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THE EFFECT OF GAMIFIED MHEALTH APP ON EXERCISE MOTIVATION AND PHYSICAL ACTIVITY

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Abstract

In this study, we propose a research model to assess the effect of a mobile health (mHealth) app on exercise motivation and physical activity of individuals based on the design and self-determination theory. The research model is formulated from the perspective of motivation affordance and gamification. We will discuss how the use of specific gamified features of the mHealth app can trigger/afford corresponding users' exercise motivations, which further enhance users' participation in physical activity. We propose two hypotheses to test the research model using a field experiment. We adopt a 3-phase longitudinal approach to collect data in three different time zones, in consistence with approach commonly adopted in psychology and physical activity research, so as to reduce the common method bias in testing the two hypotheses.

Keywords: Mobile Health, Gamification, Exercise Motivation, Motivation Affordance, Self-determination Theory.

1. INTRODUCTION

Evidence clearly shows that there is a strong relationship between regular physical activity and health, specifically in improving both physical and mental health (WHO, 2010). However, the World Health Organisation reports that there are more than 59% of adults who are not active enough in most of the countries (WHO, 2013). The public health promotion parties are seeking solutions to increase public awareness about personal health, and currently using mobile phone or smartphone as a tool to promote health seems to be a novel way to reach a wider population.

With the advancement of Information and Communication Technology (ICT) and the ubiquity of mobile phone, the mobile health (mHealth) is suggested to be an appropriate tool for physical activity intervention programmes. The term of mHealth is defined as the emerging mobile technologies with software applications in health sector (Istepanian, Laxminarayan, & Pattichis, 2006; Steven & Steinhubl, 2013). A recent survey conducted in US shows that there are slightly more than a half of the mobile phone users downloaded and used a health-related app (Krebs & Duncan, 2015). Apparently, the mHealth is a new subject to the existing scholars, and thus the design elements with evidence-based would be the most concerned topic in the early stage (Chen & Pu, 2014; Consolvo, Everitt, Smith, & Landay, 2006). In the recent years, the mHealth discipline is merging to another hot topic which is the gamification. The basic idea is that adding some game elements into the current mHealth content when designing the features. Surprising, there is limited understanding on how mHealth app or gamified mHealth app affects one's behavior through using the mHealth devices in the previous literature.

The purpose of this study is to investigate the effect of the gamified mHealth app on exercise motivation and participation behaviour. In the later parts, we first describe the proposed gamified mHealth physical activity app design based on both design theory (Malone, 1985; Zhang, 2008a) and self-determination theory (SDT; Deci & Ryan, 2000). Then, we further derive our design taxonomy and hypotheses. This is followed by descriptions of research design. Finally, we discuss our potential contributions of the current study.

2. LITERATURE REVIEW AND RESEARCH HYPOTHESES

2.1. Motivational Affordance

Theory-driven design is very important as theories provide a systematic guideline on the concepts and constructs which are inter-related. Without the theory-based approaches, the mHealth intervention in physical activity is short-term and not being recognized (Bort-Roig, Gilson, Puig-Ribera, Contreras, & Trost, 2014). In the following paragraphs, we focus on how the gamified mHealth design motivates users' physical activity behaviour by understanding it from two distinct theories – design and motivation. “How to achieve goals” is emphasized in the design theories (“In order to achieve Y, do X”) which is addressed by Malone (1985), and this issue has been further discussed by (Zhang, 2008b). Zhang (2008a) suggests that an ICT can and should include motivational affordance. Motivational affordance defines as an object or technology which can decide whether and how it can support one's motivational needs. In order to meet the design goal, various human needs, i.e. psychological, cognitive, social, and emotional, have to be fulfilled. From the perspective of artifact design, Zhang (2008a) summarizes 10 design principles for motivational affordance which can be used to satisfy the mentioned human needs. Next, we should further understand the fundamental assumptions of a motivational theory – self-determination theory (i.e. SDT, Deci & Ryan, 2000) and its empirical research in the related contexts. By comparing with the human needs suggested by Deci & Ryan (2000) and Zhang (2008a), we focus the common human needs in the following parts (i.e. Psychological / Autonomy and the Self; Cognitive / Competence and Achievement and Social & Psychological / Relatedness).

