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The Extraction Process of Durative Persuasive System Design Characteristics for Healthcare-related Mobile Applications

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Abstract

In the field of Human-Computer Interaction design, persuasive design has gradually been applied to the system development and design process, especially for mobile application design. However, most mobile applications have hitherto a very short using lifecycle. Especially, design features with long-term persuasive effectiveness remain to be further researched and developed. In this study, we focused on investigating and identifying the durative persuasive design characteristics through a data mining process and evaluating the durative effectiveness through a long-term observation process. Total five hundred healthcare-related mobile applications were selected from Apple iTunes Store and a mixed method was conducted to extract the most common persuasive design characteristics. Based on the results of extraction, a representative healthcare-related mobile application was selected as experimental subject. Total one hundred and twenty participants were observed during a six-months experiment and the monitoring data of app usage of all participants was collected once a week. According to the evaluation model for behavior change identification process, participants with habit formation features were proved to have a significant long-term perception level for ten persuasive design characteristics. Further interview research was performed to investigate the participant's long-term perceptions on those characteristics for the purpose of identifying the durative persuasions. The results indicated that a long-term durative effectiveness can be observed and healthcare-related apps designed with those characteristics could have durative effectiveness. This study may contribute to the improvement of future mobile application designs in user experience and durative persuasion, as well as bringing future benefits for both mobile application developers and users.

Keywords: *Human computer interaction, Persuasive technology, Durative persuasive design characteristics, Persuasion, Healthcare-related mobile application, Habit formation, Behavior change*

1. Introduction

Healthcare-related mobile applications, which have accompanied the explosive growth of smart mobile devices and wearable devices, are widely developing and using as brand-new medium in our daily lives.

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Healthcare-related mobile applications can be defined as a basically little, self-contained programs designed to run on mobile devices and used for assisting people to improving or enhancing their healthcare-related activities or medical activities and changing complicated healthcare-related behaviors into more user-friendly ones [8, 11]. It can be considered as a multi-tasking application programs that can virtually impact every facet of people's healthcare-related behaviors and assist people in handling their daily health care and physical exercises. Those health and fitness facility manufacturers, medical machine makers, and healthcare-related app designers are paying more and more attentions for healthcare-related apps. In fact, as of Feb. 28, 2019, over four million applications from Apple iTunes Store can be approved [appshopper.com]. Among them, for both medical category and health and fitness category are two of the most important categories, which consist of those apps related to healthy living, stress management, recreational activities, fitness, medical education, health reference for patients, healthcare professionals, etc. Prior studies have discussed about the misunderstanding and significant correlations between Medical primary category and Health & Fitness Category. Even for some professional experts or app designers cannot perceive the clearly difference of meanings between "Health" and "Medical". Therefore, merging two categories or setting up subsidiary categories was suggested and "Healthcare-related applications" was used to represent those apps from two categories. Generally, healthcare-related applications focus on people's physical activities and medical activities, such as muscle diagrams, yoga, workout tracking, running, weight loss, acupuncture, skeletal, anatomy, diseases, medical devices, health tracking, etc.

Recently, it can be observed that most of healthcare-related apps have very short-term of using life and very few downloads due to too simplified functional design, function errors, design plagiarism, etc. Especially, most of those healthcare-related applications are lack of design persuasion and user acceptance. Persuasive design characteristics for healthcare-related applications have been discussed and evaluated in the prior studies by the research approach of adopting production system in cognitive psychology [13]. However, the durative persuasion on long-term using behavior or habit formation still remains to be identified.

