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A Study of the Influences of Screen Sizes and Viewing Distances on the Performance of Nintendo Wii

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Abstract: Nintendo Wii is one of current most popular indoor recreational activities. The birth of Wii brought with it a new form of game machine that has had a major impact on the world of information technology industry. Because it combines the characteristics of recreation, leisure and interaction, the customer can both pursue exercise and experience virtual reality simultaneously. Wii need to connect to TV screen and also need a large room to play, so most of families put it in the living room. However, every family's living room size and the TV screen size are quite different. Therefore, this study aimed to evaluate the effect of screen size and viewing distance on game performance and subjective rating and providing the user with a reference for choosing proper screen. This research adopts three different size screens and three different viewing distances to simulate all activities. Fifty participants are recruited to play the Wii. Each individual's score and subjective rating are recorded with consideration of the influence of gender and age. By the experimental results, it is found that both screen size and viewing distance are the factors affecting game performance. Bigger screen and farther viewing distance lead to higher game performance and subjective ratings, but the participant's fundamental data, such as age, gender, experience, frequency and response ability, have no any influences on game performance.

Key words: Wii, screen size, viewing distance, performance, subjective rating

INTRODUCTION

Following the development of game technology, there are a lot of game machines in the current market, such as small size screens for portable game console (like NDSL and PSP) and mobile phone (Balakrishnan and Yeow, 2008), or using the bigger size monitors like PC from home or cybercafe to play the single user game or online game (Kalliny and Gentry, 2010). However, the TV connecting with game machine is the most popular way for playing the game since one can just insert game disc and then play. On the other hand, the screens for handheld games or cellular phone are so small that can be easily carried out to play, but they might damage to our vision or possibly induced other symptoms (Bos *et al*., 2010; Botella *et al*., 2011). This is because the game user always sits down before a computer screen and manipulates the mouse of the computer causing lack of mobility of the whole body. In addition, traditional game machines are connected to TV screen by cable and were then controlled by a wired controller to play the games. The way of operating is somewhat inconsistent with the real movement resulting in loss of sense of participation. Therefore, in order to generate more funs, current development tendency for game machines must include body movement with virtual reality (Kampiotis and Theodorakou, 2003), such as Nintendo Wii and XBOX Kinect. They are both the human motion sensing devices (Hsu, 2011). Wii started his idea in 2001 and commercialized his product in 2006 (Butler and Willett, 2010) which was much earlier than XBOX Kinect. The main characteristics of Wiimote are to apply the technology of gyroscope for wireless control (Daud *et al*., 2011). The players use the Wiimote to allow

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the user simulating the actual game movement in order to generate sense of participation (Cheong *et al*., 2010). Another advantage is one can play the game in his home computer screen or liquid crystal projector. It is noted that the projector screen is much bigger than computer screen and the user can keep a suitable distance away from the screen. However, there are few studies investigating the effect of the bigger screen and farther distance on game performance. Hence, this study aims to dig out the effect of different sizes of the screen and the distance between the user and the screen on the Wii game performance.

In general, the proper distance between human eyes and TV should be 3-4 times the width of the TV (Lee, 2012), but the distance between human eyes and computer screen should maintain 50-70 cm. However, users will close to TV screen unconsciously while playing the games. Based on regular viewing distance for the game machine, several data can be obtained for comparing a standard 42 inch TV to 21 inch computer screen (the ratio of width to height is 16: 9):

- **TV:** Forty two inch (width of 0.9 m) viewing distance 2.7 m = 15.6
- **Monitor screen:** Twenty one inch (width of 0.46 m) viewing distance 0.5 m = 42

The greater the value, the visual perception is greater. Hence, if we want to get better visual perception under fixed monitor size condition, we need come closer to the monitor. The game player will also have the same attitude to close to the screen. But traditional TVs always have lower resolution especially when the viewing distance is less and less. That means the human eyes are closer to TV, the image quality becomes worse resulting in generating visual pressure which is disadvantageous to game performance (Fisher, 1977; Shieh and Lee, 2007). On the other hands, human eyes in general have a view angle of 120 degree. As the distance between eyes and screen is farther and farther, the more things are seen by the viewer which can generate vision deviations resulting in distraction. Moreover, the viewing angle will be less if the distance from screen is farther and farther. The image becomes unclear (Lee, 2012) which will influence the performance of games. Therefore, maintaining suitable vision distance will have an effect on increasing game performance.

