The Association between Physiopsychological Effects and the Types of Games among University Students

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ABSTRACT--- ***In these modern days, digital games have found potential ways in clinical care that have influenced the therapeutic methods and patients' rehabilitation. This study was aimed to compare the physiopsychological effects between two types of games, which are action and strategy, in iPad®. This cross-sectional study involved 50 students from the Faculty of Health Sciences, UKM. The types of games used were Asphalt 7 and Cut the Rope for action and strategy genres respectively. Finger pulse transducer, respiratory belt transducer, and sphygmomanometer were used to measure the physiopsychological signals, such as heart rate (HR), breathing rate (BR), and blood pressure (BP) respectively. The HR and BR outputs were recorded by Powerlab 4/26T and were visualised through LabChart 7 as the games were played, while the BP was measured before and after the games were played. Before both games, the mean for systolic BP (SBP) was 111.28±8.93 and 69.86±7.79 for diastolic BP (DBP). After playing Cut the Rope, the SBP decreased to 107.98±9.93 and showed no difference in Asphalt 7. The mean for HR while playing the strategy game (65.94±9.03) was slightly lower compared to while playing the action game (66.68±11.64). Meanwhile, the mean for BR for the strategy game was 17.64±2.28, whereas, for action game, it was 18.62±2.19. The results showed that there was a significant difference in the means of SBP between before and after playing the strategy game ($p<0.05$). The measurements of BR showed significant difference for both games ($p<0.05$). In conclusion, this study suggested that there was an increase in the BP, BR, and HR for the action game. More researches in this area should be conducted, especially in determining the effects of prolonged use of iPad® games on individuals.***

Keywords - Digital games, Heart Rate, Breathing Rate, Blood Pressure

1. INTRODUCTION

Digital games, generally known as video games, have always been used especially among the young adults (Wallenius et al. 2009). As time goes by, the digital games have become more promising and are further developed in the entertainment world (Mandryk &Atkins 2007; Nacke et al. 2011; Nenonen et al. 2007; Wallenius et al. 2009). Boyle et al. (2010) stated that as more games are developed, not only adults, but children and youth too will spend their time playing games. The advancement of technology, for example, video, computer, and virtual games have potential in influencing the therapeutic and rehabilitation methods used in health care, like occupational therapy (Asegaonkar 2009).

Digital games production has led researchers to understand reactions that occur while playing games, which has been seen as a potential communication between researchers, psychologists, and game designers to convince the society that is concerned about the harmful effects of digital games (Ravaja et al. 2006). Kurita (2009) has reported the effects of different genres of games that contained violence that were observed from the occurrence of physiological signals and emotions that were focused through sensitivity.

The effects of digital games, whether it is suitable to be used as a therapeutic tool, can be seen by monitoring the physiopsychological effects and cognitive measures that occurred. Cowley et al. (2013) looked into the psychological signal that took place, for example, to evaluate a player's experience while playing a serious game. According to Du (2008), the physiological data were used to analyse the subject's physiological response that occurred during the game play.

Cognitive refers to the ability of processing information, application of knowledge, and changing the behavioural tendencies (Nehlig 2010). Dye et al. (2009) stated that playing action games after training resulted in faster reaction time towards the cognitive task. In a study involving a group of action games players, the subjects were able to target the objects precisely in a field full of moving objects compared to a group of non-action games players (Green & Bavelier 2007).

Hence, this study was conducted to identify the relationship of the physiopsychological effects and the cognitive measures between two genres of games in iPad®. Specifically, the purpose of this study was to measure the average of the physiopsychological effects and cognitive measure that happened during both games and to compare the physiopsychological effects and the cognitive measures that occurred according to the demography factor.

2. MATERIALS AND METHODS

This study was a cross-sectional study and universal sampling was employed among the university students in Kuala Lumpur. The total number of subjects involved was 50 students; 16 males and 34 females. The personal details and the medical history of the subjects were obtained through questionnaire. The exclusion criteria were students with known medical history of epilepsy, brain injury, migraine, heart failure, lung diseases or psychiatric disorders like panic attack or depression. This study had been approved by the ethics committee of the university.