The purpose of this study focused on investigating and identifying the durative persuasive design characteristics through a data mining process and evaluating the durative effectiveness through a long-term observation process. Healthcare-related mobile applications were selected from both Health & Fitness Primary Category and Medical Primary Category on Apple iTunes Store. According to the evaluation guideline of persuasive system design characteristics, a mixed method was conducted to extract the most common persuasive design characteristics. Based on the results of extraction, a representative healthcare-related mobile application was selected as experimental subject. Participants were observed during a long-term experiment and the monitoring data of app usage of all participants was monitored and collected. According to the evaluation model for behavior change identification process, the long-term perception level for the persuasive design characteristics was identified. Further interview research was performed to investigate the participant's long-term perceptions on those characteristics for the purpose of identifying the durative persuasions. The results indicated that a long-term durative effectiveness can be observed and healthcare-related apps designed with those characteristics could have durative effectiveness. This study focused on identifying the durative persuasive design characteristics of mobile applications in a long term. It established a systematic observation, evaluation, and identification process for examining the durative persuasion effects in the process of human-computer interaction design. Service advices were made to the practicality of the study results. App developers and automakers can refer to them to develop more effective and persuasive car apps. The results of this study may contribute to the improvement of future mobile application designs in user experience and durative persuasion, as well as bringing future benefits for both mobile application developers and users.

2. Theoretical Background

In the field of Human-Computer Interaction design, persuasive technology has gradually been applied to the system development and design process, especially for mobile application design. It is defined as any interactive technical system designed for the purpose of changing people's attitudes or behaviors [1, 2]. Persuasive technology in mobile applications can be used to change or influence the behavior or attitude of users [1, 3]. Both researchers and mobile app developers are focusing on increasing the mobile app's persuasive characteristics in order to motivate and influence users. In the past, behavioral psychology researchers and mobile app designers had to make guesses at solutions for changing behavior. However, most of their attempts failed. Some scholars and researchers also focus on identifying distinct persuasive software features in order to confirm and evaluate the significance of persuasive systems and behavior change support systems. In a sense, persuasive technology can be considered as some kind of design with the intent to persuade people to change their attitudes or behaviors [4]. Oinas-Kukkonen and Harjumaa classified the persuasive technologies from another perceptive, which is about whether the persuasive technologies can change user attitudes or behaviors through direct interaction or as a mediating role [2]. Persuasive technology can be found in mobile apps or websites with behavior-oriented designs like Amazon and Facebook, which can persuades users to buy more often or stay logged in. Many mobile apps, such as some health-oriented apps that incentivize weight loss and help to manage addictions and other mental health issues. Developers design their products by analyzing and evaluating the content, using established psychological research theories and methods. Most of these products or services have used persuasive design that focuses on making users feel comfortable in making decisions and helping them act on those decisions [5, 6]. Until recently, some researchers tried to make a guideline for PDC in order to help researchers and developers to understand PDC and design new apps with better persuasion [7, 8, 9, 10]. Some researchers tried to analyze the persuasive design features of mobile applications by adopting different research approaches [11, 12, 13].

Habit-formation is the process by which new behaviors become automatic. Psychological studies show that a habit is formed by three steps. It starts with a psychological pattern called a "habit loop", which is a three-part process: trigger, routine, and reward [14]. The "Trigger" tells brain to go into automatic mode and let a behavior unfold. Routine is the behavior itself. Reward is something that helps the brain remember the "habit loop" in the future. These kind of habit-making behaviors are called the "basal ganglia" by neuroscientists. It also plays a fundamental key role in the development of emotions, memories, and pattern recognition. Neuroscientists think that decisions are made in a different part of the brain called the "prefrontal cortex". However, if the habit is formed and the behavior becomes automatic, the decision-making part of brain goes into a sleep mode, which means the sub-consciousness will take control of the behavior and free the brain to do something else. This is the important role of basal ganglia which takes a behavior and turns it into an automatic routine – habit-forming is done [14]. A new research model about habit-forming is called "the Hook Model" which was constructed by Eyal [15]. His main research is about how products create habits. Using a series of experiences called "hooks", this can guide users to change their behaviors. The more often users run through these hooks, the more likely they are to form habits. He hypothesized that a product should be designed to facilitate a user's need, but ultimately alleviate a symptom of the problem they have. The "hook model" contains four steps: trigger, action, reward, and investment (TARI). Triggers are the first step of the hook. Triggers have two forms: internal triggers and the external triggers. Internal triggers refer to people's emotions that cause users to take an action. External triggers refer to something that needs users to take a specific action such as call-to-act buttons on websites. A

product designed with these triggers will attract users to act. Generally, the designer informs what to do next through external triggers. User informs what to do next through internal triggers because emotions act as frequent internal triggers [15].

