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Recommended Citation

Chang, Hsin-Lu; Sun, Routing; and Hu, Hui-Chen, "A Design Science Approach to Improve Adherence on Exercise Plan via Mobile Application Built by ResearchKit Framework" (2016). *ICEB 2016 Proceedings*. 54. <https://aisel.aisnet.org/iceb2016/54>

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A Design Science Approach to Improve Adherence on Exercise Plan via Mobile Application Built by ResearchKit Framework

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ABSTRACT

Introduction

In the modern society, mHealth is an increasingly popular concept, which refers to the use of mobile technology to improve health outcomes and healthcare services at a low cost (Martin, 2012). According to Pew Research Center, in 2015, nearly two-thirds of American adults are now smartphone owners. One-fifth of smartphone owners utilize mobile apps to track or manage health (Fox and Duggan 2012).

With the advance of science and technology, the growing number of applications are developed for self-managed health project. A wide variety of innovative functions are built to help people control diet or sport plan. Those applications provide all sorts of functions or graphical interfaces to assist users record data and keep tracking on their daily report. Currently, low proportion of health-care applications are designed for particular chronic disease group, such as hypertension, type 2 diabetes, coronary heart disease, stroke, osteoarthritis, respiratory problems and so forth. In medical industry, chronically ill patients often need more rigorous and long-term health control than ordinary people.

In the United State, more than one-third of adults are obese and childhood obesity has become an increasing trend (Ogden, Carroll et al. 2015). The most common chronic disease related to obesity is “diabetes”. In 2012, 29.1 million people or 9.3% of the U.S. population have diabetes and 27.8% of people with diabetes are undiagnosed (National Diabetes Statistics Report, 2014). As a consequence, our research is going to realize the performance of self-managed application on specific chronic disease – diabetes.

According to the best diabetes applications of 2016 from ‘healthline’ website, we can roughly categorize those applications’ main functions into four types.

Data collection

Basically, all diabetes applications provide data collection function as foundation. These types of applications pay more attention on how to analyze user data and how to present it more friendly through gorgeous graphics or spreadsheets.

Diabetic patient social group

These kinds of applications designed for diabetic patient to form social groups with a view to sharing information and exchanging useful experience with each other. It focuses more on social effects.

Directions for diet and sport

Some of diabetes applications give professional suggestion on patients’ recipe and provide suitable exercise guideline for diabetic patients to learn and keep updating the newest information.

Device-oriented

Users are able to purchase device such as blood glucose meter and download related application. Device-oriented diabetic managed applications help patient track record more precisely.

However, motivated effects of application for chronically ill patients in compliance with exercise plan according to doctors’ instruction are more crucial than general public. Currently, less application has devoted to strengthen motivated effects so as to help diabetic patients achieve better performance on self-control plan.

There have been several researches refer to the relationship between personality and performance. Discussions that concern personality as a valid predictor of job performance have flourished ever since Barrick and Mount (1991) conducted a substantial meta-analysis on the same topic. Few researches has studied the impact of personality on health managed performance. The Myers-Briggs Type Indicator or MBTI (Briggs-Myers & Briggs, 1985) is a popular and widely used personality analysis instrument. Accordingly, the objective of the research is to take MBTI test as basis to analyze personality and evaluate motivated effects on self-managed plan through mobile application.

During the design process, the research utilizes design science research methodology described by Peffers (Peffers et al. 2007) to construct a mobile application. Design science is of importance in a discipline oriented to the creation of successful artifacts. In 2015, Apple Inc. has introduced ResearchKit open source framework which allows researchers and developers to create powerful apps for medical research. The ResearchKit framework offers a variety of customizable modules that include a survey engine, visual consent flow, and active tasks. Thus, we are able to better design our iOS mobile application via

ResearchKit framework.

Specifically, the research objective is to examine completion rate which stands for the performance of motivated effects based on different notified messages pushed to people with various personality types, different frequency of motivational messages and feedback impact on individuals. Furthermore, we can develop strategies to improve the effectiveness of exercising motivation applications.

Related Work

In order to investigate effects of different messages on users with different personalities, the research refers to psychological theory describes by C.G. Jung (Jung et al., 1957). The essence of the theory is that much seemingly random variation in the behavior is actually quite orderly and consistent, due to basic differences in how people perceive and judge. To make the theory of psychological types understandable and useful, the Myers-Briggs Type Indicator (MBTI) instrument (Myers and McCaulley 1988) is one of the most widely adapted instrument. The Myers-Briggs Type Indicator (MBTI) is an introspective self-report questionnaire. It is a useful tool to indicate psychological preferences in how people make decisions. The test results can be used as the basis of further analysis. The whole results of MBTI test includes eight characteristics and sixteen kinds of personality types. MBTI assesses personality types by considering a person's preferences on four pairs of psychological types: Extraversion and Introversion (E, I) assess attitudes people use to direct their energy. Sensing and Intuition (S, N) refer to two ways of gathering information and understanding situations. Thinking and Feeling (T, F) are two ways in which to organize and structure information and come to a conclusion. Finally, Judging and Perceiving (J, P) describes how you like to live your outer life.

For the sake of narrowing our analysis down, the research takes MBTI test to classified users into two types. We only collect data and distinguish users from selected two types of all result Categories-Thinking and Feeling. Adapting MBTI, we investigate how we can motivate people to exercise using messages designed based on their personality types. As a starting point, we focus on thinking or feeling preferences, as this dimension determine how people make decisions, which is the most relevant to our context. People with thinking (T) personality type prefer applying analytical and logical principles to make objective decisions, following clear and consistent principles. People with feeling (F) personality type may opt to make decisions by reference to their own and others' values, put more weight on personal concerns and the people involved.