Beside viewing distance, screen size is also one of important factors. Lombard and Ditton (1997) compared three sizes of screen (10, 26 and 42 inch) and determined the preference by the users. They concluded that bigger size screens are more popular than smaller size screens and can excite viewer's emotional arousal (Lombard *et al*., 2000) and memory more deeply (Detenber and Reeves, 1996). However, the user will normally adjust his suitable distance to match up screen size (Hou *et al*., 2012). This means that the distance would be larger when screen sizes are bigger and vice versa. So the screen size and viewing distance are in fact indivisible. However, it is worthy investigating the relationship between game performance and subjective cognition with a combination of similar ratio of screen size to viewing distance.

However, there are some studies just aiming at discussing TV watching (Nazari *et al*., 2009), the preference of screen and multimedia (Lee, 2012), or fatigue (Bullough *et al*., 2006; Ukai and Howarth, 2008) in several screen size and viewing distance related researches. Some are aiming at possible induced symptoms for small handheld games (Bos *et al*., 2010) or cellular phone games (Botella *et al*., 2011). Fewer studies discussed the game performance for bigger screen size. Therefore, this study will focus on investigating the effect of screen size, viewing distance and the ratio of screen size to viewing distance on Wii game performance and subjective cognition. In addition, gender, ages and game experience are also our key study points.

MATERIALS AND METHODS

Participants: Fifty people were surveyed for performing experiment, twenty-five male and twenty-five female college students. The age of participants ranged from 16-22 years with naked vision or corrected visual acuity being greater than 0.9. All participants should be very familiar with the Nintendo Wii operating interface and good control of the Wii. The participants were requested to take a simple response ability test. The details are as follows:

- Each participant used his upper arm nature sagging, forearm stretch horizontally and palm inward, then separated his thumb and index finger for about 3 cm
- A research assistant placed a length of 60 cm ruler on participant's thumb and index finger and adjusted its 0 scale position to start with thumb
- Suddenly let ruler drop. The participant tried his best to grasp this ruler
- Recorded the scale of the ruler
- Repeated the above procedure five times and recorded data

Apparatus: This research mainly adopted the "Shooting Range" in "Wii Play" as an object of our study. The game included five passes as shown in Fig. 1. Goals were balloon, target, can, clay target and UFO. Players used

Fig. 1: The game of "shooting range" in "Wii play"

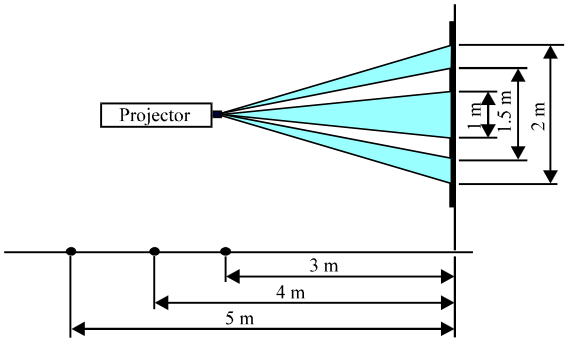

Fig. 2: The different screen sizes and viewing distances

remote controller to aim at the targets on the screen and then pushed B button to shoot down the targets. If more targets were shot, the scores were higher; if the wrong targets were shot down, some points would be deducted. This research used EPSON EMP-82 LCD projector and 70 in H70 in screen to pursue our study. By adjusting projecting distance and projector's focus, an appropriate image size could be obtained. Although, we used LCD projector to display game image, there was no need to turn off the light due to the brightness of projection (ANSI 2000 lumen). The illumination, temperature, relative humidity and background noise during the measurement and survey were 750.5 (±53.69) lux, 25.3 (±1.2)°C, 52.1 (±3.2)% and 67.3 (±4.1) dB (without Wii), respectively.

