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Do Wearable Devices Change Behavior? A Study of Smart Fitness Trackers*

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Ⅰ. Introduction

''Wearable technology'' and ''wearable devices'' are phrases that describe electronics and computers that are integrated into clothing and other accessories, which can be worn comfortably on the body (Wright & Keith, 2014). Examples of wearable devices include watches, glasses, contact lenses, e-textiles, and smart fabrics, headbands, beanies and caps, jewelry such as rings, bracelets, and hearing aid-like devices that are designed to look like earrings. Google Glass, Samsung Galaxy Gear smartwatch, and Apple watch are the most prominent gadgets that belong to the first generation of wearable devices. These wearable devices can perform many of the

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same computing tasks as smartphones and laptop computers; however, in some cases, wearable devices can outperform these hand-held devices entirely. Wearable technology tends to be more sophisticated than hand-held technology on the market today because it can provide sensory and scanning features not typically seen in mobile and laptop devices (Tehrani & Michael, 2014).

The implications and uses of these devices are far-reaching and can influence the fields of health and medicine, fitness, aging, disabilities, education, transportation, enterprise, finance, gaming, and music. The goal of wearable technology in each of these fields will be to smoothly incorporate functional, portable electronics and computers into individuals' daily lives. According to a research, although only 18 percent of the UK and US respondents surveyed have actually used wearable technology, 82 percent of those users in America and 71 percent in Britain believe that these cloud-powered devices have enhanced their lives. 63 percent of the UK and 71 percent of American respondents stated that wearable technology has improved their health and fitness (Rackspace, 2013).

By recording and reporting information about behaviors such as physical activity or sleep patterns, these devices can educate and motivate individuals toward better habits and healthier behaviors. However, the gap between recording information and changing behavior is substantial, and while these devices are increasing in popularity, little evidence suggests that they are bridging this gap. Most health-related behaviors such as eating well and exercising regularly could lead to meaningful improvements in population health only if they are sustained. If wearable devices are to be part of the solution, they either need to create enduring new habits, turning external motivations into internal ones, or they need to sustain their external motivation. This requirement of sustained behavior change is a major challenge, but many wearable devices have not yet leveraged principles from theories of behavior. Some of the wearable devices may achieve this goal, but less because of their technology and more because of the behavioral change strategies that can be designed into them.

For the developers and vendors of the wearable device, the most urgent issue of device development is how to design an effective and persuasive device that may attract user's interest or persuade them to use the device and change their behavior. From a designer and user's perspective, it is a psychological and behavioral problem. A lot of scholars and researchers have argued this issue from human behavior change and habit-forming perspectives (Kerner & Goodyear, 2017; Attig & Franke, 2019). They focused on the components of human behavior and the different types of behavior change, and also they wanted to design behavior solutions that really affect habit-forming and behavior change. However, the theoretical interpretation of behavior change after using wearable devices is not entirely clear. Previous studies highlight the behavior change after some experimental research about medical machines (Gualtieri et al., 2016 ; Poirier et al., 2016; Abedtash & Holden, 2017), however, none of them are focusing on the behavior change after using a wearable device.

This research focuses on wearable fitness trackers. Smart fitness tracker boasts at least nine different types of wear: wristband, clip, chest strap, anklebone, headband, headphone, insole, leg strap or mouthguard. The study focuses on the physical activity behavior change effect of smart wristband, which is the most popular type of fitness tracker nowadays. The purpose of the research is to investigate how people's workout behavior may change after wearing a smart band and examine what kind of role persuasive design plays in behavior change.

Ⅱ. Literature Review

Persuasive technology is a new and fast-growing research topic. Nowadays, interactive information technology is widely used in our daily lives, which can be considered as persuasive technology because this kind of interactive information technology is designed for the purpose of changing users' behavior and attitude (Fogg, 2003). Traditionally, "persuasion" or "persuasive technology" means that "to design a human communication which will influence the autonomous judgments and actions of others" (Simons et al., 2001, p. 20). Both researchers and technology developers are focusing on increasing technology's persuasive design for the purpose of motivating and influencing users. In addition, it is important for technology developers to understand how persuasive principles of motivation and influence can be designed into interactive experiences with new technology. These kinds of interactive technologies and persuasive technologies can absolutely change user's attitudes and behaviors.

2.1 Behavior Wizard

A contribution of B.J. Fogg for behavior change theory is to describe 15 ways behavior can change. It is called as "Behavior Grid" or "Behavior Wizard" (Fogg & Hreha, 2010). In the past, behavioral psychology researchers and technology designers have to guess at solutions for changing behavior. However, most of their attempts failed at last. This Behavior Wizard is frankly useful as a guide to supply a solution in order to confirm the user's behavior changing type. Because behavior is systematic, wearable device developers should know how to follow some system design principles to create a new way to form the user's habits. Furthermore, we can extend this analysis to explain that the best design approach for wearable devices is not to manipulate or transform users using purpose but to help them do what they already want to do.

