User Satisfaction and System Environment Convenience for Interface Design of Mobile Games

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Abstract
The convenience and multi-functionality of mobile devices have made mobile gaming an increasingly popular recreation but the industry competition is becoming increasingly fierce. Therefore, making research into the design flow facilitated by the user-interface a worthwhile endeavor. The five of the most popular tower defense game titles in recent years were adopted to be the cases in this study. This study was conducted using an empirical research methodology with semi-structured surveys. The missions or tasks undertaken by participants in these games serve as the bulk of the research on the interface flow. Each participant was assigned four tasks for each game, and then each participant was asked to complete a user satisfaction survey and system environment convenience scale survey. The results show that the interface's easily recognizable icons and effective tutorials were the reasons for the higher user satisfaction and system environment convenience scale ratings from participants. In addition, the three interface designs, which are (1) unrestricted areas for building, (2) tutorial explanations on the tasks, and (3) options to undo or cancel actions, provide players with a positive experience. Therefore, interface design provides intuitive control, easy-to-identify icons, simple and clear building and upgrading tasks, and well-designed task hints among other features which would help players get through the games more smoothly.

Keywords: mobile phone, game, interface, user satisfaction, system environment convenience scale

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INTRODUCTION

The majority of current software development efforts concentrate on mobile device applications and games. As the scope of mobile game development expands and barriers to development are lowered, the market will saturate with games with similar gameplay mechanics. Thus, in order to establish a foothold in the burgeoning mobile device application and gaming markets, user interface becomes a crucial element. Interface control design is important not only for its usability but also to the mental and emotional experiences of the users (Sevener 2003). Thus, the interface designer must consider how much information a user is able to process at a time (Deng and Poole 2010). Given that the purpose of mobile games is to entertain, the designer prioritizes ease-of-use and the user's subjective experience and level of satisfaction.

This study investigated the factors affecting the interface of mobile games on smartphones. The sample comprises the globally ranked top-five paid tower defense game (TDG) titles on Google Play. The selected games present similar in-game tasks but different user-interfaces. The three metrics used in this study include each participant's efficiency in terms of time taken to complete each task, their subjective experiences in terms of user satisfaction ratings, and the System Environment Convenience Scale (SECS). Through examining the design of the interface, the operation of the game, and the user's subjective experiences, the study compared the differences between factors that affect the usability of TDG interfaces and the actual situations in order to better understand players' expectations of interface design flow and players' level of user satisfaction with it.

LITERATURE REVIEW
Individual Subjective Perceptions of User Experience

User experience (UX) is the entire experience of and interaction between the user and the company, product or service. A good UX allows the user to easily complete tasks (Goto 2004), thus the UX designers should focus on how the user feels with using the product (Kraft 2012). But there is no such thing as an ultimate one-size-fits-all user interface design. In an

experiment of cloud storage interface, the interface customization resulted in higher user satisfaction (TzeHui and LanSee 2015). Thus, the individual perception of user experience can be a derivative of subjective experience. Therefore, interface design should be based on the user's habits and meet the user's physical and mental needs.

Customer Satisfaction: Using Surveys

Customer satisfaction is the resulting joy or disappointment experienced as the difference between the expected value and the individual's subjective experience value (Kotler 1994). If the subjective experience value is lower than the expected value, the customer is dissatisfied. If the subjective experience value matches the expected value, the customer is satisfied. If the subjective experience value exceeds the expected value, the customer is satisfied and pleased. Therefore, customer satisfaction was an important evaluation that there was a positive correlation between a website's usability and its aesthetics (Lin 2005).

System Environment Convenience Scale: Need for Change

Usability and learn ability were often used together to evaluate interfaces (Wilson 2013). In order to evaluate the usability of human-machine interfaces, Brooke suggested using SECS (Brooke 1986). Today, SECS is widely used to aid companies in the understanding of the usability of their products as well as the products of their competitors. Nielsen showed that the usability requirements for novice users and expert users differ (Nielsen 1993). The difference among users has become a more relevant factor, making emotional factors related to the user more important. The concept of "beyond usability" was proposed (Brooke 1996), and has begun to take root in the field of usability research, expanding from physiological factors to include psychological and emotional factors as metrics for usability. In light of this, this study adopted SECS ratings and user satisfaction levels to respectively address both usability and emotional aspects of TDG interface design on smartphones.

EXPERIMENTS

The experiments were conducted using the Android operating system on 5- to 7-inch smartphones. The five research participants were enrolled in masters or doctorate programs at the time of the experiment, and all had at least one year of experience playing TDGs. Participants were first listen to the experimenter's requirements and explanations of the tasks in the games as well as the games' mechanics. Then, participants started the experiment by engaging in the specific tasks. The time taken by each participant to complete each task was recorded. After completing the assigned tasks for one game, participants were asked to fill out user satisfaction surveys and SECS ratings to conclude the experiment.