Although prior studies developed several models to discuss persuasive system design features from different perspective, no research focused on observing the persuasion effectiveness from a long-term perspective. Even several studies discussed about habit formation process or some stable behavior change process, no researchers focused on investigating the durative persuasive design characteristics in a long term.

3. Research Approach

In this study, we tried to extract and identify the durative persuasive design characteristics for healthcare-related mobile applications. Figure 1 shows the research approach based on a three-years continuous research. Prior studies have discussed about the categorization improvement process and the extraction process of persuasive design characteristics. In our prior study, by using Python programming, we have performed an updating process for current categorization of healthcare-related mobile applications. Further extraction process for persuasive design characteristics has also been conducted to extract the most common persuasive design characteristics. In this study, we tried to develop and conduct a long-term experiment to monitor and observe the durative persuasion.

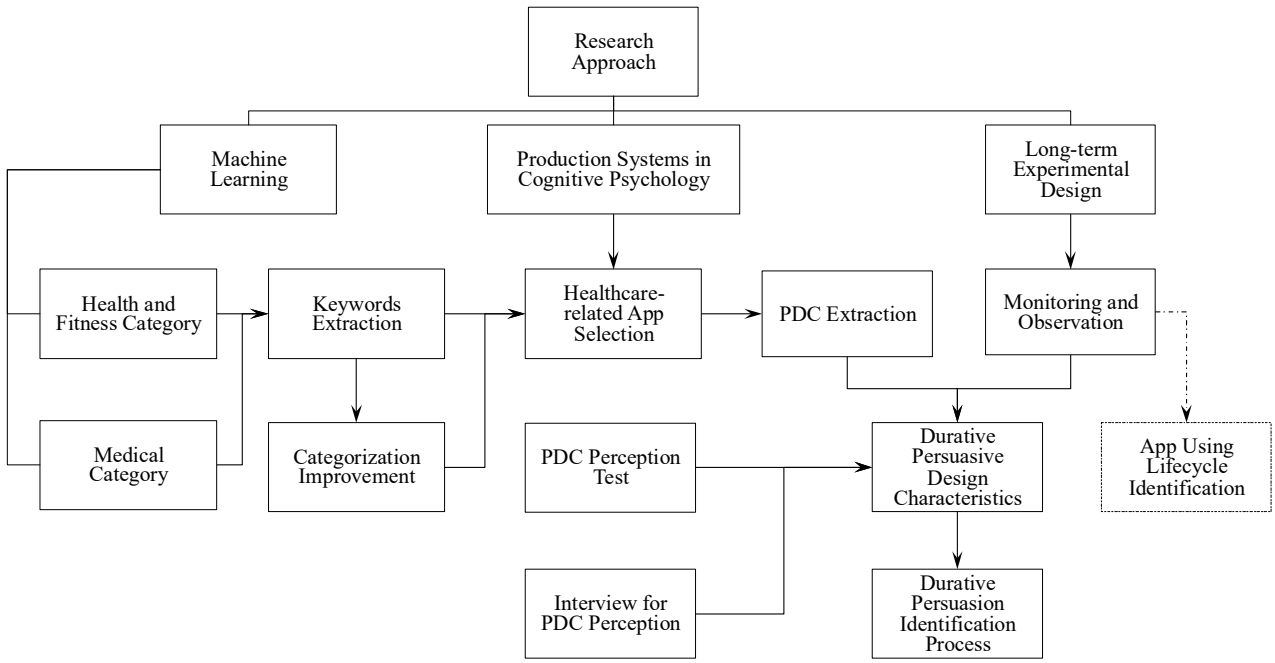

Figure 1. Research Approach

3.1 Machine Learning Process for Better App Extraction Process

Based on our first prior study from March to July in 2017, we performed the investigation process for healthcare-related apps on Apple iTunes Store. In order to have the appropriate healthcare-related apps, we used two different methods to extract the functional characteristics from both Health & Fitness category and Medical category. The description of an app plays a very important role for its discoverability and