SDT is based on fundamental assumption that individuals have innate psychological needs which are important for their psychological growth, integrity and well-being (Deci & Ryan, 2000). The assumption of innate psychological needs in SDT is that when peoples are self-determined or with inner interest towards an activity, they are more likely to engage in their own volition (Deci, 1971). When an individual participates in physical activity according to one's willingness instead of other external factor, it would be classified as a higher level of self-determination. Specifically, it is essential to satisfy human's basic psychological needs in order to understanding people's different contents of goals and regulatory processes. These psychological needs can be classified into three main needs: Autonomy, competence and relatedness (Deci & Ryan, 1985, 2000). The detailed explanation of needs in SDT and application in physical activity would be discussed in the later parts.

Autonomy is an essential element in SDT. According to Deci & Ryan (2000), autonomy defines as a sense of feeling free from pressure and it concerns the experience of integration. The most common empirical research with consistent result in education is that students show greater need satisfaction if a teacher facilitate autonomous in class when comparing with controlling condition. The autonomy approach is then further studied in virtual communities (Tsai & Pai, 2014) and job autonomy (Ke, Tan, Sia, & Wei, 2012) and similar findings are observed in the area of information system. According to Zhang (2008a), IT artifacts can satisfy certain autonomous need of users in order to increase the motivational affordances of ICT. This claim is supported by Jung, Schneider and Valacich (2010), their finding shows that users in pseudonymity condition (i.e. a durable virtual identity instead of showing user's real name) have better group performance under a laboratory experiment. In order to facilitate autonomy affordance, the ICT design should better allow users to choose how they want to express themselves by creating self-identity and choose a name to display in an environment (Zhang, 2008a).

Competence is conceptualized as a fundamental element in SDT which has a direct influence on intrinsic motivation. According to Zhang (2008a), ICT design can satisfy users' competence need by providing optimal challenge with timely and positive feedback. The ICT design should also include various levels of difficulty and complexity of a task. As the skill level of each user is varied, the ICT design should allow users to decide their own goal to challenge themselves. Another type of satisfying competence need is competition. Competition allows user to compare or challenge against others and this element is found to be the most common component that has been included in the previous ICT design (Lister, West, Cannon, Sax, & Brodegard, 2014). When studying the effect by an intervention of competition, there are often two distinct dimensions, either in positive or negative result. Prior results show that competition can satisfy competence need of some peoples and mostly are male participants (Domínguez et al., 2013; Lucas & Sherry, 2004). In addition, positive feedback at the optimal time can satisfy one's competence need through the ICT. It is suggested that feedback should focus on encouraging users instead of criticizing their performance. Previous Human Computer Interaction (HCI) research shows that both competence-support interface designs, namely performance feedback and optimal challenge, enhance the motivational affordances of a system (Jung, Schneider, & Valacich, 2010).

The last element in SDT is relatedness and it is defined as a state of loving and caring for and from others (Deci & Ryan, 2000). In Ntoumanis (2001), it is concluded that physical activity has the potential to offer a favorable environment for satisfying one's innate need of relatedness. Half of the studies show that there is a significant relationship between social support and physical activity engagement (Barber, 2012). There are a few studies focusing on the outcomes of framing relatedness as a motivational affordance. In the design research, researchers compare two distinct elements in their experiment, i.e. competition and cooperation. The result shows that users in cooperation condition have higher physical activity participation (Chen & Pu, 2014). In physical activity, social factors are important elements to capture various dimensions of human relatedness need. Prior empirical research shows that social factors are the antecedent for sustained behavior and continued use of the technology (Hamari & Koivisto, 2015). From the literatures, adding a social element into the ICT design not only enhances one's physical activity behavior but also increases the sustainability of physical activity

participation. This research finding shows even stronger result in the mobile technology environment that allows users to provide and receive “in-the-moment” support anytime and anywhere (Turner-McGrievy & Tate, 2014).