In this study, the games used were *Cut the Rope* for strategy genre, and *Asphalt 7* for action genre. The games were played through console device; iPad®. While the subjects were playing the games, physiopsychological effects, such as breathing rate (BR) and heart rate (HR), were taken into measure using respiratory belt transducer and finger pulse transducer respectively. These measurements were recorded using Powerlab 4/26T and were visualized through LabChart 7.

The task used for cognitive assessment was called Determination Test, which was assessed using the Vienna Test System panel. The Determination Test was conducted to measure the reactive stress tolerance, attention deficits, and reaction speed in the presence of rapidly changing and continuous optical and acoustic stimuli.

The subjects were given appointment and were provided with detailed information regarding the study. The subjects who agreed to participate were asked to provide their consent. Then, the subjects were asked to fill in a questionnaire regarding their background, the types of games that they usually played during leisure time, and the number of hours spent in a week playing games. After that, their BR and HR were measured using the respiratory belt transducer and finger pulse transducer respectively for about 5 minutes. Additionally, the baseline blood pressure (BP) was also measured using a sphygmomanometer.

The subjects played the strategy game for 20 minutes. Subsequently, their BR, HR, BP, and cognitive status were measured again. The subjects were given a 10-minute break before playing the second game that was the action game. The subjects played for 20 minutes, and the same parameters were measured again to determine the readings after the second game.

In both the strategy and action genres games, the subjects were needed to play only once for each game (Hebert et al. 2005; Skosnik et al. 2000). Besides, the period of time to play the games was only 15 to 20 minutes for both games, which was after an introduction of how to play the games, if needed (Drachen et al. 2010).

3. RESULTS

Table 1: Profile of the subjects

Parameters		N	Percentage (%)
Gender	Male	16	32.0
	Female	34	68.0
Course of study	Rehabilitation	24	48.0
	Health Science	16	32.0
	Health Care	5	10.0
	Others	5	10.0
Year of study	First	2	4.0
	Second	10	20.0
	Third	17	34.0
	Fourth	18	36.0
	Others	3	6.0

According to Table 1, 50 students, from a range of 20 to 23 years old, participated in this study. The participants were mostly female students (68%) in their fourth year (36%), and their course of study was rehabilitation (48%). Analyses were performed on the systolic, diastolic, BR, and HR for both games. These parameters were analysed using repeated measure ANOVA and paired t test.

Table 2: Comparison of systolic blood pressure for before and after the strategy game genre according to the demography data.

Data Demography		**Psychophysiology (Systolic Blood Pressure)**				
		n	Time	Mean ± SEM	*F* ratio	p-value
Gender	Male	16	Time 0	114.69 ± 11.28	4.306	0.043*
			Time 1	110.19 ± 6.73		
	Female	34	Time 0	109.68 ± 7.22		
			Time 1	106.94 ± 11.07		
Course of study	Rehabilitation	24	Time 0	107.63 ± 6.99	4.941	0.031*
			Time 1	106.63 ± 11.21		
	Heath Sciences	16	Time 0	113.56 ± 10.03		
			Time 1	107.50 ± 8.91		
	Others	10	Time 0	116.40 ± 8.20		
			Time 1	112.00 ± 7.79		
Year of study	Second	10	Time 0	109.20 ± 9.38	1.509	0.225
			Time 1	105.50 ± 8.70		
	Third	17	Time 0	110.24 ± 7.53		
			Time 1	108.71 ± 11.80		
	Fourth	18	Time 0	114.39 ± 10.26		
			Time 1	108.00 ± 7.87		
	Others	5	Time 0	107.80 ± 5.50		
			Time 1	110.40 ± 13.90		

ANOVA *repeated-measures* * $p < 0.05$

Table 3 : Comparison of diastolic blood pressure for before and after the strategy game genre according to the demography data.

