Traces Of The Brain's Learning Potential Present Within "Uneducational" Video Games

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Abstract. Video games, especially in mobile devices, have the reputation of being negative to the mass consumer. They are thought to be addictive, mind-numbing time waster. But is that really true? A study has been conducted to analyze video games design styles based on neuro-affective computational model using electroencephalogram (EEG). Although the objective is to classify abstract and realistic design styles, a different off-topic materials have been discovered. During the data collection, subjects completed an aptitude test using an online instrument provided by the Cambridge University's Brain Lab. The EEG instruments recorded specific brain functions (cognitive, memory, verbal, creativity) separately. After classifying the data with emotional response, each brain functions give unique valence versus arousal scatter plot. What is interesting, however, is that when all of them plotted together in a single chart, they form a pattern similar to the data collected for playing video games. Could it possibly be that playing video games indeed stimulate specific brain functions? Or are these similarities in valence versus arousal plots just plain coincidences? A future research designed for brain function correlation using other model than emotions can confirm these findings. But for now, the consistency of these findings for all the subjects are hard to ignore.

1. Introduction

Educational value in video games is nothing new. Many production studios already made educational video games that are designed to educate the end users – who are the players – with a specific topic. Most educational video games are designed to combine educational philosophy and game design principles. Such games range from spelling activities to mathematical challenges. Games like these are known as educational games. Most of the time, they are categorized as edutainment games.

Video games outside the edutainment category, however, are perceived to have no educational values [2]. They are designed purely for entertainment and fun. Such games can be a good time-killer for some situations such as during long hours of commute in a public transportation. Due to the big impressions that these games serve nothing but pure enjoyment, some people think that they are time waster. Such negative perception gave these kind of video games a bad reputation of being destructive to the society[15].

Despite the mixed views of their place in the society, video games are something that no one can ignore. While non-educational games were never intended to be educational, there are published articles that use these kinds of games to stimulate children learning [2], [4], [5]. Such research findings provoke questions whether video games have any psychological effect to the human mind/brain. Are there any

correlation between non-educational video games and learning activities? Can something that was designed purely for enjoyment can be valuable to the growth and potential of the brain?

2. Previous Works

Diving into details of the games used for experiments in the psychology of the human mind, it is startling that quite a lot of these researches use non-educational games. One of the most significant one is done by Franceschini [8] who applied action video game as a training medium to improve dyslexic children's literacy ability. The game being used is called *Space Invader* which is a 2D platform shooter with no literacy elements whatsoever. Training those children by playing *Space Invader* results in improved literacy performance. In fact, it is also claimed that action video games can actually cure dyslexia. The author did not specify why that particular game was chosen. The only criteria were that the game was chosen because it falls under the genre category.

Video games related researches are many and each has a different approach. Nevertheless, most that studied their relationship to the human psychology always found that video games have an effect on the player's mind regardless whether they are educational by design or not [2]. Their influence over the human psyche is too consistent to be assumed as coincidental. Although these video games were never meant to be educational, those researches that found it to be a 'wonder tonic' that cures psychological symptoms and boost learning potential [7], [9] are too significant to be ignored.

Those findings by other researches support the claims that video game is a medium that stimulates the mind. And it opens a huge question as to whether they have any correlation at all with specific brain's cognitive functions and their performance. A question that this paper is not to answer yet, but to reveal traces and evidences of specific learning aptitude might be present during a game play session.

3. Data Collection and Analysis

The research that this document discusses is a research to analyze two different design styles common in all video games production. The scope of the analysis is the classification of the design styles with the player's emotional state. To be able to measure emotions and apply computational models and algorithm for classification, the approach of using electroencephalogram (EEG) was proposed. By recording the brainwave signals of the player during a game play, quantitative analysis can be applied.

It must also be noted that the games chosen for this experiment has met the criteria to avoid data noise. Any attributes that can contribute to false signals or noise have been taken into account. For instance, game mechanics that are too complicated may disturb the experience factor between experienced and non-experienced players. The sounds are switched off so that the background music will not interfere with the data emotions stimulated by the video game designs. Most important of all, the video games used are not designed to be educational or put the players into any kinds of learning activities.

The concept of the data collection is simple. EEG data while playing video games was recorded so that it can be classified with a known model. In this case, the emotional model is used. Prior to the game play session, the player is exposed – and the EEG signals recorded – with emotional stimulant. The stimulated emotions of the player were recorded to serve as a working model so that the unknown signal during game play can be classified. After the emotional stimuli was administered, however, an added bonus of learning aptitude test was added just before the game play. Figure 1 is the overall flowchart of the data collection process.

Once the signals data have been acquired, they can then be analyzed quantitatively. Figure 2 is the work flow of the data analysis.

