrates results of measurement model. First, all indicators of the reflective constructs of first- and second-order showed loadings above 0.708, supporting the indicators' validity. Second, all Composite Reliabilities and Cronbach's Alpha values of first- and second-order constructs were greater than 0.70, thus confirming the measures' internal consistency reliability. In addition, all Average Variance Extracted (AVE) values of first- and second-order constructs surpassed the threshold of 0.50, supporting the constructs measures' convergent validity.

**Table 3. Measurement model result**

| Constructs | Sub Constructs | Items | Loadings | AVE | C.R. | Alpha |
|---|---|---|---|---|---|---|
| **Dialogue Support** | | | | **0.619** | **0.963** | **0.959** |
| | Praise | | | 0.770 | 0.931 | 0.900 |
| | | PR1 | 0.911 | | | |
| | | PR2 | 0.850 | | | |
| | | PR3 | 0.898 | | | |
| | | PR4 | 0.849 | | | |
| | Reward | | | 0.777 | 0.933 | 0.904 |
| | | REW1 | 0.833 | | | |
| | | REW2 | 0.888 | | | |
| | | REW3 | 0.918 | | | |
| | | REW4 | 0.884 | | | |
| | Reminder | | | 0.738 | 0.919 | 0.882 |
| | | REM1 | 0.868 | | | |
| | | REM2 | 0.881 | | | |
| | | REM3 | 0.861 | | | |
| | | REM4 | 0.826 | | | |
| | Suggestion | | | 0.736 | 0.918 | 0.881 |
| | | SU1 | 0.868 | | | |
| | | SU2 | 0.880 | | | |
| | | SU3 | 0.828 | | | |
| | | SU4 | 0.855 | | | |
| **Social Support** | | | | **0.705** | **0.966** | **0.962** |
| | Social Comparison | | | 0.854 | 0.959 | 0.943 |
| | | SCO1 | 0.943 | | | |
| | | SCO2 | 0.926 | | | |
| | | SCO3 | 0.911 | | | |
| | | SCO4 | 0.916 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Social Facilitation | | | 0.765 | 0.929 | 0.897 |
| | | SF1 | 0.877 | | | |
| | | SF2 | 0.876 | | | |
| | | SF3 | 0.867 | | | |
| | | SF4 | 0.878 | | | |
| | Competition | | | 0.813 | 0.946 | 0.923 |
| | | CO1 | 0.890 | | | |
| | | CO2 | 0.916 | | | |
| | | CO3 | 0.928 | | | |
| | | CO4 | 0.872 | | | |
| **Physical Activity Intention** | | | | **0.813** | **0.946** | **0.925** |
| | | PAI1 | 0.937 | | | |
| | | PAI2 | 0.885 | | | |
| | | PAI3 | 0.927 | | | |
| | | PAI4 | 0.855 | | | |

Note: C.R.= Composite Reliability, Alpha = Cronbach's Alpha, AVE = Average Variance Extracted.

Finally, we examined the discriminant validity of the measurement model Out loadings on each first-and second-order constructs were higher than cross-loadings with other constructs. Table 4 shows results for discriminant validity. The square root of AVE values of second-order constructs (Dialogue support and social support) and physical activity intention were higher than their correlations with each other in the path model. However, when applying the Fornell and Larcker (1981) [12] criterion for first-order constructs, we found that the correlations were only slightly below the square root of Average Variance Extracted. The lower-level construct's discriminant validity is therefore not well established, which provides empirical support for applying the second-order constructs in this study. In higher-order models, discriminant validity between the second-order constructs and the first-order constructs, as well as among the first-order constructs are not required. Thus discriminant validity between second-order constructs and physical activity intention used in the path model is confirmed.