Based on these two types, we give specific message to each participant. In line with the theory and empirical evidence, we hypothesis that messages that are logical, making suggestions based on facts and scientific evidence are more effective in motivating thinking type person. While to motivate feeling type person, emotional messages that promote positive values (such as persistence, optimistic, etc) and provide emotional support (such as encouragement, inspiration, acknowledgment, etc) are more effective. Our aim is to verify that users will motivated by messages which meet users' personalities.

Research Approach

The design science research methodology is presented by Peffer (Peppers et al. 2007). There are six stages during the design process including problem identification and motivation, objective of a solution, design and development, demonstration, evaluation and communication. At the design stage, we focus on how message effect differed between participants with different personalities. Building on the design science theory, we developed an iOS application using ResearchKit. ResearchKit is an open source framework introduced by Apple in 2015. For medical research, ResearchKit framework enables our iOS app to become a powerful tool. Developers can use a variety of customizable modules such as informed consent, surveys and active tasks to build useful medical application.

The benefits of using ResearchKit are:

Low cost for large-scale data collection. Any iPhone user anywhere in the world can opt-in for the research by downloading the research application in an Apple store.

Requires minimal programming expertise for application development. ResearchKit is composed of pre-constructed modules that make developing an application a much more efficient and easier task. Three basic modules include informed consents, surveys, and active tasks.

Enables longitudinal tracking of participants. ResearchKit enables researchers to easily "follow" the participants with the application installed in participants' mobile phones.

Provides real-time tracking and feedback. With the mobile application, researchers can track real time status of the participants and give feedback or suggest adjustments based on participants' performances.

Collects many types of data. With the capability of iPhones, researchers can collect many types of data that were not possible to collect in the past, such as participants' location and movement.

The purpose of the application is to help participants schedule personal exercise plan and make sure that they are indeed abide

by the plans. We develop the application as a design artifact according to design science guideline described by Hevner (Henver et al., 2004). Within the search process during design, the instantiation we created to improve adherence is the solution to our research objective.

Artifact

The artifact is the iOS application which provides basic exercise plan list. In the beginning, participants may be asked for signature after viewing the research consent and finish a MBTI survey built by ResearchKit framework. The powerful ResearchKit tool provides consent module for us to implement complicated consent flow. Participants can easily finish online consent rather traditional paper work. The survey module includes lots of questionnaire type so that we can utilize it to classify personality type more convenient. After setting exercise plan, the system pushes notifications with specific message type to remind users according to the MBTI result at scheduling time. In order to make further comparison, we are going to collect results from participants who receive and do not receive messages. The application records all scheduling times and remind users to check whether they complete the sport item at the end of the scheduling day. The system automatically calculates average completion rate of each person and all data is stored for advanced analysis in the future work.

ResearchKit is still a novel method for scientific research projects, and there are many challenges in conducting research using this method. Some of those challenges include: the potential for sampling bias, difficulty in verifying the validity of inputs, and data security and privacy issues. While using Apple's ResearchKit as design framework, we explored the ways to overcome these challenges.

The mobile application offers the following features and materials:

- Study information and patient consent page
- Survey about participants' demographic information, living situation, initial motivation level, and exercise habit
- MBTI survey to determine personality type
- User set daily exercise goal and alarm
- Display of motivational messages and feedbacks
- Survey about motivational level and percentage of exercise goal achieved

Experiment Design

The subjects will be randomly distributed to three groups when first registered personal information on the application. One group with matched messages. Namely, logical messages are sent to subjects who are identified as thinking type and emotional messages are given to users with feeling type personalities. Another group with mismatched messages. That is, logical messages are delivered to subjects who are feeling type and emotional messages are transmitted to users with thinking type personalities. The third group is set as the control group which is composed of both thinking and feeling type subjects. However, people in the control group receive no messages. The research is plan to collect results after subjects continuously use the application for a month. We can further compare completion rates among three groups and even find out factors which may influence final results such as gender, race and so forth.

Phase One Experiment

The subjects will be randomly distributed to three groups when first registered personal information on the application. One group with matched messages. Namely, logical messages are sent to subjects who are identified as thinking type and emotional messages are given to users with feeling type personalities. Another group with mismatched messages. That is, logical messages are delivered to subjects who are feeling type and emotional messages are transmitted to users with thinking type personalities. The third group is set as the control group which is composed of both thinking and feeling type subjects. However, people in the control group receive no messages. The research is plan to collect results after subjects continuously use the application for a month. We can further compare completion rates among three groups and even find out factors which may influence final results such as gender, race and so forth.

Phase Two Experiment

Based on phase one experiment design, we add frequency and feedback factors into the original design. After the subjects are randomly distributed to three groups when first registered personal information on the application, we further randomly assigned frequency type and feedback type to each user in each group. The frequency factor is focus on notification times. We classify notification times into one time and two times groups. Messages with one time notification are pushed at scheduling time set by each user. However, in two times group, the first message is sent 30 minutes before setting time and the second message is pushed at scheduling time just as the way in one time group. Another factor is about feedback message. We also divided feedback type into two groups – with and without feedback. The feedback message contains completion rate of each participant and shows along with the phase one notified message. The results are collected and analyzed to verify if feedback message and notified frequency indeed improve exercise adherence on exercise plan.

Expected Contribution

The clear contribution of this research is the design artifact—the application. The main purpose for the research is to assist chronically ill patients in compliance with exercise plan with a viewing to managing their health condition. This focuses on

validation, evaluation and the challenges of improvement inherent in the evaluation process. Not only can the application help patients with chronic disease improve exercise adherence but it also brings useful information for future research and application development. Developers are able to build more effective and efficient healthcare application base on the findings of the research.

Keywords: mHealth, Design science, Myers–Briggs Type Indicator, ResearchKit

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