Experimental design: The independent variables in this study are shown in Fig. 2. There were three different screen sizes (1, 1.5 and 2 m of diagonal length) and three different viewing distances (3, 4.5 and 6 m), thereby formed a two factor experiment.

Dependable variables were the scores of the game playing. Research assistant would ask all participants about their subjective rating, such as controller maneuverability, eye fatigue, viewing definition...etc, so as to understand the correlation among them. The experimental procedure for this study is as follows:

- Notified each participant to know the objective and procedure of this experiment and tested their response ability
- Let each participant play the game for two minutes to get with screen size and distance before pursuing the experiment
- Participants randomly took turns in the playing the nine preset game conditions. Recorded the scores for each condition and asked the participant to fill out the questionnaire regarding subjective rating

Data analysis: The score and corresponding subjective rating was analyzed and discussed. Starting from descriptive statistics, the best suitable screen size and viewing distance could be determined by comparing their corresponding score and subjective rating for the above nine conditions. Then analysis of variance was conducted to determine the effect of each factor on game performance and subjective rating. If there exists significant difference, Fisher's Least Significance Difference (LSD) tests could be used to find out the source of the difference. Finally, by using Pearson's and Spearman's rank correlation coefficients, the correlation between game performance and subjective rating could be obtained.

RESULTS

Scores: There were three kinds of screen size which were 1, 1.5 and 2 m and three kinds of viewing distance which were 3, 4.5 and 6 m using in this study. Participants were randomly assigned to play Wii game under various combinations of screen size and viewing distance, the resulting average score and its deviation were shown in Table 1. It was noted that the highest average score (367.13) happened at the combination of 2 m screen size and three different viewing distances, but the lowermost score (324.28) happened at the combination of 1 m screen size and three different viewing distances. In addition, it was also noted that the highest average score (354.63) happened at the combination of 6 m viewing distance and three different screen sizes, but the lowermost average score (339.36) happened at the combination of 3 m viewing distance and three different screen sizes. Furthermore, there was a tendency that the bigger the

screen size the score would be higher as we could see in Table 1. The score also became higher with increasing the distance when the screen sizes were bigger than 1.5 m.

Based on the two way ANOVA result, it was revealed that screen size ($F = 22.24$, $p<0.001$) and viewing distance ($F = 3.07$, $p = 0.047$) were the significant factors that affect the game performance. There was no significant interaction effect of screen size and viewing distance ($F = 0.80$, $p = 0.524$). The game performance was significant lower when the screen size less or equal than 1 m, but the game performance for 6 m viewing distance was much better than 3 m. The main reason maybe because the participant felt that it was more maneuverable with farther distance. Near distance would make the participant more uncomfortable to use the remote controller and could not see the whole screen clearly which lower the average score.

The influences of apparatus' feature: For investigating the effect of each fundamental data on game performance, each data is divided into several categories shown as below:

- **Age:** Below 18, 18-20 and above 20
- **Gender:** Male and female
- **Experience:** Less than one month, 1-5 months, more than 6 months
- **Frequency:** Less than 5 times per month, 6-15 times per month, more than 16 times per month
- **Response ability:** Less than 10 cm, 10-20 cm and more than 20 cm

Table 1: The average and standard deviation of scores among different combinations of screen sizes and viewing distances

Screen size (m)	Viewing distance (m)	S/D	Average score	Standard deviation
1.0	3.0	1/3	320.92	56.00
	4.5	2/9	329.24	52.74
	6.0	1/6	322.68	50.72
1.5	3.0	1/2	346.76	51.86
	4.5	1/3	353.56	59.28
	6.0	1/4	363.82	60.33
2.0	3.0	2/3	350.40	83.77
	4.5	4/9	373.58	39.48
	6.0	1/3	377.40	50.90

S: Screen size, D: Viewing distance

Fundamental data in this study was treated as independent variables and the game performance was treated as dependent variable. With combination of different size and distance, one-way ANOVA is performed. The results were shown in Table 2. As we could see from the table, each fundamental data had no significant influence on game performance. Therefore, the participant attribute could not be a decisive factor in this experiment.