Demography Data		**Psychophysiology (Diastolic Blood Pressure)**				
		n	Time	Mean ± SEM	*F* ratio	p-value
Gender	Male	16	Time 0	71.81 ± 8.29	0.135	0.715
			Time 1	70.25 ± 8.36		
	Female	34	Time 0	68.94 ± 7.49		
			Time 1	69.56 ± 11.80		
Course of study	Rehabilitation	24	Time 0	67.29 ± 6.93	0.021	0.885
			Time 1	68.29 ± 10.79		
	Heath Sciences	16	Time 0	71.19 ± 7.43		
			Time 1	69.13 ± 9.05		
	Others	10	Time 0	73.90 ± 8.75		
			Time 1	74.40 ± 12.77		
Year of study	Second	10	Time 0	66.40 ± 9.28	0.024	0.877
			Time 1	68.70 ± 9.50		
	Third	17	Time 0	69.59 ± 8.09		
			Time 1	71.12 ± 12.84		
	Fourth	18	Time 0	71.89 ± 6.25		
			Time 1	69.61 ± 9.38		
	Others	5	Time 0	70.40 ± 8.50		
			Time 1	68.00 ± 12.71		

ANOVA *repeated-measures*

Tables 2 and 3 display the measurement for the strategy game. As for systolic blood pressure, the rate was higher after playing the game among the female subjects from the rehabilitation course and especially among students from the

1st, 2nd, and 3rd years. There was a significant mean difference for the systolic blood pressure between the baseline and after the game for gender (F=4.38, p<0.05). There was also a significant mean difference between the baseline and after the game between courses (F=4.94,p<0.05).

Meanwhile, the results for systolic and diastolic blood pressures for the action game are presented in Tables 4 and 5. Table 4 indicates that the systolic blood pressure was higher after the action game for male from other courses, especially among the 3rd year students. However, there was no significant mean difference (p<0.05). Table 5 indicates that the diastolic blood pressure was higher after the game for both male and female students from all courses and all years, except the 2nd year students. However, there was no significant mean difference (p<0.05).

Table 4: Comparison of systolic blood pressure for before and after the action game genre according to the demography data.

Demography Data		**Psychophysiology (Systolic Blood Pressure)**				
		n	Time	Mean ± SEM	*F* ratio	p-value
Gender	Male	16	Time 0	114.69 ± 11.28	0.255	0.616
			Time 1	116.88 ± 10.27		
	Female	34	Time 0	109.68 ± 7.22		
			Time 1	108.74 ± 8.58		
Course of study	Rehabilitation	24	Time 0	107.63 ± 6.99	0.446	0.508
			Time 1	107.08 ± 7.25		
	Heath Sciences	16	Time 0	113.56 ± 10.03		
			Time 1	112.62 ± 9.92		
	Others	10	Time 0	116.40 ± 8.19		
			Time 1	119.50 ± 10.08		
Year of study	Second	10	Time 0	109.20 ± 9.38	0.293	0.591
			Time 1	106.00 ± 9.76		
	Third	17	Time 0	110.24 ± 7.53		
			Time 1	110.88 ± 7.87		
	Fourth	18	Time 0	114.39 ± 10.26		
			Time 1	114.17 ± 10.22		
	Others	5	Time 0	107.80 ± 5.50		
			Time 1	113.40 ± 12.76		

ANOVA *repeated-measures*

Table 5: Comparison of diastolic blood pressure for before and after the action game genre according to the demography data

Demography Data		**Psychophysiology (Diastolic Blood Pressure)**				
		n	Time	Mean ± SEM	*F* ratio	p-value
Gender	Male	16	Time 0	71.81 ± 8.29	3.558	0.065
			Time 1	74.69 ± 9.33		
	Female	34	Time 0	68.94 ± 7.49		
			Time 1	69.62 ± 8.51		
Course of study	Rehabilitatio n	24	Time 0	67.29 ± 6.93	3.583	0.065
			Time 1	68.00 ± 8.35		
	Heath Sciences	16	Time 0	71.19 ± 7.43		
			Time 1	72.13 ± 8.08		
	Others	10	Time 0	73.90 ± 8.75		
			Time 1	77.60 ± 8.98		
Year of study	Second	10	Time 0	66.40 ± 9.28	2.506	0.120
			Time 1	66.30 ± 10.14		
	Third	17	Time 0	69.59 ± 8.09		
			Time 1	71.12 ± 8.98		
	Fourth	18	Time 0	71.89 ± 6.25		
			Time 1	73.33 ± 7.98		
	Others	5	Time 0	70.40 ± 8.50		
			Time 1	74.00 ± 8.94		

ANOVA *repeated-measures*

According to Table 6, the HR was higher among the females and the 2nd year students for the strategy game. On the other hand, from Table 7 for action games, the HR was higher among the male students, and this was found to be significant (t=-2.183,p<0.05).