categorization. Generally, a successful app or a branded app has a higher profile based on its name, description, and the category, no matter whether it has other information or factors. Based on the official ranking list for popular apps, total 237 apps from health & fitness category and total 240 apps from medical category were evaluated. The CSV files were saved which consisted of several attributes, such as app name, subtitle, description, and update information. Although some prior researchers believed that rating and review attributes and comments attributes contained keywords information about the relevant app, we ignored such information that was not composed directly by app developers or App Store. Another reason is that numerous app remarks or comments are subjective and have too much irrelevant information. We developed a computer program under Python 2.7 environment with Scikit-Learn package 0.19.1 to extract stems and library CountVectorizer and library TfidfTransformer were used for the calculation of words segmentation weight. The intersection and union process for extracting words was called Stemming and lemmatization. It belongs to natural language processing (NLP). Stemming is the process for reducing inflected (or sometimes derived) words to their stem, base or root form (a written word form). Lemmatization in linguistics is the process of grouping together the different inflected forms of a word so they can be analyzed as a single item. Based on greedy strategy design, MaxMatch algorithm is often used to segment words in natural language processing. The stems extracting process showed that "fitness (frequency=471)", "weight (frequency=391)", and "health (frequency=770)" can be recognized as the represented functionalities or characteristics for health & fitness apps. Similarly, "medical (frequency=405)", "health (frequency=596)", and "drug (frequency=245)" can be identified as the represented functionalities or characteristics for medical apps. The purpose of the stem extracting process was to find out some stems that may represent the features of related apps. Based on the results, we found that Medical category and Health& Fitness category have a significant correlation, especially for word "Health" and "Medical". Only those apps with significant professional information about medical treatment, curing, and recovery treatment were clearly identified as Medical category. Therefore, merging the Medical category and Health &Fitness Category into one primary category, or setting up the Health and the Fitness category as two secondary categories of the primary Medical category would be a better choice [10].

For the purpose of having a better classification for healthcare-related apps and selecting a better represented app with appropriate functionalities and characteristics, we performed the second method for extracting the keywords index. Total 520 apps from both Health & Fitness category and Medical category were selected and Latent Semantic Analysis (LSA) with Singular Value Decomposition (SVD) was performed to extract the keywords. Based on the extracted data from Apple iTunes Store, Individual information processing theorem was adopted. We developed several principles based on the prior studies and asked five participants to attend our study for one month. At the beginning, all of the participants were asked to stay together in our research room. A presentation about categorization methods for subject app was prepared well. We performed the information processing with the following steps (limited by pages, only brief introductions were listed). From step one to five showed the categorization teaching process, and from step six to eight showed the categorization learning process. 1. Gain the participant's attention. 2. Bring to mind relevant prior learning. 3. Point out important information. 4. Present information in an organized manner. 5. Show participants how to categorize related information. 6. Provide opportunities for participants to elaborate on new information. 7. Show participants how to use coding when memorizing lists. 8. Provide for repetition of learning [12]. After the teaching process, all of the participants were asked to read and understand the categorization information about both health & fitness category and medical category. After several rounds of reading and understanding, all of the participants were asked to select the most representative three functionality keywords from the keyword lists extracted by TF-IDF and SVD. For

Health & Fitness Category, "keywords"="fitness, health, weight, training, exercise, running, tracker, sleep" were identified. Similarly, for Medical Category, "keywords"= "medical, care, doctor, blood, health, drug, pressure, patient, treatment" were identified. By comparing the extracted results from two different methods, we believe the appropriate characteristics for healthcare-related apps can be recognized. "Keywords"= "fitness, weight, health, medical, health, drug" were confirmed as the represented characteristics.

3.2 Extraction Process of Persuasive Design Characteristics by Production System

In this process, the production system in cognitive psychology was adopted to improve the extraction process of persuasive design characteristics for healthcare-related mobile applications. A research approach with four stages was developed. We developed and updated the evaluation guideline for persuasive design characteristics (PDC). We tried to summarize and analyze each of 28 PDC and prepared related production rules. Verification process for both guideline approach and production system approach were performed. The most popular 100 apps from both medical category and health and Fitness category were selected and evaluated by production systems. Based on cognitive psychology theories and ACT-R (Adaptive Control of Thought-Rational), we developed a production system that consists of a collection of if-then rules to perform the information processing for each of the persuasive system design characteristics.

