Abstract

Aim: The study aimed to examine the acute effect of a battle mobile game playing between 3 games (45-60 min) and 7 games (135-180 min) on heart rate (HR), stress levels, cognitive function, and visual short-term memory (VSM) in healthy university students.

Methods and Results: Twenty university students aged 20-22 volunteered. The Realm of Valor (ROV) mobile game was used. Participants were separated into 4 teams, and each team was randomly assigned to play either 3 games or 7 games. All variables were assessed before and after gaming. Results showed that HR increased in both gaming conditions after playing (p<0.05). Stress levels were higher after 7 games than after 3 games (p<0.05). Cognitive function was greater changes in the 3 games than that in the 7 games (p<0.05). Neither the 3 games nor the 7 games affected visual short-term memory.

Conclusions: Playing the ROV mobile game for 7 games or more than 135 minutes could increase stress levels, whereas 3 games may not affect stress response and cognitive function. Thus, suitable time spent playing games, especially a battle game, should be advised to avoid inducing stress responses in university students.

Effects of mobile game playing time on stress response, cognitive function, and visual short-term memory in healthy university students

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Keywords: A battle mobile game / Short-term memory/ The Realm of Valor/ Visual short-term memory test

Highlights
• HR increased after playing 3 and 7 games.
• Stress levels were higher after 7 games than after 3 games.
• Cognitive function was greater changes in the 3 games than that in the 7 games.
• Neither the 3 games nor the 7 games affected visual short-term memory.

Introduction

Nowadays, the world has developed into a digital era with mobile phones considered an essential device that humans need for daily living. As such, the Internet and online games are more accessible to everyone. As a result, the use of social media, such as Facebook and Instagram, watching movies, listening to music, searching for information, sending and receiving emails, making financial transactions, reading books, and playing online games are prevalent (1). According to the Thailand Internet User Behavior 2019 Survey by the Electronic Transactions Development Agency (1), the Thai student population spends the highest number of hours on the Internet with an average of 10 hours and 50 minutes per day of online presence compared with other age groups. In addition, the survey also reported that playing games (34.1%) is one of the first ten popular online activities of Thai Internet users. The combination of gaming and social networking on mobile phones has gained popularity among adolescents (2). However, excessive playing of mobile games for long periods, including overnight playing, may be associated with physiological (3, 4) and psychosocial problems (5, 6).

The Realm of Valor (ROV) (7) is a popular online mobile battle arena game. ROV is a multiplayer game that had various game modes such as 1 player vs 1 player, 3 players vs 3 players, and 5 players vs 5 players (5v5) rank mode. Each player can match their teams randomly or group up into teams at the initiation of a game. Then, the game system will randomly allocate opponent teams or create a game room for battles. Normally, each ROV game lasts around 15 - 20 minutes depending on team ability and the gamers usually play a minimum of 3 games (~45 -60 minutes) each time. However, it is also likely that players play ROV continuously for long periods.

Mobile gaming and frequent use patterns have been increasingly linked to adolescent health problems and associated with smartphone addiction (8, 9). Therefore, time spent playing mobile games may play a crucial role in contributing to adverse effects. The previous survey study by Yamaguchi (10) on 5000 Japanese people aged 15-69 years showed that playing mobile games for about 1.5 hours or less per day could exert benefits on people’s well-being. On the other hand, a long period spent playing mobile games, especially a battle game or a competition game, has been reported to elicit negative physical and psychological responses (11).

As far as we know, no studies have addressed the effects of mobile game playing time on immediate changes in stress response, cognitive function, and memory. The present study aimed to compare the effect of 3 games (~45 -60 minutes) and 7 games (~135-180 min) playing ROV on heart rate (HR), stress, cognition, and short-term memory in healthy university students.

Materials and Methods

Participants

This study used a randomized crossover design. Sample size estimates were calculated from a previous study (12) using G*Power 3.1.9.2 analysis (Effect size: f = 0.4, Alpha = 0.05, power = 0.85, sample size = 18, critical F = 4.49, Lambda = 11.5). Therefore, a sample size of 20 participants (18 participants plus 2 participants for an expected 10% dropout) was required.