"Behavior Wizard" refers to a method that help designer to identify specific types of behavior targets, confirm the behavior change type, and match those to relevant solutions (Fogg, 2009). It is described as a matrix of 15 types of behavior change. Table 1 shows the Behavior Wizard matrix. It is formed by two axes. The horizontal axis segments behaviors into five flavors that use five different colors to represent five different behaviors: do new behavior that is unfamiliar, do familiar behavior, increase behavior intensity or duration, decrease behavior intensity or duration, and stop doing a behavior. The vertical axis represents behavior's durations: one time, span of time, or ongoing. With the 15 behavior types, "Behavior Wizard" can isolate, identify and clarify the target behavior and distinguish from others. It is also useful to help people to identify what triggers the behavior. By using this wizard, most people can articulate a target behavior and clearly know how to develop a plan to preserve or change their behavior.

2.2 Persuasive System Design Model

Some scholars and researchers also 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. Actually, Fogg (2003) has provided a widely utilized framework to help developers to understand the persuasive technology.

<Table 1> Behavior Wizard matrix

BEHAVIOR GRID	GREEN	BLUE	PURPLE	GREY	BLACK
	Do new behavior	Do familiar behavior	Increase behavior intensity	Decrease behavior intensity	Stop existing behavior
DOT	GREEN DOT	BLUE DOT	PURPLE DOT	GREY DOT	BLACK DOT
One time	Do a new behavior one time	Do a familiar behavior one time	Increase behavior one time	Decrease behavior one time	Stop behavior one time
SPAN	GREEN SPAN	BLUE SPAN	PURPLE SPAN	GREY SPAN	BLACK SPAN
Period of time	Do behavior for a period of time	Maintain behavior for a period of time	Increase behavior for a period of time	Decrease behavior for a period of time	Stop behavior for a period of time
PATH	GREEN PATH	BLUE PATH	PURPLE PATH	GR EY PATH	BLACK PATH
From now on	Do new behavior from now on	Maintain behavior from now on	Increase behavior from now on	Decrease behavior from now on	Stop behavior from now on

However, it cannot be used directly to evaluate the persuasive system design or even as guidance to lead developers following some effective principles to design a system with persuasive features. Persuasive system development should follow three steps and some design principles. First, developers should learn to understand and confirm the key issues behind the persuasive system before implementing the system. Second, developers should analyze the context for persuasive systems, and recognize and evaluate the intention, the event, and the persuasion strategy. Third, to design actual system qualities for a new information system or to evaluate the features of an existing system will be required (Oinas-Kukkonen & Harjumaa, 2009).

Persuasive System Design Model (PSD Model) was conceptualized by Harri Oinas-Kukkonen and Marja Harjumaa in 2009 (Oinas-Kukkonen & Harjumaa, 2009). This model focuses on the detailed analysis of the persuasion context, the event, and the strategy. The persuasion context means the intended change in behaviors and attitudes. The event refers to identify the context of use and users of technologies. The strategy means to develop the content of the message and delivery route that tightly integrated with target users. PSD model also provides 28 detailed persuasive system design principles with four categories – primary task support, dialogue support, credibility support, and social support (Table 2). Until recently, some scholars have made a guideline for PSD features in order to design new apps with better persuasion (Lehto & Oinas-Kukkonen, 2015; Zhang et al., 2016a; Zhang et al., 2016b; Zhang et al., 2017). Some scholars have further discussed the persuasive effectiveness of PSD characteristics and how they influence user behavior and habit formation (Zhang & Wan, 2018a; Zhang & Wan, 2018b). Further research was conducted on the durative persuasion and long-term behavioral changes of PSD features to address the causal relationship between durative persuasion and behavior change (Zhang & Wan, 2019).

<Table 2> 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

Ⅲ. Research Approach

This research employed an experimental study to examine whether the user's workout behaviors changed after using wristband from the “Behavior Wizard” perspective. A representative smart wristband from a major vendor was selected as the objects of experimental study. In the experiment, by comparing users' workout behavior before and after using the wristband, behavior changes of all the experiment participants were classified into one of the 15 behavior change types. Users perceived persuasive design characteristics were measured on the basis of the PSD model, and group differences were tested among different behavior change groups.

3.1 Participants

Ten Fitbit Charge 2 were purchased and used in this research. The experiment lasted five rounds, and ten participants used Fitbit Charge 2 for two weeks in each round. Altogether 50 participants joined the research, however, two dropped out during the experiment because of personal issues, and only 48 participants left. Participants of the experiment were students recruited from several undergraduate-level business classes of a university in Korea. Only those who were voluntary to try the wearable device were chosen for the research. The initial sample consisted of 48 students (22 males and 26 females), 31(18 males and 13 females) of whom exercised regularly in leisure time while 17(4 males and 13 females) did not do any exercise at all (Table 3). The primary inclusion criteria for the experiment were nonusers with no experience of smart wristband before the experiment. Existing users of the wristband may have already changed their behavior with their experience of the smart wristband. None of the 48 experiment participants had used wearable devices before the experiment. One question in the posttest survey regarding experience in wearable devices before the experiment also proved this result.