Production rules (or productions) for each of twenty-eight PDC were conducted. Based on the updated evaluation guideline three professional researchers were asked to analyze and develop the production rules for each of the PDC by introducing if-then model. For each of twenty-eight PDC, all of the conditions need to be refined.

Participants were asked to evaluate the top one hundred healthcare-related apps. All of those participants didn't have any direct information or knowledge about persuasive system design. They were asked to understand all of those production rules first and then evaluate and identify the PDC from the apps. Total 97 valid data was collected. The results were listed as follows. For example, by using production system approach (PS), total 53 healthcare-related apps were identified to have the PDC of self-monitoring (C1). Based on the evaluation results, it can be concluded that only 16.5% of healthcare-related apps have less than five PDC. More than 47.4% of healthcare-related apps have no less than ten PDC. Furthermore, some PDC have been well used in most of the healthcare related apps, such as Reduction (C2, 93 apps), Personalization (C3, 65 apps), Reminder (C10, 69 apps), Surface Credibility (C21, 66 apps), etc.

Table 1. Summary for Evaluation Results

PDC	PS	PDC	PS	PDC	PS	PDC	PS	PDC	PS	PDC	PS	PDC	PS
C1	46	C5	30	C8	17	C13	0	C17	38	C21	66	C25	17
C2	93	C6	45	C10	69	C14	10	C18	14	C22	45	C26	15
C3	65	C7	12	C11	15	C15	26	C19	0	C23	9	C27	16
C4	56	C8	55	C12	55	C16	55	C20	9	C24	19	C28	13
Self-monitoring (C1); Reduction (C2); Personalization (C3); Tunneling (C4); Simulation (C5); Rehearsal (C6); Rewards (C7); Real-world contexts (C8); Tailoring (C9); Reminder (C10); Praise (C11); Suggestion (C12); Similarity (C13); Social role (C14); Liking (C15); Trustworthiness (C16); Expertise (C17); Verifiability (C18); Authority (C19); Third-party endorsements (C20); Surface credibility (C21); Social comparison sharing (C22); Cooperation (C23); Normative influence (C24); Social facilitation (C25); Competition (C26); Recognition (C27); Social learning (C28).													

3.2 Experimental Design for Long-term Observation and Monitoring

In the second research stage, the pre-test and post-test questionnaires for quasi-experiment were finished and pilot checked based on literature review and expert evaluations. Meanwhile, an experimental observation process was proceeded to observe and discover participant's app using behavior, app using frequency, and monitoring their habit formation process. By using paid monitoring apps, participant's everyday app using conditions can be recorded and observed on time. For a using habit formation, the experimental observation period should be no less than six months. Meanwhile, participant's app using habits and app using life cycle were recognized. Total one hundred and twenty participants were invited to this experiment. All of their smartphones are in iOS system. Among them, eighty-six participants are undergraduate students; sixteen participants are graduate students; three participants are university professors, ten participants are company employees, and five participants are individual business owner. Participants were invited to a six months experiment that was conducted from August 2017 to November 2018 for two grounds. Participant's app usage data were collected once a week. They were asked to read the app description and download the test app. Furthermore, participants were asked to download and install the tracking app named "Moment" during the experiment. It can be used to track participant's usage for test app. Simultaneously, a built-in app usage monitoring software in iPhone was also used to collect the related data about app using time. According to the tracking data, healthcare-related app's using life cycle can be observed as searching & browsing, trying-out, maintaining usage, system residency, deleting/using rejection. Searching & browsing can be considered as a kind of app store experience. Trying-out normally can be considered as first open. Maintaining usage contains two steps. One is about attempting simple tasks; another is about attempting complex tasks. System residency consists of two activities. One is about the app updating; another is about the residency forgetting. Deleting or using rejection can be considered as discontinued or permanently stopped or rejected for a period of time.