Defining In-game Task Experiment

The games used in this study were selected from a pool of games on Google Play. According to data from the well-known market data and insights company App Annie, during the month of June from 2013 to 2017, the paid TDG titles ranked in the world top-five were selected as the samples as the following: *(G1) Bloons TD5, (G2) Kingdom Rush Origins, (G3) Epic War TD 2, (G4) Dungeon Warfare, (G5) Anomaly Defenders*. The various tasks undertaken in TDGs such as building defensive configurations, upgrades, and deconstruction are all designed differently. The content of this study's experiments regards the "construction and upgrading of defensive structures", which this study defines as one of the core elements of TDGs. In each game, players have to perform the following four tasks in order: (1) building defensive structures under normal circumstances; (2) building defensive structures while under attack; (3) upgrading defensive structures under normal circumstances; and (4) upgrading defensive structures while under attack. Since the objective of the research was focused on the process of players operating the interface when carrying out tasks in the game, the research scope excludes the game's other interfaces, color schemes, and sound effects.

User Satisfaction Survey and System Environment ConvenienceScale Survey

Based on the user satisfaction survey of websites (Lin 2005), the user satisfaction survey in this study was designed to fit the special characteristics of mobile platforms. After completing all four tasks for each game, participants were asked to fill out the survey (a total of eight items marked as *US1* to *US8*) using a seven-point Likert scale (1 = extremely dissatisfied, 7 = extremely satisfied). The SECS survey was drawn from the experiment designed by Brooke (1986, 1996). Participants rated each item of the interface (a total of ten items marked as *SECS1* to *SECS10*) across a five-point Likert Scale (1 = strongly disagree, 5 = strongly agree).

RESULTS

Performance with Tasks in Terms of Time

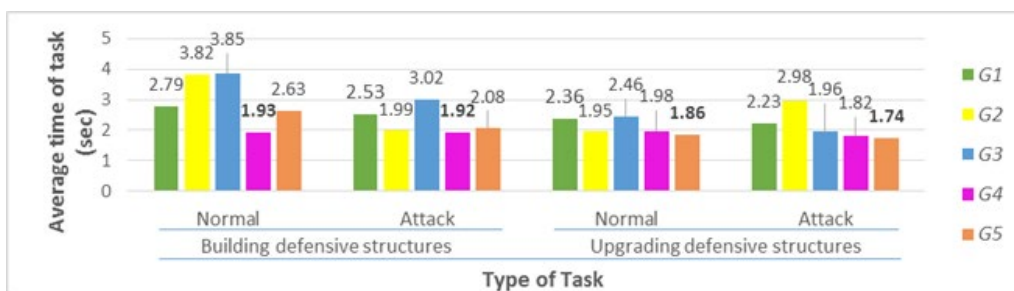The participants engaged in four specific tasks and the average times taken by participants to complete each

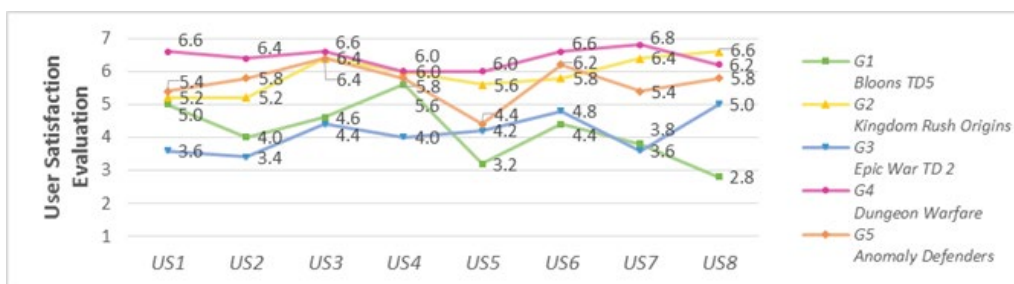**Fig. 1.** Bar graph of average times for tasks completed by participant per game
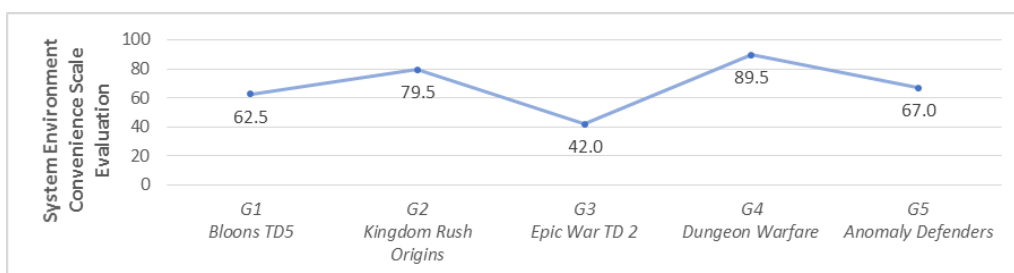