Although satisfying human’s basic psychological needs are important, Zhang (2008a, p.145) addresses that “the ultimate goal of designing an ICT for human use is to achieve high motivational affordance so that users would be attracted to it, really want to use it, and cannot live without it.” Based on this claim, we suggest to include gamified design into our theoretical model.

2.2. Gamification

Currently, the term of gamification has been widely applied in mHealth physical activity platform. Gamification is defined as merging a game playing element into a non-game context (Deterding, Dixon, Khaled, & Nacke, 2011, p.9). Besides, gamification is also known as the transformation of an existing system into a game (Seaborn & Fels, 2015, p.18). It has been long adopted in the various contexts. For instance, education or learning is the most common context that integrates gamified elements (Hamari, Koivisto, & Sarsa, 2014). The Nintendo’s Pocket Pikachu (Fogg, 2002) and later Wii Fit are typical examples that can be used to explain the meaning of gamification in encouraging players to participate physical activity through virtual character and video games. The idea of including gamified elements into health related app is to motivate users to keep doing exercise. The most common gamified elements include competition, progress bar, leaderboard, award/badge, point, rule and feedback, and story theme, etc. (Deterding & Dixon, 2011; Huotari & Hamari, 2012; Law, Kasirun, & Gan, 2011).

In King, et al. (2013), their proposed gamified mHealth design shows that the physical activity participation in all subjects increases while sedentary behavior decreases. In another study, the gamification approach may have novelty effects that users’ behavior is not sustainable (Koivisto & Hamari, 2014). Therefore, from the literature, we understand that not all users are motivated by the gamified features or sometimes even discouraged (Domínguez et al., 2013). Also in Seaborn & Fels (2015), they conclude that the majority of applied research on gamification is not grounded in theory and does not use gamification frameworks in the design of the system.

There are indeed a few gamification studies in physical activity context by using the lens of SDT. For example, Peng, Lin, Pfeiffer, & Winn (2012) focus on how autonomous and competence support in a physical activity game influence players. They conduct a lab experiment and invite students to experience an exercise game. However, the limitation of the study is that the relatedness element cannot be manipulated and included in their study, in which this element is found to be the most important factor affecting users behavior from the previous design and applied research (Chen, Zhang, & Pu, 2014; Consolvo, McDonald, & Landay, 2009; Hamari & Koivisto, 2013). Based on those research results, the question on how an individual is motivated by gamified features to be physically active and the effectiveness of the gamification intervention are still unanswered.

Seldom studies have been done to examine the gamification effect in the health and physical activity context, especially the effect on different gamified features from users’ perspective. Also, the effectiveness of the gaming effect is still under studied (King, Greaves, Exeter, & Darzi, 2013). To identify the effective feature which can provide insight in the future development of the mHealth physical activity intervention (Baranowski, Anderson, & Carmack, 1998). To address this, we view gamification as an additional ICT design to enhance the motivational affordance of a mHealth app. As mentioned by Zhang (2008a), ICT design can support conflicting objectives based on certain principles, and more importantly, the design guided by theoretical framework is more reliable and convincing.

In the current study, we develop a mHealth app to satisfy all users’ fundamental needs: autonomy, competence and relatedness. Based on the suggestions in prior studies, participants’ autonomy need has already been satisfied as all participants choose to use the gamified mHealth app at their own choice. Also, they are allowed to choose any usernames to display in the current study (Liu, Li, &

Santhanam, 2013; Zhang, 2008a). Therefore, in the later parts, we mainly focus on two motivational affordances: afford competence and relatedness. We operationalize each affordance into two gamified elements based on the suggestions from Weiser, Weiser, & Bucher (2015) & Zhang (2008a). Moreover, we elaborate how the gamified design elements act as a motivational affordance based on the literatures and propose a theoretical model for this study (Figure 1).