4. Data Analysis and Results

Based on the collected data of experimental observation process and quasi-experiment, participant's using behavior was evaluated and analyzed. Based on Fogg's behavior change theory, Wendel's behavior change design rules, and Eyal's habit-formation app design rules, an evaluation process was proceeded to confirm participant's behavior change or habit formation. The evaluation standards were developed and checked by using inter-rater reliability method. Meanwhile, participant's perception for test app's persuasive design characteristics was confirmed. If they can continue to perceive some persuasive design characteristics that means these characteristics have durative convincing effectiveness or durative persuasive effectiveness. Some of the characteristics may not be durative perceived, that means these design characteristics have no durative features. According to the investigation results and the experimental observation data, an empirical test about which "DPDC" may actually affect user's habit formation was performed. Persuasive design characteristics confirmed by the empirical test which can actually cause user's long-term behavior change or habit formation were chosen as a future design and research guideline. It can also be used to modify current TAM model and PSD model. In this study, the following evaluation rules were followed to estimate participant's behavior change type. Some test questions in pre-test are used to estimate the behavior status before the test. Some test questions in post-test are used to predict participant's using intention in the future. For example, "1→A" means test question"1": "Have you ever used test app or something similar to test app while you perform healthcare-related activities?". "→" means "to choose". "A" means the answer "No" for question 1. The detail descriptions for each types of behavior change were developed. Limited by the pages,

several examples were shown as follows. According to the evaluation rules and related logic evaluation flow chart of behavior change, participant's long-term behavior change can be observed.

Evaluation Rules for Green-Path Behavior Change

Status	Test Question	Flavor / Duration Behavior	Behavior Change Type	
Pre-test	1→A	Green Behavior	Green-Path Behavior	
Post-test	1→B{B-1→A; B-3→A}	Path Behavior		
No.	Question		Answer	
Pre1	Have you ever used test app or something similar to test app while you perform healthcare-related activities?		A	No
Post1	In the test period, have you used the test app while performing healthcare-related activities?		B	Yes
PostB-1	What's the using frequency of test app while you performing healthcare-related activities in the test period?		A	Always when I needed.
PostB-3	Do you have any experience that not use test app even though you needed it to perform healthcare-related activities?		A	No, I always use it.

Evaluation Rules for Blue-Path Behavior Change

Status	Test Question	Flavor / Duration Behavior	Behavior Change Type	
Pre-test	1→B or {B-1→A or A-1→App-A}	Blue Behavior	Blue-Path Behavior	
Post-test	1→B{B-1→A; B-3→A}	Path Behavior		
No.	Question		Answer	
Pre1	Have you ever used test app or something similar to test app while you perform healthcare-related activities?		B	Yes
PreB-1	Have you ever used test app?		A	Yes
PreA-1	Please write down the name of used health apps before the test.		Test app	
Post1	In the test period, have you used the test app while performing healthcare-related activities?		B	Yes
PostB-1	What's the using frequency of test app while you performing healthcare-related activities in the test period?		A	Always when I needed.
PostB-3	Do you have any experience that not use test app even though you needed it to perform healthcare-related activities?		A	No, I always use it.

Figure 2. Example of Evaluation Rules

The logic evaluation flow chart of behavior change showed the core evaluation principles that can help researchers to identify participant's behavior change process and habit formation process. Normally, healthcare-related app itself is used to serve a health behavior or to perform healthcare-related activities. The app using behavior of healthcare-related apps normally can be considered as performing relevant activities. Therefore, the PDC of healthcare-related apps can be considered to have the ability to affect participants to perform healthcare-related activities. The pre-test and posttest flow chart are shown below.