<Table 3> Participants summaries

Characteristic	Frequency	Percentage (%)	Characteristic	Frequency	Percentage (%)
Gender			Health status		
Male	22	45.8	Ill	3	6.2
Female	26	54.2	Ordinary	11	22.9
Age (Years)			Healthy	26	54.2
15-19	2	4.2	Very healthy	8	16.7
20-24	36	75.0	Workout		
25-30	10	20.8	Exercise	31	64.6
			No exercise	17	35.4

3.2 Procedures

During the experiment, experiment assistants introduced general features of fitness tracker (Fitbit Charge 2) and experiment procedures to all the experiment participants. Then assistants helped experiment participants download Fitbit mobile application from app stores into each participant's smartphone and connect Fitbit Charge 2 with Fitbit mobile application. In the follow-up phase of the study, all the participants answered a pretest survey that is developed based on Business Wizard to measure their workout behaviors before using a wristband. After two weeks of the actual use of the device, they answered a posttest survey when they return the device. In the experiment, participants were requested to wear the fitness tracker every day during two week experiment period, however, they can freely choose to use any features of wristband and Fitbit application, or do exercise. No further suggestions or intimations were given to the participants in avoidance of interference from non-device’s persuasive effectiveness. Participants only depended on their own willingness to choose whether to change their behavior from their interaction with the wristband. In the pretest survey, participants were asked the following questions: (1) type of exercise the participants do before participating in the experiment, (2) frequency of exercise every week and duration of each time they do exercise. Some participants do more than one type of exercise, all the exercise types they do were recorded, and frequency for each type of exercise was asked and recorded. In the posttest survey, type of exercise and frequency of exercise during the two week experiment period were asked again, besides these, if the type of exercise or frequency of exercise changed, external reasons caused the change besides the smart band itself were asked. Participants, who changed their exercise behavior during the experiment because of obvious external reasons, like exams or friends’ invitations, were excluded from the study. By a comparative analysis of the pretest and posttest survey, we confirmed the type of user's behavior change that happened in the experimental study. Some examples of classifying behavior change types are presented in table 4. For participants who did not work out before the experiment, but started to work out in the experiment, we further asked them in the posttest whether the exercise was new to them or familiar which has done before to distinguish between a green behavior change and a blue behavior change. When frequency or duration of exercise changed, we compared the weekly exercise intensity (Frequency × duration) before the experiment and during the experiment to determine whether the intensity of exercise per week increased or not to tell between a purple behavior change and a grey behavior change.

<Table 4> Examples of behavior change classification

Participant	Pretest Survey			Posttest Survey			Behavior Change
	Exercise	Frequency (/week)	Duration (/time)	Exercise	Frequency (/week)	Duration (/time)	
A	Swimming	1	1 hour	Swimming	1	1 hour	Retain Exercise
B	No	-	-	No	-	-	No Exercise
C	Jogging	2	1 hour	No	-	-	Black Span
D	No	-	-	Walking	2	1 hour	Blue Span
E	Walking	3	1 hour	Walking	4	1.5 hours	Purple Span
F	No	-	-	Skate Board	2	2 hours	Green Span
G	Health Club	7	2 hours	Health Club	5	2 hours	Grey Span

3.3 Measurements

By systematic literature review, we initially established an English version of the questionnaire. It is then interpreted into Korean and finally translated back to English with the aid of two independent translators to verify conceptual equivalence and identify any language or terminology problem. Besides questions asking basic demographic information and exercise behavior, in the posttest survey, participants also answered questions regarding the persuasive design of smart wristband. 13 persuasive design principles, which are used in smart band design, were selected from the PSD model. This study adapted tested and proven multi-item scales from prior studies (Fogg, 2002; Oinas-Kukkonen & Harjumaa, 2009; Nelson et al., 2016) and developed new measurements for constructs without empirical support. Participants were asked to respond using a seven-point Likert scale ranging from "1: strongly disagree" to "7: strongly agree".

Ⅳ. Data Analysis and Result

4.1 Behavior Change

Human behavior is a complicated phenomenon, which can be affected by many factors in a real-world setting. In the posttest, participants who changed their workout behavior were also asked for the reason. Some participants specifically pointed out that they stopped or decreased the frequency of the behavior because of exams or assignments, or some said that they began yoga or ballet owing to their friends' invitation, while some couldn't pinpoint any specific reason for their behavior change. Since this research is examining the effect of design features of the smart band on behavior change, behavior change caused by any external incentives other than the smart band itself was eliminated from the result. 14

participants among all the participants answered that they were affected by external reasons (Table 5), among whom 9 participants who only demonstrated one behavior change (caused by external incentives) were excluded from the final result. 5 participants showed two behavior changes and only reported external reasons for one of the behavior change. Since the sample size is not large enough, for them, only the behavior change caused by external incentives was deleted, while the other behavior change, which had no specific incentive, was remained in the final result. They were considered as the same as participants with one single behavior change. Results after deleting behavior change caused by external reasons are shown in Table 6 and Table 7.