Healthy university students (10 males and 10 females) between 20 to 22 years of age participated. The inclusion criteria included patients who played the ROV mobile game 2-3 times per week for at least 1 hour per session and not being e-sports athletes. The exclusion criteria included patients who had underlying diseases such as attention deficit hyperactivity disorder and schizophrenia, abnormal vision (in case of nearsightedness or farsightedness, glasses or contact lenses were accepted), and hearing. Participants provided written informed consent after an explanation of the experimental procedures, potential risks, and benefits of the
study. Participants were excluded if they were taking medication classified in the group of antidepressants and antihistamines. Ethical approval was obtained from the Human Experimentation Ethics Committee of xxx (xxx), with protocol and procedures conforming to the 2013 Declaration of Helsinki.

**Experimental procedures**

The overall procedure of the present study is illustrated in Figure 1. Participants completed a questionnaire providing information on body weight (BW), height, medical history, period of gaming per session, and in the week. The day before data collection, participants were instructed to sleep at least 6-8 hours, abstain from caffeine for 12 hours, and not take additional medication that may be confounding for the study such as nasal decongestants, or other drugs that may cause drowsiness and affect the nervous system. The study was set up at home. On the day of data collection, participants were responsible for the preparation of the gaming equipment and gaming area for playing the games over the Internet. Participants were appointed to attend the online session at 3.00 p.m. Following detailed instructions of the session requirements, participants recorded resting HR using a wristband watch (Apple Watch Series 2) and completed the Suanprung Stress Test-20 (SPST-20), Stroop Color and Word Test (SCWT), and visual short-term memory test (VSMT). Afterward, participants were separated into 4 teams (5 players per team) and each team was randomly assigned to play against the other team using a computer-generated program. For example, if the team played the ROV for 3 games in one setting, they were assigned to play 7 games in the next setting 7 days apart. Immediately after finishing each gaming condition, participants recorded their HR and completed the cognitive and memory tests.

[Figure 1 insert here]

**The Realm of Valor (ROV)**

The ROV is a multiplayer online battle arena game that can be freely downloaded and installed. The ROV players are assigned to characteristic types of heroes with each unique ability in the game regarding the set of powers and skills. Participants process the game mobile screen information during competitive team play in a specific stimulation arena (7). During gameplay, participants in each team can be involved in team member communication using the Voice over Internet Protocol (VoIP) (13).

**Suanprung Stress Test-20 (SPST-20)**

The Suanprung Stress Test (SPST-20) is widely used for stress evaluation in the Thai population (14-16). The SPST-20 has high reliability and validity with Cronbach’s alpha of 0.7 (14). Participants completed the test on the online website with an investigator available online in case assistance was required. The SPST-20 consists of 20 questions. The scoring criteria are as follows: 1 point of the stress score represents no stress; 2 points of the stress score represent low stress; 3 points of the stress score represent moderate stress; 4 points of the stress score represent high stress; 5 points of the stress score represent the highest level of stress. Total scores for the 20 questions (total score range 0–100) were considered for assessment on the level of stress as follows: 0-23 points, low stress; 24-41 points, moderate stress; 42-62 points, high stress, > 63 points, severe stress.

**The Stroop Color and Word Test (SCWT)**

The SCWT is a neuropsychological test that is widely used to measure multiple cognitive functions such as attention, processing speed, cognitive flexibility, and working memory (17). Since the present study was done during the pandemic of COVID-19 situation, we used the SCWT available from https://freebrainagegames.com/stroop.html to assess cognitive functions. The software program provides 6 color options for each word displayed on the computer screen. Participants are provided with names of colors that appear in different colors. For example, the word “red” may appear in green. Participants are requested by keyboard use to indicate as fast as possible the color of the word. The SCWT was taken for 5 minutes and the total scores on completion of the SCWT were used for analyses.
Visual short-term memory test (VSMT)

The VSMT is a neuropsychological test that is used to measure the ability to retain a small amount of visual information over a short time (18). This study used the VSMT available online at https://www.cognifit.com/memory-test?irclickid=2Tj2zPQ-txy IU51VVZTY1 war UkJVU QXQ-m180kirgwc=1.