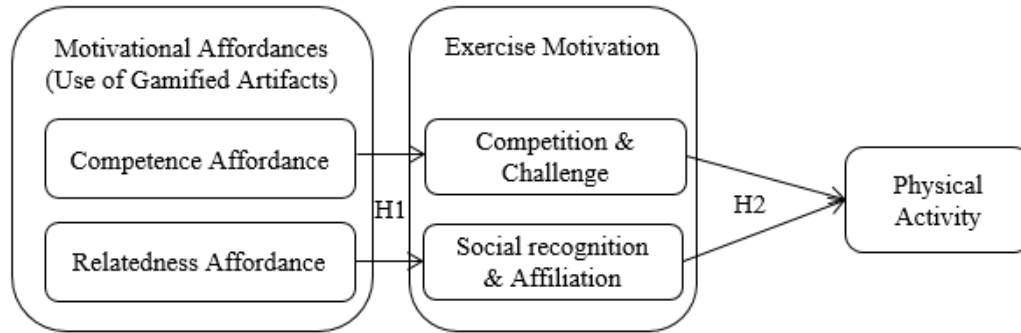


Figure 1. Research Model.

2.3. Afford Autonomy

As mentioned in earlier paragraph, one of the design elements that can facilitate autonomy support is to let users to create their own identity. In our proposed mHealth design, we allow users to choose any display names that different from the other users. Also, users can choose to walk with a partner who is someone they know or users can meet a new friend through the app. The choice of creating a username to represent one’s social identity in a platform is found to be more effective than anonymous (Frost, Matta, & MacIvor, 2015; Jung et al., 2010). Although there are some other elements that can satisfy one’s autonomy need, but to satisfy this need is not our focus in this study as all the register users are supposed to register the app by their own choice.

Next, we present our proposed gamified feature design elements as follow, the overview of gamified features is listed in Table 1.

Motivational Affordance	Exercise Motivation	Gamified Features Design	References
Afford Competence	Challenge	Achievement badges	Lister, West, Cannon, Sax, & Brodegard, 2014; Peng et al., 2012
	Competition	Leaderboard	
Afford Relatedness	Social Recognition	“like” function	Klasnja & Pratt, 2012; Lister, West, Cannon, Sax, & Brodegard, 2014
	Affiliation	Form a team (walking with a friend)	

Table 1: Overview of gamified features in mHealth physical activity

2.4. Design of Afford Competence

Challenge. Challenge in gamified features includes achievement badges, points and levels, etc. These features are served as a reward-based gamification (Nicholson, 2012). Especially, the point system is described as a required element of all gamified systems (Bartel & Hagel, 2014). In the game-playing

research, this competence affordance can be treated as “individual games” (Liu et al., 2013). In our interface design, users are allowed to set their own target instead of the “one-size-fits-all” general target, and hence users are motivated to do exercise towards their personal goal (Consolvo et al., 2006). Once the users meet a certain goal, they will immediately receive a notification message with specific achievement badge and positive feedback to enhance users’ motivation to achieve their goals (Blohm & Leimeister, 2013).

Competition. A gamified feature of competition is the use of leaderboard. Competition can be classified as competition and cooperative-competition games (Liu et al., 2013). In our mHealth design, the leaderboard is displayed in a website which shows all registered users’ and groups’ step records and rankings. Anderson et al. (2007) find a playfulness of gamified mHealth platform, which allows competing to each other, could be indirectly affect participants to walk more. Furthermore, in the digital game setting, researchers find that players will play longer time if they compete with the player who has similar skill level (Liu et al., 2013). On the contrary, displaying real name or using anonymous demonstrates negative or not significant effect on adding this competition elements (Consolvo et al., 2006; Frost et al., 2015). Thus, as mentioned, users can choose a nickname to represent themselves, and this can prevent those users who do not want others to know about their real identity and performance.

2.5. Design of Afford Relatedness

Social recognition. A like button is designed to let users to express their supports and cares to others and the number of “like” is treated as the level of support from others. A study defines the like function as an indicator for social influence and positive recognition (Hamari & Koivisto, 2015). According to the key mHealth design requirement suggested by Consolvo et al. (2006), social influence should be designed to support users and this further emphasis in Campbell, Ngo, & Fogarty (2008). The most successful games relies heavily on social interaction.