Table 6: Comparison of heart rate measurements in the strategy game with demography data

Demography Data		**Psychophysiology (Heart Rate)**			
		n	Mean ± SEM	t / *F* ratio	p-value
Gender	Male	16	65.13 ± 5.63	-0.053	0.598[a]
	Female	34	66.24 ± 10.45		
Course of study	Rehabilitation	24	66.04 ± 9.22	0.073	0.930[b]
	Heath Sciences	16	65.31 ± 8.62		
	Others	10	66.70 ± 10.07		
Year of study	Second	10	69.80 ± 9.64	0.823	0.488[b]
	Third	17	64.29 ± 9.03		
	Fourth	18	65.28 ± 9.07		
	Others	5	66.20 ± 7.92		

[a] Independent *t* test

[b] One-way ANOVA

Table 7: Comparison of heart rate measurements in the action game with demography data

Demography Data		**Psychophysiology (Heart Rate)**			
		n	Mean ± SEM	t / *F* ratio	p-value
Gender	Male	16	61.63 ± 10.23	-2.186	0.034*[a]
	Female	34	69.06 ± 11.64		
Course of study	Rehabilitation	24	69.83 ± 11.17	2.569	0.087[b]
	Heath Sciences	16	65.94 ± 12.46		
	Others	10	60.30 ± 9.38		
Year of study	Second	10	71.40 ± 14.11	1.326	0.277[b]
	Third	17	66.94 ± 9.60		
	Fourth	18	65.94 ± 11.73		
	Others	5	59.00 ± 11.27		

[a] Independent *t*-test

[b] One-way ANOVA

From Table 8, it can be noticed that the BR was higher among the male subjects from the rehabilitation course and among 4th year students for the strategy game. In Table 9, the BR for action game indicated slightly higher mean rate for males from rehabilitation course and 3rd year students.

Table 8: Comparison of breathing rate measurements in the strategy game with demography data

Demography Data		**Psychophysiology (Breathing Rate)**			
		n	Mean ± SEM	t / *F* ratio	p-value
Gender	Male	16	18.50 ± 2.94	1.586	0.128[a]
	Female	34	17.24 ± 1.79		
Course of study	Rehabilitation	24	17.42 ± 2.41	0.682	0.511[b]
	Heath Sciences	16	19.08 ± 2.32		
	Others	10	17.30 ± 2.21		
Year of study	Second	10	16.90 ± 1.66	0.587	0.627[b]
	Third	17	17.82 ± 2.86		
	Fourth	18	18.00 ± 2.09		
	Others	5	17.20 ± 1.92		

[a] Independent *t*-test

[b] One-way ANOVA

Table 9: Comparison of breathing rate measurements in the action game with demography data

Demography Data		**Psychophysiology (Breathing Rate)**			
		n	Mean ± SEM	t / *F* ratio	p-value
Gender	Male	16	19.19 ± 2.11	1.263	0.213[a]
	Female	34	18.35 ± 2.21		
Course of study	Rehabilitation	24	19.08 ± 2.32	0.682	0.511[b]
	Heath Sciences	16	18.63 ± 1.82		
	Others	10	17.50 ± 2.22		
Year of study	Second	10	18.60 ± 2.99	1.263	0.213[b]
	Third	17	18.82 ± 2.56		
	Fourth	18	18.50 ± 1.65		
	Others	5	18.40 ± 0.894		

[a] Independent *t* test

[b] One-way ANOVA

From Table 10, the comparison between the strategy and the action games indicated that there was a significant difference of BR for both games (t=-2.69, p<0.05). However, there was no significant mean difference of HR for both games.