The test offers the choice of animal or nature pictures. Participants used animal pictures for the 3 games condition and nature pictures for the 7 games condition. Participants were asked to remember the picture on the screen in random order and click on the picture that previously appeared as quickly as possible without error. This test was taken for 5 minutes. The response time (in milliseconds) and percentage of error (in percentage) that were shown on the screen after finishing the test were recorded and used for analyses.

Statistical analysis

The Shapiro-Wilk test revealed that data were normally distributed. In addition, the sphericity of data was considered using Mauchly’s test of sphericity, and where the sphericity assumption was violated Greenhouse-Geisser corrections were used. A two-factor mixed model analysis of variance (MM ANOVA) was used to evaluate the effect of condition groups (3 games and 7 games) and time (pre-and post-playing). Any interactions between group and time were revealed using post-hoc paired t-tests with a Bonferroni correction to determine any differences within each group between the time points. Data were presented as mean ± standard error of the mean (SEM), the differences (F value), the effect size partial eta-square ($\eta^2$), and the significance (p) are shown. To account for differences from pre-game, the values of percentage changes (%[?]) were calculated using the formula: [(post minus pre-playing) and divided by pre-playing] multiplied by 100. Differences in the %?[?] between the two conditions were analyzed using the independent t-test. Cohen’s d and 95%CI were also calculated to determine effect sizes to compare means between conditions. Statistical significance was accepted at $p < 0.05$ and 0.05 $\leq p < 0.1$ interpreted according to guidelines by Curran-Everett and Benos (18). All statistical analysis was performed using SPSS software version 20.

Results

The general characteristics of the participants and gaming behavior are presented in Table 1.

For HR, there was an effect of time (pre vs. post) ($F (1,46) = 28.27; \eta^2 = 0.38; p < 0.001$) with an increase in HR after playing 3 games (11 bpm, $p = 0.001$) and 7 games (12 bpm, $p = 0.001$) (Table 2). However, there was no effect for the gaming condition (3 games vs. 7 games) ($F (1,46) = 0.44; \eta^2 = 0.02; p = 0.51$). In addition, there was no difference in %?[?] of HR between 3 games (14%) and 7 games (16%) (Table 3, Figure 2).

For SPST-20 scores, there was an effect of time (pre vs. post) ($F (1,46) = 5.11; \eta^2 = 0.12; p = 0.03$), with higher stress scores after 7 games ($p = 0.02$) but not after 3 games ($p > 0.05$) (Table 2). However, there was no effect of condition (3 games vs. 7 games) on stress scores ($F (1,46) = 0.84; \eta^2 = 0.06; p = 0.36$) (Table II). For %?[?] of stress scores, there was a trend for a difference between 3 games (4%) and 7 games (23%) ($p = 0.07$) (Table 3, Figure 2).

For SCWT scores, there was an effect of time (pre vs. post) ($F (1,46) = 14.00; \eta^2 = 0.23; p = 0.001$), with higher scores after 3 games ($p= 0.001$), but not after 7 games ($p > 0.05$) (Table 2). However, there was no effect for condition (3 games vs. 7 games) on SCWT scores ($F (1,46) = 2.64; \eta^2 = 0.029; p = 0.11$) (Table 2). For %?[?] of SCWT scores, the 3 games had higher changes (14%) than the 7 games (5%) ($p =0.03$) (Table 3, Figure 2).

For VSMT, there were no differences in the average values of percentage accuracy and test response time within and between conditions ($p > 0.05$) (Table 2). In addition, there was no difference in %?[?] for
percentage accuracy of VSM but a trend for a difference in % of test response time between 3 games (1%) and 7 games (-5%) (p = 0.05) (Table 3, Figure 2).