After excluding behavior change caused by external incentives, 39 participants were analyzed as final data (Table 6), among whom 15 were males and 24 were females. Pretest showed 22 participants (56%) worked out in leisure time before they participated in the experiment, while 17 (44%) did not do any exercise at all. 73% of males worked out (11 out of 15), and 46% of females did exercises (11 out of 24). Workout in the gym (6) and

<Table 5> Behavior change caused by external reasons

Behavior change	Number of participants	Reasons for change
Grey Span	5	Busyness (exams, assignments, etc.)
Black Span	3	Busyness (exams, assignments, etc.)
Purple Span	2	Weight management, preparation for a ball game
Green Span	2	Friend invitation
Green Dot	1	Family member invitation
Blue Span	1	Family member invitation

<Table 6> Pretest and posttest result

Total Number=39(15M/24F)	Exercise	No Exercise
Pretest	22(11M/11F)	17(4M/13F)
Posttest	30(13M/17F)	9(2M/7F)
Note: M: male, F: female		

<Table7> Behavior change result

	Number of People	Retain Exercise Status		No Exercise	
No Change	20(8M/12F)	11(6M/5F)		9(2M/7F)	
Change	19(7M/12F)	-		-	
	Green	Blue	Purple	Grey	Black
Dot	-	-	-	-	-
Span	1	11	7	2	2
Note: M: male, F: female					

walking outside (5) were the most popular exercises among college students, followed by jogging outside (3) and others.

From posttest results, during the two weeks experiment period, 30 participants (77%) did some exercises and 9 (23%) did not work out. 87% of males (13 out of 15) and 71% of females (17 out of 24) did exercises. Compared with the pretest result, both genders' workout ratio increased and 8 more participants (6 females and 2 males) engaged in some kinds of exercises after they wore a fitness tracker. Further analysis showed that these 8 participants all started walking during the experiment. In the posttest, walking outside (15) became the predominant exercise, followed by workout in the gym (6), jogging outside (3) and others. From 5 to 15,10 more participants engaged in walking after they wore a fitness tracker, some of whom started walking from scratch and some of whom switched to walking from another type of exercise. Taken together, these results suggest that wearing a smart band promotes users' walking behavior.

Classifying behavior change using Behavior Wizard showed that 19 participants changed their behavior while 20 did not change (Table 7). Among those participants who did not change, 11(6 males and 5 females) retained their workout status, as usual, 9 (2 males and 7 females) did not do any exercise both before and during the experiment. Some participants were observed two types of behavior changes because they did two types of exercises. Blue span (11), purple span (7), grey span (2), black span (2), green span (1) were observed behavior change types in the experiment, while five types of behavior change did not exist: green dot, blue dot, purple dot, grey dot, and black dot. Path behavior (from now on) was impossible to be investigated due to the short experiment period in this study.

Results of behavior change type revealed that after using smart band, blue span and purple span were the two most frequently observed behavior change types. Among 11 blue span behavior changes, 10 participants (8 did not work out and 2 did other types of exercise in pretest) started a familiar walking behavior and 1 started a familiar rowing behavior. Among 7 purple span behavior changes, 4 participants increased walking frequency, 2 increased workout frequency in the gym, and 1 increased jogging frequency. These two behavior change types clearly demonstrated that the smart band had an effect in promoting walking behavior among experiment participants, especially in persuading people who did not work out to start walking. The stimulating walking effect was more remarkable for female participants than male because 9 out of 14 (10 started walking and 4 increased walking frequency) were female.

Additionally, the other three behavior

<Table 8> Validity and reliability

Construct	Item	Factor Loading	AVE	C. R.	Cronbach's Alpha
Surface credibility	Surface_credibility1	0.885	0.616	0.888	0.851
	Surface_credibility2	0.775			
	Surface_credibility3	0.660			
	Surface_credibility4	0.840			
	Surface_credibility5	0.744			
Expertise	Expertise1	0.967	0.788	0.880	0.766
	Expertise2	0.801			
Rehearsal	Rehearsal1	0.831	0.707	0.906	0.864
	Rehearsal2	0.897			
	Rehearsal3	0.818			
	Rehearsal4	0.816			
Facilitation	Facilitation1	0.639	0.604	0.814	0.827
	Facilitation2	0.651			
	Facilitation3	0.989			
Comparison	Comparison1	0.624	0.528	0.816	0.714
	Comparison2	0.734			
	Comparison3	0.743			
	Comparison4	0.795			
Competition	Competition1	0.580	0.713	0.906	0.900
	Competition2	0.934			
	Competition3	0.896			
	Competition4	0.916			
Self-monitoring	Self-monitoring1	0.980	0.800	0.940	0.911
	Self-monitoring2	0.934			
	Self-monitoring3	0.930			
	Self-monitoring4	0.708			
Reminder	Reminder1	0.802	0.688	0.898	0.857
	Reminder2	0.867			
	Reminder3	0.834			
	Reminder4	0.812			
Praise	Praise1	0.871	0.704	0.875	0.819
	Praise2	0.946			
	Praise3	0.676			
Reward	Reward1	0.949	0.911	0.976	0.968
	Reward2	0.949			
	Reward3	0.974			
	Reward4	0.945			
Personalization	Personalization1	0.648	0.670	0.897	0.844
	Personalization2	0.855			
	Personalization3	0.921			
	Personalization4	0.871			
Suggestion	Suggestion1	0.773	0.788	0.937	0.928
	Suggestion2	0.935			
	Suggestion3	0.899			
	Suggestion4	0.936			
Reduction	Reduction1	0.969	0.925	0.961	0.920
	Reduction2	0.955			