Table 10: Comparison of heart rate and breathing rate between the strategy and the action games

Psychophysiology	Games genre	**Mean ± SEM**	***t***	**p-value**
Heart rate	Strategy	65.94 ± 9.03	- 0.404	0.688
	Action	66.68 ± 11.64		
Breathing rate	Strategy	17.64 ± 2.28	-2.699	0.010*
	Action	18.62 ± 2.19		

Paired *t* test * p<0.05

4. DISCUSSION

Digital games can be used as one of the psychotherapeutic methods for the youth and children, especially with mental health care (Ceranoglu 2001; Griffiths et al. 2003). The results showed that the most favourable genre chosen was the puzzle genre games. According to Lenhart et al. (2008), 72.0% of their subject also chose game with puzzle genre and only 67% of the subjects chose to play action games. Moreover, computers are still the most popular medium when it comes to playing digital games despite other devices like the iPad® or mobile phones. This is supported by Nacke and Craig (2010) who showed that 96% of the players were fond of their personal computers when playing games. Moreover, university students have better access to computers, as computer usage was more favourable in completing their study assignments compared to using tablets and smartphones.

This study suggested that male students played games for longer hours per day compared to female students. Funk et al. (2003), and Valadez and Ferguson (2012) also found that the males spent more hours playing games in a week than the females. Men spent an average of 9.26 hours per week to play games, as females played games only for about 3.48 hours per week (Valadez & Ferguson 2012).

This study showed that playing Cut the rope significantly caused lower systolic BP compared to playing Asphalt, which is an action game. This has been consistent with a follow-up study for 5 years among adults aged 20 years and above that showed that there was a significant increase in the systolic BP and the development of hypertension among adults who consistently played video games (Markovitz et al.1998).

Furthermore, the HR measured during Cut the Rope and Asphalt 7 showed an increment, but with no significant difference between both games. The results were supported by Mandryk et al. (2006) that proved that there was no correlation between HR and the players' subjective measures, such as stress. However, a study by Drachen et al. (2010) found that the ascending of the HR was able to prove that the players were in a stressful condition.

Besides, this study showed that the measurements of the BR increased significantly in Asphalt 7 compared to Cut the Rope game play. The rise of the BR was thought to be caused by emotional arousal, whereas the descending of the BR measurements was said to happen in a relaxed environment (Stern et al. 2001). Besides, a study carried out by

Mandryk and Inkpen (2004) showed that there was no significant difference in both HR and BR for the two different games played, and this might have happened due to the type of games chosen.

Thus, this study provides the idea and supports that action games, such as Asphalt 7, will influence one's physiological stress. The findings in this study indicated that the action game had shown an increment in the physiological parameters compared to the strategy game, especially in the systolic and diastolic BPs. Conversely, it showed that the action game did not influence the blood pressure of the subjects in this study, This results found in this study contrasts with the results conducted by Garre et al. (1998), which discovered a significant increase in the systolic blood pressure between techno and classical music groups.

5. CONCLUSION

Generally, the physiopsychological measures, like the systolic blood pressure and the BR, and also the cognitive measures, have a connection with the types of games played using the iPad®. As found in this study, an action game, Asphalt 7, can be used as a therapeutic method as it gave only a slight difference in the physiopsychological effect. All the changes in the physiopsychological measures were in a normal range for the youth. In further study, more researches should be conducted especially in determining the prolonged effect from the use of iPad® games on individuals. Besides, future studies should look into more extreme action games to identify any significant changes in the physiopsychological measures.

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7. REFERENCES

[1] Asmita Asegaonkar. 2009. Use of interactive video, computer & virtual-reality games in rehabilitation : A Systematic & Qualitative Review. Thesis Master of Science. State University of New York.

[2] Astrid Nehlig. 2010. Review Article : Is Caffeine a Cognitive Enhancer?. *Journal of Alzheimer's Disease* 20: 85-94

[3] Brezinka, V. & Hovestadt, L. 2007. Serious Games Can Support Psychotherapy of Children and Adolescents. *LNCS* 4799 : 357-364

[4] Buss, D. M. 2011. Evolutionary psychology: A new science of the mind. Boston, MA. Ceranoglu, T. A. 2010. Video Games in Psychotherapy. *Review of Journal Psychology* 14(2): 141-146.

[5] Drachen, A., Nacke, L. E., Yannakakis, G., & Pedersen, A. L. 2010. Correlation between Heart Rate, Electrodermal Activity and Player Experience in First-Person Shooter Games. *ACM* 49-54.