Discussion

This study determined the acute effects of mobile game playing time on changes in stress, cognitive function, and memory in healthy university students. The main finding showed that HR was similarly increased after the 3 and 7 games, whereas the 7 games increased the SPST-20 stress scores compared to the 3 games. Cognitive function, assessed by SCWT, was greater changes in the 3 games than that in the 7 games. Neither the 3 games nor the 7 games affected VSM.

In the present study, the mean values of time spent playing 3 games and 7 games ranged between 45 and 60 min and between 135 and 180 min, respectively. This is in line with Anunpattana et al (7) that people usually spent time playing the ROV ~15-20 min per game (7). Participants’ characteristics showed that the mean values of time spent using the internet in this study (6 - 8 hours per day) were less than those reported in Thai people (10 hours 36 min per day) (1). This occurrence could confirm that participants in this study were university students who non-gaming users, so playing mobile games might be their recreational activity after class. It is notable that during the pandemic COVID-19, time spent playing mobile games dramatically increased in this age group (16-24 years old) (19). Even though the study of Barr & Copeland-Stewart (19) observed positive effects of playing games on player well-being during this pandemic situation, the information of time spent playing mobile games on physiological and psychological responses is not known.

In the present study, HR after the ROV game increased by 14% and 16% in 3 games and 7 games, respectively. Similarly, Valladao et al. (20) reported HR response during a 3-hour playing the Fortnite battle-royale style game was higher than the resting HR by an average of ~ 9%. This is not surprising, an alteration between an increase and decrease in HR could occur throughout the game via activation of the autonomic nervous system. Due to the ROV game being a battle game that requires teamwork against opponents, several game situations could induce stress. For example, when the gameplay turns out to be unsatisfactory or gaming in a high-pressure event, such situations would stimulate the sympathetic nervous system and accelerate the heartbeat (21, 22).

For cognitive function, a previous study (23) reported that specific types of video games, i.e., the excitement game and the fear game could affect the stress system as well as the cognitive system of humans more than the puzzle game. Inconsistency, our data showed that continuously playing games for 3 games (~45 -60 minutes), not for 7 games (~135-180 minutes), could have a benefit on cognitive function. In fact, the ROV is classified as an excitement game according to the style of the game which is composed of battle and competition against the opponent. In the same way, the overall gameplay of ROV could also enhance the thinking process and reasoning ability of the player. Therefore, this study demonstrated a positive effect of playing the ROV on cognitive function if playing for a short duration rather than a long duration. This result suggests that time spent playing mobile games could affect cognitive function in a safe way if players manage their time to play properly.

Visual short-term memory (VSM) is the capacity of a human to hold a limited amount of visual information for a short period of time (18). Previous works have reported a VSM advantage among action video game players (24-26). The recent finding showed a trend of faster VSM in non-gaming users who play 7 games than
those who play 3 games. Similarly, the study done by Wilms et al. (26) measured the effect of action video gaming on VSM in 3 groups: non-players (< 2 h/month), casual players (4–8 h/month), and experienced players (> 15 h/month) and indicated an improvement of encoding speed to VSM seems to depend on the time devoted to gaming.

For limitation, it should be noted that participants reported pre- and post-home gameplay outcomes of the measurements during the COVID-19 pandemic. Several limitations should be noted. Firstly, observations were not obtained in the controlled laboratory environment. However, the experimental design of the present study has high ecological validity which increases the practical aspects of the study as young individuals usually engage in playing mobile games at home. Secondly, the major limitation of this study was that using online neuropsychological assessments, i.e., SCWT and VSMT. Therefore, the results of cognitive function and visual short-term memory are necessary to confirm using standard tests. Lastly, the relatively small sample size may not be representative of the characteristics of the broader population of university students. Further studies are required to determine the long-term effects of playing a battle mobile game on physiological and psychological responses in expert gamers.

Conclusions

In summary, either short or long-duration playing the battle mobile game could elicit HR responses. A short-duration gameplay may not affect stress response and cognitive function. Whereas the longer time spent playing the game, the higher the stress responses. VSM seems faster in non-gaming users who spent a long duration than a short duration playing the ROV game. Thus, in university students, when choosing mobile battle games as a choice of recreational activity, time spent playing games should be taken into account.

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References