**Table 4. Discriminant validity**

| Constructs | Mean | S.D | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower-order Constructs | | | | | | | | | | | | |
| 1. Praise | 4.994 | 1.386 | 0.877 | | | | | | | | | |
| 2. Rewards | 4.766 | 1.501 | 0.776 | 0.881 | | | | | | | | |
| 3. Reminder | 5.021 | 1.405 | 0.810 | 0.717 | 0.859 | | | | | | | |
| 4. Suggestion | 4.902 | 1.293 | 0.741 | 0.760 | 0.750 | 0.858 | | | | | | |
| 5. Comparison | 4.791 | 1.710 | 0.189 | 0.088 | 0.257 | 0.240 | 0.924 | | | | | |
| 6. Facilitation | 4.430 | 1.533 | 0.147 | 0.105 | 0.178 | 0.221 | 0.814 | 0.875 | | | | |
| 7. Competition | 4.591 | 1.582 | 0.232 | 0.173 | 0.249 | 0.273 | 0.849 | 0.745 | 0.902 | | | |
| Higher-order Constructs | | | | | | | | | | | | |
| 8. DS | 4.922 | 1.262 | 0.921 | 0.899 | 0.904 | 0.895 | 0.814 | 0.184 | 0.255 | 0.831 | | |
| 9. SS | 4.608 | 1.502 | 0.204 | 0.130 | 0.253 | 0.263 | 0.957 | 0.909 | 0.930 | 0.234 | 0.840 | |
| 10. PAI | 5.291 | 1.334 | 0.235 | 0.289 | 0.269 | 0.188 | 0.301 | 0.210 | 0.290 | 0.235 | 0.289 | 0.902 |

Note: DS: Dialogue Support, SS: Social Support, PAI: Physical Activity Intention
Diagonal elements are the square roots of the AVE

### 3.2 Structural Model

Analysis of the structural model drew on Hair et al. (2014) [10]. The analysis showed minimum collinearity in predictors in the structural model, as all the Variance Inflation Factor (VIF) values were far below the threshold of 5 [13]. Furthermore, the $R^2$ value of physical activity behavior change intention was 0.113, which is acceptable in social science research. Subsequently, applying the bootstrapping procedure (5000 bootstrap samples; no sign changes), we examined the magnitude of the path coefficients and their significance. The results (presented in Table 5) confirmed that social support had a strong positive impact on physical activity behavior change intention (0.252; $P < 0.01$). Moreover, the assessment of the path model supported the hypothesis that dialogue support of smart band increased users' physical activity behavior change intention (0.179; $P < 0.05$). Consequently, empirical data supported hypotheses 1 and 2. Social support (0.252) was proved to be a more effective strategy than dialogue support (0.179) to promote smart band users' physical activity behavior change.

Table 5 Structural model results

| Structural Path | Path Coefficient | T-value | Conclusion |
|---|---|---|---|
| Dialogue Support→Physical Activity Intention | 0.179 | 2.318** | H1 supported |
| Social Support→Physical Activity Intention | 0.252 | 3.093*** | H2 supported |

Note: *p<0.1, **p<0.05, ***p<0.01

## 4. DISCUSSION

The most obvious finding emerging from this research is that social support strategies have a greater effect on behavior change than dialogue support strategies. There are several possible explanations for this result. First, collective exercise is more possible to sustain than the individual workout. Dialogue support strategies provide an environment for collective exercise, while social support strategies mainly support the individual exercise. Social comparison, social facilitation, competition strategies provide a virtual environment where smart band users can feel friends doing exercise together with them, check friends' real-time workout performance, compare performance with friends, and compete with friends in a virtual hiking game. Smart band users feel they are not doing exercise alone. Individual workout relies more on strong self-motivation and self-discipline. Individuals who lack self-motivation are hard to stick to sports. However, working out together with a small group of friends can easily continue due to peer pressure even though one may hesitate to give up. In reality, it's difficult for everyone in the group to meet and work out together regularly at the same time and in the same place in this busy society, but dialogue support strategies make it possible notwithstanding. Second, the competition of dialogue support strategies, like playing a hiking game, stimulates people's workout interests while making tedious exercises pleasing and easier to engage in. Games make the workout, not a responsibility one has to perform, but rather a fun full of entertainment. Third, social support strategies, such as ranking higher in steps rank or winning a competition game, make good use of people's emulation to encourage more exercise. The stronger the will to win, the more exercise people may do. In summary, interaction with others makes social support strategies more effective to stimulate physical activity than dialogue support strategies.