change types with low frequency were investigated. One participant (green span) started playing skateboard during the experiment period because of her strong interest in it. Two participants (grey span) decreased their behavior frequency for yoga and hula-hoop for no specific reason. Moreover, two participants (black span) stopped their usual exercise behavior and started walking. Human behavior may be affected by many potential factors other than using a smart band, thus the behavior change types only observed one or two times in the experiment couldn’t lead to any conclusion. Although the participants did not clearly realize or answer the reason that caused their behavior change, some potential unconscious reasons may still exist, which made the result inconclusive.

In summary, the results in this section indicate that using a smart band increases people’s walking behavior, especially for those who do not walk to exercise in their spare time. For people who walk as an exercise in their leisure time, wearing a smart band can increase their walking frequency. However, the effect of a smart band promoting other types of exercise is not clear from this study.

4.2 Validity and Reliability

Before comparing persuasive design differences, confirmative factor analysis was run to test the validity and reliability of the measurement testing users’ perceived persuasive design of fitness tracker. Items with low factor loadings were removed from the measurement model. The results showed that the measures of constructs meet all the requirements in terms of reliability and validity (Table 8). First, all measurement items of the constructs had factor loadings over 0.58, supporting the indicators' validity. Second, all composite reliabilities (over 0.814) and Cronbach's alpha (over 0.714) of constructs were greater than 0.70, thus confirming the measures' reliability. In addition, all average variance extracted (AVE) values of constructs were over 0.528, and surpass the threshold of 0.50, supporting the construct measures' convergent validity.

4.3 Group Difference

After the experiment, nearly half of the participants changed their workout behavior, and half remained their existing workout behavior or no exercise status. To find out what kind of role persuasive design plays in stimulating behavior change, we compared differences between participants who retained no exercise status (No exercise at all group) and participants who began a familiar workout behavior (Blue span group), participants who retained their workout behavior (Retain exercise group) and participants who increased workout frequency (Purple span group). Green span, grey span, and black span group were not included in the group difference analysis due to the relatively small group size, which may make the result inclusive. Analysis of these three groups did not meaningfully contribute to the final result. To compare the group difference, an independent sample t-test was used. Levene’s test tested whether population variances between the two groups were equal or not. According to Levene's test result, either a pooled t-test or an unequal variance t-test was used to test the difference.

4.3.1 No exercise at all group - Blue span group

Persuasive design characteristics had demonstrable differences between no exercise at all group and blue span group (Table 9). Blue span group had a higher level of perceived persuasive design principles than no exercise at all group. Surface credibility (p=0.018), expertise (p=0.015), competition (p=0.037), self-monitoring (p=0.011), reminder (p=0.047), reduction (p=0.016) were significantly different at 0.05 level, while rehearsal (p=0.076), comparison (p=0.071), praise (p=0.073), personalization (p=0.062), suggestion (p=0.065) were significantly different at 0.10 level. Interestingly, differences in facilitation (p=0.157) and reward (p=0.141) were not significant. Participants who started a familiar workout behavior perceived that a higher level of persuasive characteristics (except for facilitation and reward) was devised into the device than those who did not do exercise at all.

<Table 9> Differences between no exercise at all group and blue span group

	No exercise at all	Blue span	T value	P value
Surface credibility	5.511	6.350	-2.662	0.018**
Expertise	4.889	6.188	-2.732	0.015**
Rehearsal	4.667	5.594	-1.908	0.076*
Facilitation	5.444	5.875	-1.488	0.157
Comparison	5.889	6.500	-1.946	0.071*
Competition	5.375	6.500	-2.295	0.037**
Self-monitoring	5.611	6.531	-2.918	0.011**
Reminder	5.500	6.438	-2.208	0.047**
Praise	5.148	6.333	-1.927	0.073*
Reward	5.333	6.250	-1.553	0.141
Personalization	5.278	6.281	-2.016	0.062*
Suggestion	4.944	5.750	-2.047	0.065*
Reduction	5.222	6.375	-2.718	0.016**

Note: ***p<0.01, **p<0.05, * p<0.10

4.3.2 Retain exercise status group - Purple span group

Comparing the retain exercise group and purple span group, none of the persuasive design principles was significantly different (all p values were great than 0.05, even 0.10) (Table 10). Participants who increased workout intensity did not perceive the persuasive design of the smart band differently from those who retained exercise status in the experiment.