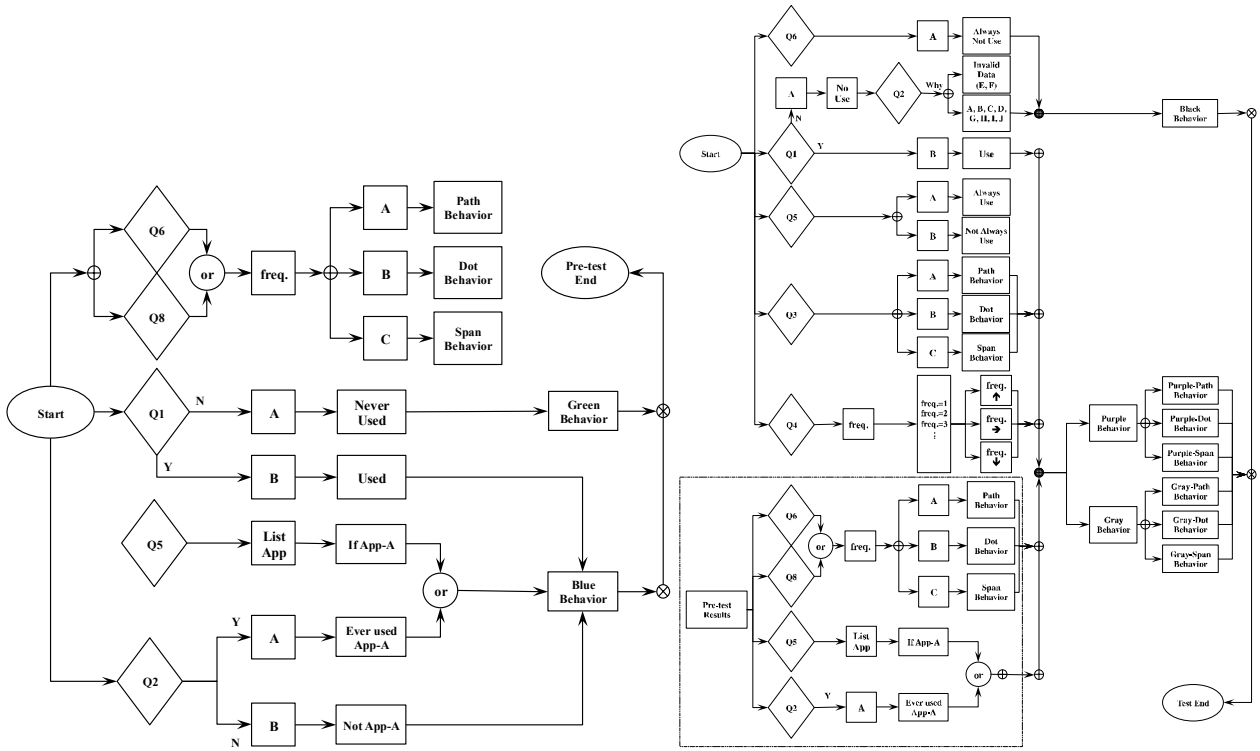

Figure 3. Evaluation Flow Chart for Durative Persuasive Design Characteristics

Based on the results of pre-test and post questionnaires and the monitoring results of six months' data, self-monitoring (0.936), tunneling (0.817), reminder (0.792), praise (0.809), rewards (0.896), trustworthiness (0.779), expertise (0.784), social comparison sharing (0.903), normative influence (0.852), and competition (0.814) have identified to have durative persuasive effectiveness on participant's healthcare-related activity performing. All of their Cronbach' Alpha are between 0.779 and 0.936 which appears to have good reliability. The factor loading for measures of each durative persuasive design characteristics was selected with the minimum 0.509. That means only those measures have at least 0.5 can be selected during the exploratory factory analysis. The factor loadings of the other measurement items that lower than 0.5 were deleted. For the purpose of checking the participant's perceptions for DPDCs of test app, hypotheses were developed. The persuasive effectiveness questionnaire uses 7-point Likert Scale to allow participants to value their persuasiveness perceptions from "Strongly disagree" to "Strongly agree". If their population means are more than "4" (neither agree or disagree), it means participants can perceive the persuasive design principles of test app. $H_{(1\text{-}10)}$: The population means of "self-monitoring, tunneling, reminder, praise, rewards, trustworthiness, expertise, social comparison sharing, normative influence, and competition" are less than or equal to 4 ($\mu \leqslant 4$). The results of one sample t-test showed that all of the hypotheses (from H1 to H10) were all rejected (Sig. one-tailed, 0.000 ~ 0.0015). That means participants can significantly perceive the durative persuasive design characteristics of test app during the long-term experiment. The interview results and data analysis for participant's daily usage of test app also proved those results mentioned before. Especially, for some characteristics, such as "remind", have proved to have very strong persuasive effectiveness on participant's daily usage of healthcare-related apps. For total one hundred and twenty participants (valid data=118), their perceptions for ten durative persuasive design characteristics were summarized as follows: self-monitoring (98 times), tunneling (87), reminder (118), praise (117), rewards (114), trustworthiness (104), expertise (98), social comparison sharing (112), normative influence (110), and competition (106).