Fig. 2. Line chart of User satisfaction

Fig. 3. Line chart of SECS for aggregate scores

task in the game were shown in **Fig. 1**. Tasks of building defensive structures took the shortest amount of time in game *G4*. Tasks of upgrading defensive structures took the shortest amount of time in game *G5*. Shorter times suggest that the usability of an interface while performing a certain task is higher, allowing participants to complete their tasks quicker.

User Satisfaction and System Environment Convenience Scale Analysis

A t-test was conducted for the results of the user satisfaction surveys to show a Cronbach's Alpha of 0.923 for the reliability of the eight items on the survey. The reliability of the survey in this study meets requirements of alpha value being greater than 0.7 (Churchill and Peter 1984). **Fig. 2** shows the results of the user satisfaction survey. Items *US1~US7* showed highest ratings in game *G4* that game *G4* received the highest average rating. This suggests that participants found game *G4*'s interface the most satisfying. In addition, the average rating for item *US5* was the lowest among all other items. This results suggest that the

tutorial portion of the interface requires further improvements.

The aggregate scores of SECS were computed according to the research of Brooke (Brooke 1986). Game *G4* had the highest score but game *G3* had the lowest score as shown in **Fig. 3**. A high aggregate score for system environment convenience suggests favorable interface design.

DISCUSSION

Based on our findings, it seems game *G4* has the best interface design out of the TDGs selected in this study, e.g., the icon for purchasing materials in game *G2* was a dollar sign (**Fig. 4(a)**) while in game G4 the icon for purchasing was a dollar sign and text (**Fig. 4(b)**). When comparing the icon presentations, game *G4* showed faster icon recognition amongst the participants, and can use the interface more quickly and accurately. Thus, it can be said that the degree of icon recognition is crucial for smooth and seamless gameplay.

(a) G2:
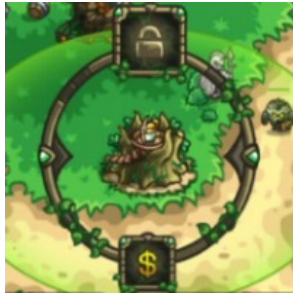
(b) G4:

Fig. 4. Defensive construction game interface

In game *G5* during defensive structure upgrading, participants were able to interact quickly with the interface, though the aggregate rating of user satisfaction and score from the SECS for game *G5* ranked third. Further investigations revealed that the color schemes for icons in game *G5* were lacking, resulting in the players often overlooking existing defensive structures when building new ones which ultimately undermined their defensive capabilities. In addition, the game mechanics for game *G5* were relatively more complicated than those of the other games. *G5*'s tutorial was relatively difficult to follow, resulting in low ratings from participants.

Besides, this study can offer three suggestions for interface design to raise user satisfaction based on the interface interactions during the process of game play:

(1).   **Choosing a Terrain Map:** The degree of the restricted map affects the freedom to play strategically and innovatively, thus the "unrestricted map" was popular that allows construction in any undeveloped area on the map.

(2).   **Explanation of In-game Effects:** Before the player can buy, build or upgrade anything, the interface must provide the player with all relevant information so that they understand what the purposes and objectives are. The player would thus be better able to grasp the situations that happen in the game and have a smoother playing experience.

(3).   **Undoing or Cancelling Actions:** When players make a mistake in their gameplay, be it a mistake they themselves made or a mistake caused by the game's interface, being able to cancel or undo an action is critical and indispensable.

CONCLUSION AND RECOMMENDATIONS

With regard to interface flow, the meticulous design of icon should ultimately strengthen a player's ability to quickly recognize, remember and become familiar with the game mechanics so that he/she has a more pleasant experience of the game. Among popular paid TDGs, the game play interface may seem similar but the games that have better icon recognition are clearly the ones that have shorter playing times. Based on the results from this study, a game should have an intuitive interface, easily recognizable icons, simple and clear construction and upgrade actions, and designed task reminders to encourage seamless gameplay. Games with better interfaces allow players to reach their objectives effortlessly and in a satisfying manner. If they experience higher user satisfaction, players will be more willing to continue playing.

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