Were the group differences between no exercise group and blue span group because no exercise group did not use the smart band or band app as much as blue span group? To answer this question, we further tested whether band usage was different among different groups using one-way ANOVA. Differences in daily band usage and daily band app usage among the four groups (Retain exercise status, no exercise at all, blue span, purple span) were not significant (band usage F=0.912, p=0.448; app usage F=0.777, p=0.516). As a result, the role of different band usage on group differences of persuasive design characteristics that we found can be excluded.

Ⅴ. Discussion

This research found that nearly half of the participants changed their workout behavior while half retained their workout status or no exercise status. Wearing a fitness tracker itself doesn't promise all the users to change their workout behavior, and only those who get substantial persuasive stimulation can change their behavior. Results also demonstrated that half of the participants who did not do exercise in their spare time started exercising in the experiment. They started to try due to curiosity about the new device or other internal motivations at the beginning. Once they

<Table 10> Differences between retain exercise group and purple span group

	Retain exercise	Purple span	T value	P value
Surface credibility	5.000	4.850	0.203	0.842
Expertise	4.800	4.125	0.802	0.438
Rehearsal	4.850	4.313	0.524	0.610
Facilitation	4.633	4.167	0.470	0.647
Comparison	5.450	5.375	0.125	0.903
Competition	5.475	4.688	0.657	0.551
Self-monitoring	4.875	5.063	-0.170	0.868
Reminder	5.225	5.250	-0.031	0.976
Praise	5.167	5.417	-0.380	0.710
Reward	5.075	4.250	1.007	0.334
Personalization	4.850	5.313	-0.684	0.507
Suggestion	4.875	4.125	1.126	0.282
Reduction	4.900	5.500	-0.637	0.536

started, they interacted with the device. Persuasive strategies, like a sedentary reminder, setting step goals, self-monitoring, etc., stimulated them to continue their exercise behavior, falling into a positive reinforcement cycle. All these new spotters started walking other than diverse exercise, probably because walking is the easiest exercise type, and one can easily start walking regardless of time and place. Other types of exercise may need exercisers to have a certain level of skills or physical abilities or even physical restrictions to engage in. Furthermore, an examination of persuasive design strategies used in the smart band currently available in the market also gives us another possible answer. Most of the persuasive strategies devised in smart band, such as setting step goals, comparing steps ranking among friends, praising when step goals are achieved, are only focus on stimulating and encouraging users to walk, while no specific strategies are set for other types of exercise behavior, like jogging, bicycling, etc., which explained why only walking behavior of new exercisers was observed in the research.

While half of the experiment participants started walking, half still persisted no exercise status. Results also showed that participants who started working out perceived higher levels of persuasive design designed into the smart band than participants who preserved no exercise status. Although all device users use the same smart band devised with same persuasive designs, different individuals may perceive it diversely as usage pattern and interaction level differs. Usually, smart band users who work out regularly are viewed to have a higher level of device usage frequency than people who don't work out. However further analysis result showed that daily band usage frequency and Fitbit app usage frequency were not significantly different among different behavior change groups, which suggested that this perceived difference in persuasive design between people who started working out and people retained no exercise status we observed in the study was not caused by different device usage frequencies. As the smart band was a brand-new experience for all the participants who wished a try, they kept using the device and tried all the functions during the study no matter they worked out or not. The perceived difference in persuasive design may be because that those who start exercising, the more they exercise, the more deeply they are involved with the device and a higher level of human device interaction they get, like ranking higher in the steps ranking, getting more appraisals as they achieving more step goals, which finally starts a positive reinforcement loop, and promotes more exercises. For those who do not have the motivation to start exercise or start exercise just a little bit at beginning, the less they exercise, the lower levels of human device interaction they get, which lead to a lower level of persuasive stimulation perceived, finally fail to form a positive reinforcement loop, and stop the new try or remain sedentary without any move. Notwithstanding, among all the pervasive strategies, facilitation and reward were found not significantly different between new exercisers and participants who remained no exercise. Facilitation, knowing others are doing exercise, does not have sufficient direct stimulating effect like ranking or competition, which make people have a strong motivation to rank higher or win the competition immediately. Reward, like trophy and medal, provided by the smart band when users achieve goals or win a competition, is only a virtual symbol. Even though people get a trophy or medal, they can not change it for any realistic benefit, which makes it have no practical stimulation effect for more exercises.