Affiliation. The affiliation feature is designed in both individual, group, unit levels. First, users are allowed to form a team by inviting friend, family member or others to become their walking partner. Users will be motivated as their partner who can closely monitor each other’s record through the app. Second, users can also choose to walk for their department or unit in their respectively university or corporate from the perspective of the unit level. This feature allows users to cooperate each other to set and achieve their team goal (Klasnja & Pratt, 2012; Yoganathan & Kajan, 2013). As in the gamification design literature, including social features is beneficial for creating sustainable and engaging gamification. Users will feel more attached to the group when they have more friends within the system (Hamari & Koivisto, 2015). It is also supported in a game research, the affiliation feature is classified as cooperative games (Liu et al., 2013) that players show loyalty to the game if it provides social cohesion with interpersonal features (Park, Nah, DeWester, & Eschenbrenner, 2008).

2.6. Exercise Motivation

Understanding of ones’ exercise motives can help to predict their behaviour. Therefore, it is very important to know the surface-level of exercise participation motives from a practical perspective (Markland & Ingledew, 1997). In Ingledew, Markland, & Ferguson (2009), they conceptualize exercise motivation in 14 subscales, i.e. stress management, revitalisation, enjoyment, challenge, social recognition, affiliation, competition, health pressures, ill-health avoidance, positive health, weight management, appearance, strength & endurance and nimbleness. Consistent results show that the exercise motivation can be used to predict one’s physical activity participation (Frederick & Ryan, 1993). Also, some other studies suggest that designing different programme context is vital in order to meet the individual exercise motivation (Ingledew et al., 2009; Ingledew & Markland, 2008). Thus, we hypothesize that different users will have their own exercise motivation, and therefore the gamified features cannot be used to predict ones’ exercise behavior without knowing and satisfying both their corresponding needs and exercise motivations. Therefore, we suggest that one’s exercise motivation

can be triggered by the use of gamified features through using the personalized mHealth devices, and as a result one's physical activity behavior will be enhanced. Therefore, we formulate the following two hypotheses.

Hypothesis 1a: The use of gamified artifact (leaderboard/Achievement badges) is facilitating competence affordance which will have a positive relationship with exercise motivation (i.e. competition and challenge).

Hypothesis 1b: The use of gamified artifact ("like" function/form a team) is facilitating relatedness affordance which will have a positive relationship with exercise motivation (i.e. social recognition and affiliation).

Hypothesis 2: Exercise motivation will have a positive relationship with physical activity behavior.

3. METHODOLOGY

3.1 Overview

We will conduct a field experiment and decide to use a pre-test vs post-test control group to examine the effect of the use of gamified mHealth in a business sector. Also, we plan to adopt a 3-phase longitudinal approach to collect data in three different time zones, in consistence with approach commonly adopted in psychology and physical activity research, so as to reduce the common method bias in testing the two hypotheses. More specifically, we will collect data in three time periods, i.e. 4 months in between each period, named in Time 1, 2, and 3 (see figure 2). In Time 1, we measure participants' exercise motivation and physical activity behaviour using a survey. Then, participants are invited to use the mHealth app throughout the experiment period. A daily personalized message will be sent out to participants and the message content will be based on their reported exercise motivation. After that, we continue to collect data in Time 2 and 3. Moreover, users' demographic information will be collected and their walking steps will be extracted directly from the system.

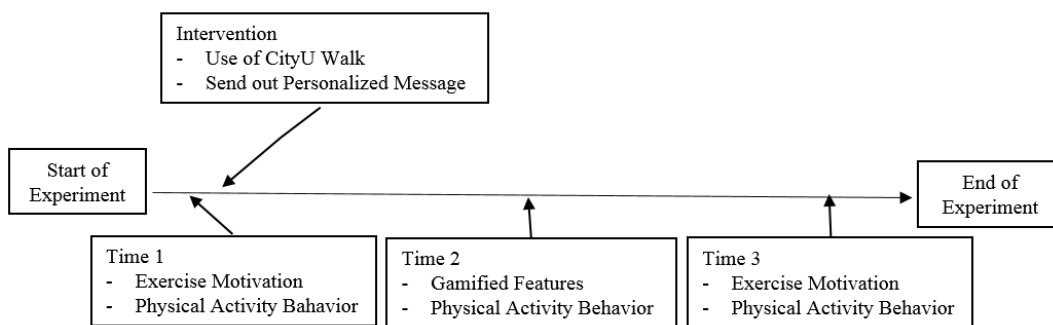


Figure 2. The Experiment Procedure.