Subjective rating: The subjective rating questionnaire in this study totaled nine questions as shown in Table 3. Each question the participants were requested to provide a subjective rating on 5-point scale to indicate their level of satisfaction which were Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) and Strongly agree (SA). Table 3 showed the subjective rating including average point and standard deviation for each question under various combinations of size and distance. The results showed that the bigger the screen size the higher the scores were for each question. In addition, the scores at visual distance of 3 m were normally lower than the others.

By performing ANOVA, Table 4 showed the effect of screen size and viewing distance on subjective rating. For the screen size item, all questions reached level of significance ($p<0.05$), meaning that screen with bigger size had higher perception. The possible reason was the space for maneuvering was quite enough, so it was very easy to use and play. The factor of viewing distance reached level of significance only for "How do you feel your performance?" and "Do you feel you can catch up with the speed of the game?" However, the LSD method suggested that the performance was worse at the distance of 3 m. The possible reason was that you would feel the object moving so faster that you could not catch up with it. Also, the space was so small that affected the game performance as well.

Table 2: The influences of apparatus' features on performances of different screen sizes (S) and viewing distances (V)

		Age		Gender		Experience		Frequency		Response ability	
S (m)	V (m)	f-value	p-value	f-value	p-value	f-value	p-value	f-value	p-value	f-value	p-value
1.0	3.0	2.26	0.116	0.04	0.850	2.72	0.076	0.70	0.500	0.04	0.957
	4.5	1.38	0.262	0.12	0.727	2.25	0.117	1.55	0.223	0.68	0.511
	6.0	3.70	0.032*	0.13	0.725	2.52	0.091	0.90	0.414	0.53	0.589
1.5	3.0	2.02	0.144	0.41	0.525	0.15	0.861	0.00	0.999	1.31	0.278
	4.5	2.46	0.096	0.24	0.625	2.06	0.138	1.09	0.343	0.41	0.668
	6.0	0.97	0.385	0.02	0.888	0.41	0.668	0.08	0.919	1.55	0.223
2.0	3.0	0.57	0.569	0.22	0.639	0.34	0.713	1.68	0.197	0.25	0.781
	4.5	0.54	0.587	0.87	0.355	1.68	0.197	4.77	0.013*	1.10	0.341
	6.0	0.12	0.886	0.00	0.948	2.14	0.128	0.42	0.657	0.38	0.686

*$p<0.05$

Table 3: The subjective rating averages and standard deviations (SD) of different screen sizes (S) and viewing distances (V)

	S (m)	1			1.5			2		
Questions	V (m)	3	4.5	6	3	4.5	6	3	4.5	6
Can you clearly see the image on the screen?	Average	3.16	3.32	3.06	3.38	3.28	3.52	3.38	3.58	3.34
	SD	0.89	0.65	0.77	0.70	0.67	0.74	0.70	0.67	0.80
Can the object be easily targeted?	Average	2.92	3.24	3.20	3.26	3.32	3.46	3.56	3.60	3.68
	SD	1.03	0.77	0.99	0.88	0.87	0.91	0.76	0.78	0.84
Can the cursor be easily maneuvered?	Average	2.76	3.02	2.76	3.18	3.40	3.48	3.56	3.72	3.56
	SD	0.96	0.82	1.00	0.83	0.86	0.86	0.84	0.88	0.88
Do you understand the contents and objectives of the game?	Average	3.32	3.42	3.48	3.44	3.60	3.70	3.74	3.84	3.92
	SD	1.04	0.78	0.76	0.76	0.76	0.81	0.75	0.74	0.78
Do you feel interested in playing this game?	Average	2.98	3.16	3.00	3.08	3.18	3.60	3.56	3.56	3.46
	SD	1.13	0.77	0.97	1.01	0.69	0.93	0.99	0.95	0.99
Is it easy to play for a beginner?	Average	2.86	3.04	2.98	3.36	3.52	3.66	3.52	3.70	3.60
	SD	1.16	0.95	1.08	0.80	0.81	0.72	0.86	0.74	0.73
How do you feel your performance?	Average	2.58	2.80	2.88	3.16	3.46	3.42	3.42	3.64	3.60
	SD	1.16	0.88	1.14	1.00	0.81	0.86	0.86	0.92	0.83
Do you feel comfortable with such a distance and screen size?	Average	2.92	2.86	2.90	3.30	3.50	3.64	3.74	3.72	3.76
	SD	1.21	1.01	1.20	0.99	0.81	0.69	0.69	0.64	0.74
Do you feel you can catch up with the speed of the game?	Average	2.64	2.78	2.84	3.10	3.28	3.58	3.46	3.60	3.62
	SD	1.01	0.89	0.96	0.95	0.81	0.88	0.79	0.93	0.70