Results also showed that participants who retained workout and those who increased working out frequency perceived no difference in smart band persuasive design. These two groups of people are both exercisers, and their human device interaction levels may be similar, thus perceived persuasive strategies are similar. Persuasive design in the smart band seems to be not the reason why people increase their exercise frequency. The true reason may be mostly because of their internal motivations, other than external persuasive stimulations. Moreover, existing exercisers do different types of exercises, like yoga, bicycling, which can’t be motivated by persuasive strategies mainly devised to promote walking behavior for the smart band.

Ⅵ. Conclusion and Future Research

This research classified people’s behavior change after wearing smart band into different behavior change types and found perceived persuasive design was different among people who did not do exercise at all and people started excising after wearing a smart band. However, the perceived persuasive design was not significantly different between people retained exercise status and those who increased exercise intensity. The contribution of this research is finding out the smart band has an effect to stimulate people to walk, and smart band persuasive design has a different effect on different groups of people. Persuasive design devised in the smart band can motivate people who do not do any exercise to start walking but its effect to motivate existing exercisers to increase exercise frequency is not verified.

The results of the research provide meaningful suggestions to practitioners, especially wearable devices and mobile apps designers. First, current persuasive designs of smart band focus only on promoting walking behavior, such as setting step goals, monitoring steps, comparing step rankings among friends. Developers should devise principles to promote other types of exercise behavior, like bicycling, yoga, etc. Current designs of smart band mainly count steps, set competition, and give praise, reward, reminder based on step results, further smart band design may praise users when they have been actively jumping or weight lifting for a certain period of time, or design some virtual games for yoga or bicycling. Second, people usually stop trying new or familiar exercise before they get sufficient persuasive stimulation. Trigger is identified as one of the important factors in Fogg's persuasive technology research. How to trigger people to start first exercise attempt, and reach a certain human device interaction level, perceive a sufficient amount of pervasive stimulation and get into the positive enforcement loop is the key that device designers should put more thoughts in. Third, many smart band users give up wearing smart band after a short honeymoon period. In the beginning, the novelty of the new device attracts their curiosity, however, the lack of persistent stimulation makes them give up using it any more. As a result, the persuasive strategy should be devised to a step-by-step base. The stimulation that gives to long time users should not remain the same as to users at the beginning stage. A deepening persuasive strategy is needed, which does not exist in the current smart band design. Many gamification strategies used in game design may be introduced into the smart band design. Finally, Reward is not an effective persuasion in current device design. To make it an effective persuasive strategy, developers should devise practical rewards, such as points or coupons, which can be used in purchasing exercise-related stuff or exchanging for gym usage hours or individual coaching service. The more practical benefits get from reward strategy, the more exercise people will do.

The findings from this study make several contributions to the current literature. The findings of this research provide insights for measuring behavior, more specifically measuring behavior change. The study suggested behavior results could be effectively observed and classified into different behavior change types using Behavior Wizard, which provides examples for other behavioral science researchers to follow. Furthermore, this study provides a feasible way to measure the persuasive design features of smart devices. Persuasive design is widely used in smart device design, however, how to effectively measure the effect of persuasive design is almost blank. This research successfully operationalized and measured persuasive design features by using the PSD model, which provides guidance for smart technology researchers. Taken together, this research contributes to behavior research on smart devices.

The major limitation of the research is that the number of experiment participants is not large due to the insufficient number of the smart band can be used in the experiment and limited research time. The number of people in each behavior change group used in the T-test or ANOVA is even small, which makes the result less convincing. Behavior research is usually hard to study a large number of people in an experimental setting. Because of the specific characteristics of the research, every participant needs to wear a tracker for two weeks, the rotation rounds or rotation rate largely restrict the total number of people who can participate in the research. Moreover, although we tried our best not to give any suggestions or directions, which may affect experiment participants' exercise choices, experiment participants may still change their behavior because they noticed the research purpose and tried to satisfy researchers' anticipation (Hawthorne Effect). This may mask the true behavior change picture. Furthermore, despite behavior changes caused by external reasons have been deleted from the final result, however, the effect of external reasons cannot be fully eliminated because even though people do not perceive, there may still be some unconscious external reasons exist. Besides, this research did not employ a control group in the experiment, which limited the validity of the research result. Finally, among Fogg's 15 types of behavior change, path behavior--changing behavior from now on--was impossible to be studied due to the short experiment time.

Due to these limitations, further researches can be carried out in the following directions. The persuasive design does not play a role in stimulating existing exercisers, then, what other internal motivation factors or external factors can increase existing exercisers' workout intensity need to be studied. Questions like how to design an effective reward strategy, what practical reward can be provided, and how much reward should be given to different achievements (achieving a daily goal, winning a competition, ranking first in the ranking list, etc.) are similarly worth further investigation. Additionally, how to design effective strategies to stimulate people to do diverse types of exercises other than walking, like bicycling, yoga, etc. is a fruitful research topic likewise. Ultimately, since the limitation of the research is the small sample size used in the experiment, further research could observe behavior change over a larger sample size, or employ a longitudinal study using repeated measures to examine behavior change over time.