3.2 Design of the mHealth app

In this section, we present a robust system which consists of two subsystems: (1) mHealth app, named "CityU Walk" and (2) webpage. The CityU Walk app is a pedometer that counts users' walking steps and records their daily total step counts. Users can check and compare their step records (7-day records) through the app by swiping left from the screen. It also shows the approximation of users' distance walked and calories burned. Besides, it illustrates the frequency distribution of users' step counts in a daily basis at the bottom of the app. The steps frequency is displayed as a graph. Before users start to use the app, they have to input some personal data such as gender, year of birth, email, height and weight etc. Also, they can create a display name to represent themselves. In the group or unit level, users can choose to contribute their steps to a walking partner, and residence hall or department/unit. All the data collected from the app (i.e. users' steps record) will be synchronized to

the server depending on the Android and iOS app management system. All the users' step records and rankings will be shown on the webpage in form of leaderboard. Other gamified features will be pushed by the system (or the walking partner) when the user achieves certain goal.

3.3 Pilot Study

There are two main reasons in conducting a pilot study for the current study. First, we need to confirm the proposed survey items and check for its reliability and construct validity. Second, we want to understand more about the feasibility of the mHealth intervention in all individual, group and unit levels. Before the study, we have to test, refine and confirm our hypotheses through the pilot study.

A pilot study will be conducted in an administrative department in one of the universities in Hong Kong and 30 staff will be invited as a participant. One-group pre-test vs post-test will be designed. We adopt a 3-phase longitudinal approach to collect data in three different time zones, in consistence with approach commonly adopted in psychology and physical activity research, so as to reduce the common method bias in testing the two hypotheses. Survey will be sent to all staff who have used the proposed mHealth app. After confirming the experimental setting and new instrument, the study will be replicated in a larger sample at the main study.

3.4 Measures

Most of the questionnaire items are adapted from existing scales except the use of gamified features which is developed for this study. Besides the measure of physical activity behavior is available in Chinese, all the other questions will be translated in future by using the back translate method. To confirm the scales for current study, we conduct a pilot test with 30 individuals to validate the new instrument.

Gamified Features. The use of gamified features will be measured with multi-item instruments which ask subjects to rate the extent of various gamified features. All features are listed in Table 1. We develop two set of scales to measure the exogenous variables: competence and relatedness affordances.

Exercise Motivation. The second version of the Exercise Motivations Inventory (EMI-2) will be used to measure participants' exercise motivation, specifically competition & challenge and social recognition & affiliation (Markland & Ingledew, 1997).

Physical Activity. The measure of physical activity is adapted from a cross-national monitoring instrument, i.e. The International Physical Activity Questionnaire – short versions (IPAQ; Craig et al., 2003; Macfarlane et al., 2007). Respondents are required to provide their physical activity frequency, time and intensity for the last 7 days in all three time periods. Also, users' actual participation in physical activity, specifically in walking steps, will be collected from the system database.

Non-response bias will be measured. As we collect all the users' demographic data through the app registration, therefore, it is feasible for us to compare the key factors between both respondents and non-respondents.

4. POTENTIAL RESULTS AND CONCLUSION

The expected result in the current study is that the proposed gamified features can be used to predict different exercise motivation that will further enhance users' physical activity participation at last. The mHealth physical activity intervention is supposed to be an effective workplace health programme. Also, according to prior findings, exercise motivation related to social support - "social recognition" and "affiliation" will have stronger positive effect on participants' physical activity participation. It is because both exercise motives can satisfy human relatedness need.

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