Table 4: The ANOVA of screen sizes and viewing distances on subjective ratings

	Screen size			Viewing distance			Interaction	
Questions	f-value	p-value	LSD#	f-value	p-value	LSD^	f-value	p-value
1	5.16	0.0060*	2>1.5>1	0.70	0.499	-	1.89	0.111
2	11.97	<0.001*	2>1.5>1	2.07	0.128	-	0.43	0.789
3	29.25	<0.001*	2>1.5>1	2.19	0.113	-	0.67	0.610
4	10.71	<0.001*	2>1.5, 1	2.36	0.096	-	0.06	0.994
5	9.68	<0.001*	2>1.5>1	0.93	0.397	-	2.03	0.089
6	23.42	<0.001*	2, 1.5>1	1.85	0.159	-	0.32	0.862
7	28.77	<0.001*	2, 1.5>1	3.38	0.035*	6, 4.5>3	0.10	0.983
8	33.85	<0.001*	2>1.5>1	0.59	0.552	-	0.62	0.649
9	33.01	<0.001*	2>1.5>1	3.78	0.024*	6>3	0.58	0.680

*p<0.05, LSD#: "2>1.5, 1" means that the score of "2 m (screen size)" is higher than the others significantly, LSD^: "6>3" means that the score of "6 m (viewing distance)" is higher than "3 m" significantly

Table 5: The distribution of game scores and subjective rating of each question

	Q1		Q2		Q3		Q4		Q5	
Rating	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
SD	286.8	21.41	320.9	71.97	323.8	50.25	237.5	84.15	349.3	51.04
D	336.5	58.57	339.2	59.08	337.4	54.87	331.7	60.80	341.1	66.43
N	345.2	58.03	344.3	58.31	353.8	60.58	338.9	59.42	346.8	55.22
A	350.6	60.93	354.9	62.38	347.9	63.67	353.8	58.45	349.7	62.42
SA	396.9	56.87	362.1	45.51	362.2	51.12	372.4	56.04	363.6	70.57
ANOVA	f-value	p-value	f-value	p-value	f-value	p-value	f-value	p-value	f-value	p-value
	6.11	<0.001*	2.07	0.084	2.06	0.085	6.19	<0.001*	0.78	0.536
LSD#	1 < 3, 4, 5						1 < 2, 3, 4, 5			
	5>1, 2, 3, 4						5>4>1, 2, 3			

	Q6		Q7		Q8		Q9	
Rating	Average	SD	Average	SD	Average	SD	Average	SD
SD	329.3	64.42	336.3	58.06	337.1	59.63	344.9	48.97
D	335.7	60.98	343.9	66.71	321.3	54.41	332.7	62.59
N	344.5	61.41	349.5	54.60	351.6	56.28	355.1	54.29
A	357.2	53.38	349.8	64.44	356.3	54.37	346.8	66.78
SA	354.8	75.79	362.6	48.67	350.3	89.92	360.7	55.76
ANOVA	f-value	p-value	f-value	p-value	f-value	p-value	f-value	p-value
	2.29	0.059	0.85	0.495	4.24	0.002*	2.32	0.056
LSD#			2<3, 4, 5					