[6] Du, X. 2008. Can a videogame be used to learn biofeedback? http://summit.sfu.ca/item/9168 [25 September 2012].

[7] Dye, M. W.G., Green, S. & Bavelier, D. 2009. Increasing Speed of Processing With Action Video Games. *Current Directions in Psychological Science* 18(6): 321-326

[8] Feng, J., Spence, I. & Pratt, J. 2007. Research Report: Playing an Action Video Game Reduces Gender Differences in Spatial Cognition. *Psychological Science* 18 : 850-854

[9] Friedenberg, J., & Silverman, G. (2006). Cognitive science. An introduction to the study of the mind. Thousand Oaks, CA: Sage.

[10] Funk, J.B., Buchman, D.D., Jenks, J., & Bechtoldt, H. 2003. Playing violent video games, desensitization, and moral evaluation in children. *Applied Develpmental Psychology* 24 : 413-436

[11] Green, C.S. 2008. The Effects of Action Video Game Experience On Perceptual Decision Making. Tesis Ph.D. University of Rochester.

[12] Green, C.S. & Bavelier, D. 2007. Research Article: Action-video-game Experience Alters the Spatial Resolution of Vision. *Psychological Science* 18(1): 88-93

[13] Griffiths, M.D., Davis, M.N.O., & Chappell, D. 2003. Breaking the Stereotype: The Ease of Online Gaming. *Cyberpsychology & Behavior* 6(1):81-91

[14] Kurita, S. 2009. Playing violent and non-violent video games : Physiological and emotional responses as a function of motivational activation. Tesis Ph.D. Indiana University

[15] Kutner & Olson 2008. Grand Theft Childhood. New York: Simon & Schuster, Inc.

[16] Lenhart, A., Kahne, J., Middaugh, E., MacGill, A., Evans, C., & Vitak, J. (2008). Teens,video games and civics: Teens gaming experiences are diverse and include significant social interaction and civic engagement. *Pew Internet & American Life Project*. Retrieved from http://www.pewinternet.org/Reports/2008/Teens-Video-Games-and-Civics.aspx

[17] Mandryk, R.L. & Inkpen, K.M. 2004. Physiological Indicators for The Evaluation of Co-located Collaborative Play. *ACM*

[18] Mandryk, R. L. & Atkins, M. S. 2007. A Fuzzy Physiological Approach For Continuously Modeling Emotion During Interaction With Play Technologies. *Int. J. Human-Computer Studies* 65: 329-347

[19] Markovitz, J. H., Raczynski, J.M., Wallace, D., Chettur, V. & Chesney, M. A. 1998. Cardiovascular Reactivity to Video Game Predicts Subsequent Blood Pressure Increases in Young Men: The CARDIA Study. *Psychosomatic Medicine* 60:186-191.

[20] Nacke, L.E., Kalyn, M., Lough, C., & Mandryk, R.L. 2011. Biofeedback Game Design: Using Direct and Indirect Physiological Control to Enhance Game Interaction. ACM: Canada

[21] Nenonen, V., Lindblad, A., Hakkinen, V., Laitinen, T., Jouhtio, M., & Hamalainen, P. 2007. Using Heart Rate to Control an Interactive Game. *ACM* : 853-856.

[22] Ravaja, N., Saari, T., Salminen, M., Laarni, J., & Kallinen, K. 2006. Phasic Emotional Reactions to Video Game Events: A Psychophysiological Investigation. *Media Psychology* 8 : 343-367.

[23] Sherry, J. L. 2004. Flow and media enjoyment. *Communication Theory* 14 : 328–347.

[24] Valadez, J.J. & Ferguson, C.J. Just A Game After All: Violent Video Game Exposure And Time Spent Playing Effects On Hostile Feelings, Depression And Visuospatial Cognition. *Computers in Human Behavior* 28:608-616.

[25] Wallenius, M., Rimpelä, A., Punamäki, R. & Lintonen, T. 2009. Digital game playing motives among adolescents: Relations to parent–child communication, school performance, sleeping habits, and perceived health. *Journal of Applied Developmental Psychology* 30: 463-474.