It is also interesting to note that half of the respondents surveyed in the study had been wearing smart fitness tracker shorter than one year, and only 27% were long-time users (longer than two years). A possible explanation for these results may be the lack of user viscosity in fitness tracker design, especially for long-time users. The fitness tracker is not viewed as a daily life necessity, thus after a honeymoon period, the novelty wears off quickly. Another possible explanation for this is that there are plenty of substitutions available in the market, like Apple Health, Samsung Health, etc. Most users only value steps counting feature other than other diverse features provided by a fitness tracker, which can be easily substituted by mobile step counting applications. The last explanation is discommodity in using a fitness tracker, such as charging on regular bases, using both tracker and mobile app, synchronizing between the device and mobile app, especially feeling uncomfortable during sleep (wearing 7/24 to track sleep patterns). All these reasons make smart band users churn or become inactive.

## 5. Implication and limitation

The findings from this study make several contributions to the practice. First, dialogue support strategies are proved to be less critical, which may stem from a less effective design in reward and suggestion strategies. Current smart bands available in the market merely measure workout status and sleep pattern, but seldom give professional advice accordingly. Users have no idea about how to improve their current health status. Moreover, smart bands only provide virtual rewards when users make some achievements. These weaken the effectiveness of suggestion and reward strategies used in fitness tracker design. Wearable device designers should design devices which can give professional advice from professional coaches or physicians based on AI algorithms and different workout or health status recorded by trackers, and provide coupons or points as rewards which can be used in purchasing real sports equipment or workout services. These effective designs may make dialogue support strategies a strong motivator for workout behavior. Second, social support strategies are proved to be more noteworthy. Wearable device designers should conceive funny competition games to provide a virtual environment for group exercise. Besides games for walking, diverse games for sports, bicycling, yoga, etc., which are uncomplicated even for old people to play, are needed. Third, more attention should be given to retaining existing users as current devices have very low attractions to them. Upgraded persuasive strategies, benefits and premium services different from new users need to be provided to prevent them from churning. For idle users, who stopped wearing the device for a while, strategies to wake them up and trigger their return and become active users again need to be carefully devised. Forth, mobile apps (Apple health, etc.) on smartphones appear to be strong competitors to wearable fitness trackers, hence how to provide more essential services than mobile apps and make wearable devices a necessity for daily life, is a prominent problem under resolved, which needs further practical efforts.

The findings of this study have a number of limitations deserve future studies. It is unfortunate that the study did not include primary task support and system credibility support strategy from the PSD model, and each strategy in dialogue support and social support strategies is not tested individually but as a part of higher-order constructs. It is because of the considerably high correlation and lack of discriminant validity among individual strategies. Another limitation is the relatively small sample size used in the study, and an especially remarkably high percentage of short-time users (shorter than 6 months or shorter than 1 year) in the final sample, who may not thoroughly use all the features of the smart band. All these limitations further lay the groundwork for future research into individual persuasive strategies, or a group of strategies (highly cautious about the high correlation among them), for example studying reward strategy or suggestion strategy. Additionally, self-motivation is an important determinant to workout behavior, a study of how self-motivation interacts with persuasive strategy, and how do they stimulate workout behavior together, which may give us fruitful findings in the future.

## 6. CONCLUSION

Wearable devices are widely used in our daily life. The main goal of the current study is to examine the effect of fitness tracker persuasive design on users' workout behavior. The sample surveyed in this study indicated that half of the respondents had been wearing a smart fitness tracker shorter than one year, and only 27% were long-time users (longer than two years). The empirical finding had provided a deeper insight into how smart band pervasive design affects users' workout behavior intention. Dialogue support and social support strategies were both proved to be effective in increasing people's workout behavior intention, especially social support strategies. Social support strategies had a greater effect on behavior change than dialogue support strategies. The findings from this study make several contributions to the practice. Wearable devices developers can employ the result from this study to help them design devices, which can persuade people to do more exercises and preserve a healthier life.

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