5. Discussions and Future Research

According to the experiment and interview results, total ten durative persuasive design characteristics were identified. Among them, "reminder", "praise", "rewards", "social comparison sharing", and "normative influence" can be considered as the most popular durative persuasive design characteristics for most of the participants. More than 93% of the participants can perceive those characteristics, especially for "reminder". It was indicated that healthcare-related apps with the design characteristic of "reminder" could significantly affect the app usage in a long term, especially for healthcare-related applications. Based on our interview records, more than 89% of the participants said it was difficult to adhere to healthcare-related activities or related behaviors, especially for performing some resistance trainings, such as quitting smoking, abstaining from alcohol, sleeping on time, losing weight, etc. Almost every participant believed that if an app had features, such as "reminder", "praise", "rewards", or "social comparison sharing", they could use the health app for a longer period of time and engage in related sports or activities. "Praise" is often considered to be positive energy incentives, which can effectively help app users focus more on related activities, and extending the app using frequency and time. In our research, "rewards" can motivate most participants to pay more attention to health-related activities, especially some virtual or actual rewards. "Social comparison sharing", which based on the widespread applications of social network service, has been widely accepted by most of the participants. Most of them preferred to show their positive attitude and healthy life to their friends or to strangers. Most participants focused on the positive effectiveness of healthcare-related app usage, and the characteristics of "competitive" and "normative influence" can better reflect such appeal.

Six months experiment was considered to be reasonable and effective. We tried to collect participant's data once a week. In our observation process, based on the data and interview records, some of our participants may stop to use the test apps for several days because of some personal reasons. Such behavior was not considered as a "stop" behavior. By observing the records, if participant's app using behavior was maintained at a certain frequency and time, then we could recognize it as a continuous using behavior. During the interview, the participants explained the continuous using behavior and answered the relevant questions. If those explanations or answers truly reflect the user's perception of the persuasive design characteristics, and the participant's using behavior records also truly reflect such phenomenon, then we could consider that the relevant persuasive design characteristics have durative persuasive effectiveness.

Based on our experiment, ten persuasive design characteristics were identified to have durative persuasion in a long term. Self-monitoring, tunneling, reminder, praise, rewards, trustworthiness, expertise, social comparison sharing, normative influence, and competition were identified to have durative persuasive effectiveness on participant's healthcare-related activity performing. This study is the first attempt to confirm the durative persuasion for the HCI design of healthcare-related mobile application. The implications of durative persuasive design characteristics can influence the fields of mobile app design, information system design, education, health and fitness, game design, enterprise, products and services design, etc. It can directly affect system designer's design basis, as well as affecting researcher's research directions about Technology Acceptance Model, Persuasive System Design Model, etc. Our future research will focus on identifying the causal relationship between durative persuasive design characteristics and user's behavior change or habit formation. Furthermore, updating for the TAM Model can also be considered as a more useful evaluation standard for system designers and researchers. The most innovativeness of this research can be explained in twofold. This research attempts to make several contributions to research and practice in the field of persuasive technology and long term behavior change or habit formation. Especially, this research is designed to make a systematic approach to extend the persuasive design research with durative

features and integrate durative persuasive design characteristics with habit formation research. This study will have great significance in discovering the interrelationship between mobile app's durative persuasive characteristics (or long-term continued convincing characteristics) and the mobile app using habit formation. The research findings can help app designers follow appropriate "DPDC" to design more effective and more persuasive apps with higher user preferences. From the academic point of view, this research tries to evaluate the durative persuasive design characteristics of current health apps, and identify exactly which durative persuasive design characteristics can eventually continued affecting user's behavior and finally realizing habit formation, which can help mobile app designers and researchers to better understand user's preferences and long-term using behavior.

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