Appendix Korean measures

Construct	Item	Measure
Surface credibility	Surface_credibility1	인터페이스를 신뢰할 만하다.
	Surface_credibility2	인터페이스는 유능하다.
	Surface_credibility3	인터페이스는 레이아웃은 명료하다.
	Surface_credibility4	인터페이스의 도표와 이미지를 신뢰할 만하다.
	Surface_credibility5	인터페이스의 수치를 신뢰할 만하다.
Expertise	Expertise1	수치를 측정하는 것은 전문적이다.
	Expertise2	운동상태를 측정하는 것은 전문적이다.
Rehearsal	Rehearsal1	운동할 수 있는 가상적인 환경을 제공한다.
	Rehearsal2	운동할 수 있는 가상의 게임을 제공한다.
	Rehearsal3	가상환경에서 운동할 수 있는 어드벤쳐를 제공한다.
	Rehearsal4	가상환경에서 운동할 수 있는 단체시합을 제공한다.
Facilitation	Facilitation1	친구가 나의 운동상태를 관찰하고 있다
	Facilitation2	'친구가 운동하고 있다'고 나는 알고 있다.
	Facilitation3	친구의 운동상태를 관찰할 수 있다.
Comparison	Comparison1	친구들의 걸음 수 순위를 보여준다.
	Comparison2	나의 걸음 수 순위를 보여준다.
	Comparison3	소셜 네트워크 서비스를 통하여 운동결과를 공유하고 비교할 수 있다.
	Comparison4	친구와 운동결과를 비교할 수 있다.
Competition	Competition1	친구와의 시합을 통해 더 운동할 수 있도록 만든다.
	Competition2	친구와 챌린지에 참여할 수 있다.
	Competition3	가상적인 시합을 통해 친구에게 도전장을 내밀 수 있다.
	Competition4	나는 가상시합에서 친구와 경쟁할 수 있다.
Self-monitoring	Self-monitoring1	운동행위를 확인할 수 있다.
	Self-monitoring2	운동결과를 확인할 수 있다.
	Self-monitoring3	운동상태를 확인할 수 있다.
	Self-monitoring4	바이오리듬을 확인할 수 있다.
Reminder	Reminder1	한 시간마다 걷도록 상기시킨다.
	Reminder2	진동을 통해 걷도록 상기시킨다.
	Reminder3	계속 움직이도록 상기시킨다.
	Reminder4	움직이도록 상기시키는 데 효율적이다.
Praise	Praise1	목표달성 시 문장을 사용하여 칭찬한다.
	Praise2	목표달성 시 진동을 통하여 칭찬한다.
	Praise3	목표달성 시 애니메이션을 통하여 칭찬한다.
Reward	Reward1	목표달성 시나 시합에서 가상적인 상을 준다.
	Reward2	목표달성 시나 시합에서 트로피를 준다.
	Reward3	목표달성 시나 시합에서 배지를 준다.
	Reward4	목표달성 시나 시합에서 표창을 준다.
Personalization	Personalization1	개인의 정보를 입력할 수 있다.
	Personalization2	선호에 따라 기능을 설정할 수 있다.
	Personalization3	개별성에 따른 정보를 제공한다.
	Personalization4	개별성에 따른 서비스를 제공한다.
Suggestion	Suggestion1	운동에 대해 제안을 준다.
	Suggestion2	운동에 대해 전문적인 의견을 준다.
	Suggestion3	운동에 대해 권고를 한다.
	Suggestion4	운동에 대한 도움말을 준다.
Reduction	Reduction1	운동 상태의 기록을 더 간단하게 만든다.
	Reduction2	운동 상태의 측정을 더 간단하게 만든다.

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<Abstract>

Do Wearable Devices Change Behavior? A Study of Smart Fitness Trackers

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Purpose

The study focuses on the physical activity behavior change effect of smart wristband, which is the most popular type of fitness tracker nowadays. The purpose of the research is to investigate how people's workout behavior may change after wearing a smart band and examine what kind of role persuasive design plays in behavior change.

Design/Methodology/Approach

This research employed an experimental study to examine whether the user's workout behaviors changed after using wristband from the “Behavior Wizard” perspective. A representative smart wristband from a major vendor was selected as the objects of experimental study. In the experiment, by comparing users’ workout behavior before and after using the wristband, behavior changes of all the experiment participants were classified into one of the 15 behavior change types. Users perceived persuasive design characteristics were measured and group differences were tested among different behavior change groups.

Findings

This research found that nearly half of the participants changed their workout behavior while half retained their workout status or no exercise status. Half of the participants who did not do exercise in their spare time started walking in the experiment. Results also showed that participants who started working out perceived higher levels of persuasive design devised into the smart band than participants who preserved no exercise status, except for facilitation and reward strategies. Participants who retained workout and those who increased workout frequency perceived no difference in smart band persuasive design.

Keyword: Persuasive technology, persuasive system design model, behavior change, behavior wizard, wearable device, fitness tracker

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