*p<0.05, #LSD: "5>1, 2, 3, 4" means that the score of "Strongly agree" is higher than the others significantly

Table 5 not only showed the average game score and its standard deviation of the subjective rating for each question, but also compared their subjective rating difference by ANOVA, during which all the measures

Table 6: The Pearson's and Spearman's rank correlation coefficients of scores and subjective ratings

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Pearson	0.185	0.132	0.094	0.212	0.059	0.132	0.077	0.138	0.076
p-value	<0.001*	0.005*	0.046*	<0.001*	0.213	0.005*	0.103	0.003*	0.106
Spearman	0.172	0.123	0.108	0.201	0.083	0.156	0.066	0.156	0.084
p-value	<0.001*	0.009*	0.022*	<0.001*	0.077	0.001*	0.165	0.001*	0.073

* $p<0.05$

reached the level of significance ($p<0.05$) for 1, 4 and Q 8. Basically, the higher the subjective rating for 1, 4 and Q 8, the more score participants would get which were direct influence factor. All other questions did not reach the level of significance, but had similar tendency. In addition, by calculating Pearson's and Spearman's rank correlation coefficients as shown in Table 6, it showed a significant correlation between the subjective ratings and game scores for all questions except 5, 7 and Q 9. This result was quite similar with the above discussion. Therefore, there was a certain amount of correlation between subjective rating and game score.

DISCUSSION

By the result of the experiment of this study, the bigger the screen size, the higher the score is achieved. The corresponding subjective rating is also higher. Hence, the screen size has significant influence on Wii game. It is also noted that all participants like to use bigger screen size and get significant higher scores while maintaining the same viewing distance. Lombard and Ditton (1997) ever made a comparison for smaller size, but he reached similar results. In general, game user can clearly control all game details with the bigger screen and he won't miss any small object during playing the game and thereby getting higher game performance and subjective ratings. However, we can't make any advancement for game performance and subjective rating due to the limitation of screen size (70×70 inch). But if we can make bigger screen, there may exist a so-called inflection point resulting in decreasing game performance which is another issue for further study.

In the aspect of viewing distance, different viewing distances generate different game performance, but the subjective rating reaches level of significance just for a few questions. It appears that the game performance at 3 m viewing distance is slightly lower. The possible reason is because the shorter distance will make game user more uncomfortable and the object moving on the screen also make the game user feel it moves faster than that at farther distance due to the speed stress effect. On the other hand, slight changing angle at shorter viewing distance will cause the cursor move a lot on the screen since Wii Remote has a difficulty to make a fine adjustment movement to accurately hit the target. As regards the viewing distance between 4.5 and 6 m, there are no big difference for game performance and subjective rating. But for farther viewing distance, there is a need for further discussion. Moreover, it is surveyed from Table 1 that there are three places where the Screen size/Viewing distance are all equal to 1/3, but there are indeed significant difference in scores. So the user can automatically adjust his distance away from the screen to match up the size of the screen. That is bigger screen size with farther distance and smaller screen size with nearer distance (Hou *et al*., 2012). However, we cannot use this simple ratio to explain their relationship. Furthermore, the XBOX Kinect applied the advanced technology to detect the movement of human hand efficiently (Gongbo *et al*., 2012). The related results could then be compared with each other.

CONCLUSIONS

In this study, the screen size and viewing distance are the two significant factors affecting game performance and subjective rating, during which the screen size is most significant factor. From current technology, there is limitation on home TV screen size and resolution. So the game user must adjust the distance away from the screen in order to clearly see the details of the game. However, too small screen size and too near distance will significantly affect the game performance as discussed in the aforementioned. But following the technology advancement, we are expecting much bigger size of LED TV or Projector with very high resolution will be developed. Therefore, using big screens with high resolution for playing the game is a current trend because their game performance and subjective rating are better than any traditional small screen TV or Projector. However, increasing the size of desktop computer screen does not mean that it can increase the operating efficiency. So the upper size limit for screen is worthwhile for further study. This study was aimed to evaluate the effect of screen size and viewing distance on game performance and viewing distance. LCD projector is utilized to simulate three different size screens (1-2 m) and three different viewing distances (3-6 m). Participants' age ranged from 16 and 22 all with normal vision (0.9~). For the future study, actual TV screen or even bigger screens and

farther viewing distance will be adopted to perform more experiments. Participants with different age/generation groups and with different visions can be also hired. Vision fatigue and some symptom related risk evaluation may be introduced to establish the standard for defining most suitable screen size and viewing distance.

REFERENCES

Balakrishnan, V. and P.H. P. Yeow, 2008. Hand anthropometry and SMS satisfaction. J. Applied Sci., 8: 816-822.

Bos, J.E., S.C. de Vries, M.L. van Emmerik and E.L. Groen, 2010. The effect of internal and external fields of view on visually induced motion sickness. Applied Ergonomics, 41: 516-521.

Botella, C., J. Breton-Lopez, S. Quero, R.M. Banos, A. Garcia-Palacios, I. Zaragoza and M. Alcaniz, 2011. Treating cockroach phobia using a serious game on a mobile phone and augmented reality exposure: A single case study. Comput. Hum. Behav., 27: 217-227.

Bullough, J.D., Y. Akashi, C.R. Fay and M.G. Figueiro, 2006. Impact of surrounding illumination on visual fatigue and eyestrain while viewing television. J. Applied Sci., 6: 1664-1670.

Butler, D.P. and K. Willett, 2010. Wii-habilitation: Is there a role in trauma?. Injury, 41: 883-885.

Cheong, S.N., W.J. Yap and M.L. Chan, 2010. Design and development of a cost effective Wiimote-based multi-touch teaching station. Inform. Technol. J., 9: 589-594.

Daud, H., N. Yahya and R. Harun, 2011. Wireless control mechanism for EM source and receiver positioning for offshore application. J. Applied Sci., 11: 1087-1095.

Detenber, B.H. and B. Reeves, 1996. A bio-informational theory of emotion: Motion and image size effects on viewers. J. Commun., 46: 66-84.

Fisher, R.F., 1977. The force of contraction of human ciliary muscle during accommodation. J. Physiol., 270: 51-74.

Gongbo, C., G. Hongbin, W. Dongsu and S. Jin, 2012. A research on hand position detection by camera array. Inform. Technol. J., 11: 110-117.

Hou, J., Y. Nam, W. Peng and K.M. Lee, 2012. Effects of screen size, viewing angle and players? immersion tendencies on game experience. Comput. Hum. Behav., 28: 617-623.

Hsu, K.S., 2011. Application of a virtual reality entertainment system with human-machine sensor device. J. Applied Sci., 11: 2145-2153.

Kalliny, M. and L. Gentry, 2010. Marketing in the 22nd century: A look at four promising concepts. Asian J. Market., 4: 94-105.

Kampiotis, S. and K. Theodorakou, 2003. Virtual reality in the teaching of motor skills: Literature review. J. Applied Sci., 3: 36-39.

Lee, D.S., 2012. Preferred viewing distance of liquid crystal high-definition television. Applied Ergon., 43: 151-156.

Lombard, M. and T. Ditton, 1997. At the heart of it all: The concept of presence. J. Comput-Media. Comm., Vol. 3, 10.1111/j.1083-6101.1997.tb00072.x.

Lombard, M., R.D. Reich, M.E. Grabe, C.C. Bracken and T.B. Ditton, 2000. Presence and television. Human Commun. Res., 26: 75-98.

Nazari, M.R., A.H. Hasbullah, S. Parhizkar, A.R. Shirazi and H. Marioriad, 2009. The impact of visuals: Using television program to transform environmental health concepts to people. J. Applied Sci., 9: 2619-2624.

Shieh, K.K. and D.S. Lee, 2007. Preferred viewing distance and screen angle of electronic paper displays. Applied Ergon., 38: 601-608.

Ukai, K. and P.A. Howarth, 2008. Visual fatigue caused by viewing stereoscopic motion images: Background, theories and observations. Displays, 29: 106-116.