The EEG signals during game play session cannot yet identify the participants' emotional valence and arousal when they are playing the game. These unknown data are to be analyzed with the emotional model established earlier during the EEG working protocol session. By using machine learning algorithm, the emotional valence and arousal of the participants during play time can be determined.

The machine learning classification of unknown data determines their emotional valence and arousal by comparing the signals with the established model. The algorithm looks at the unknown signals for

trends and characteristics that mimic the emotions model. Once it recognizes the emotions of the unknown data, it automatically labels them accordingly. Thus, there are two sets of data:

1. Training data: which is obtained during protocol, is used to build the emotions model.
2. Testing data: which is obtained during game play, is used to test the built model.

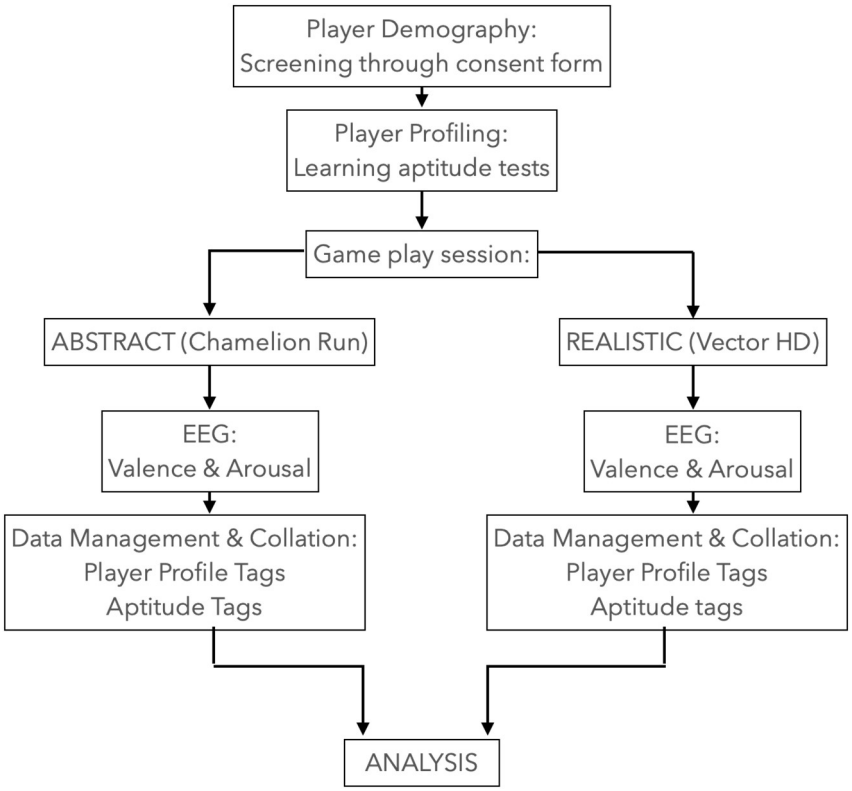

Figure 1. Data Collection Flowchart

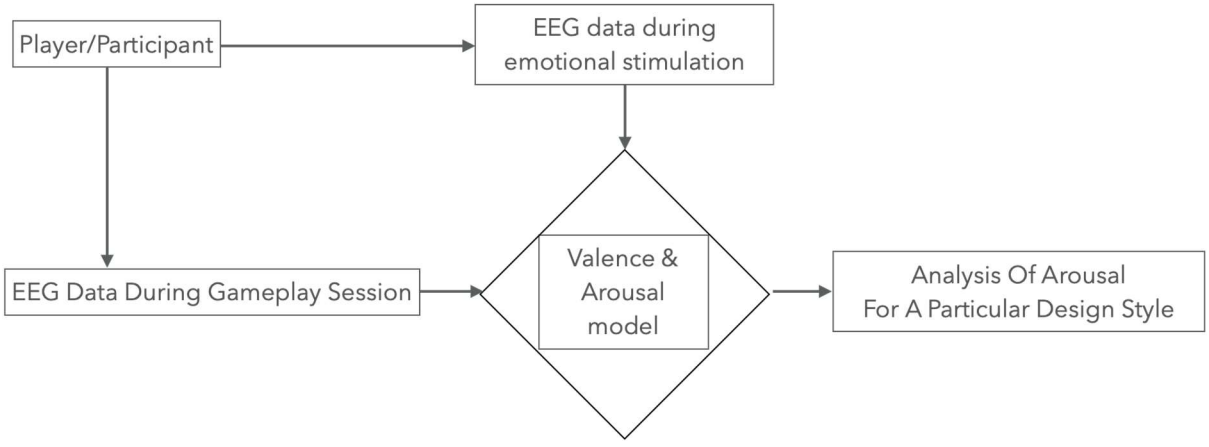

Figure 2. Data analysis work flow. Emotionally stimulated data were used as the known variable and trained to create a working model. Unknown variable from game play can then be classified.

The learning aptitude test was originally meant to be as a component for profiling the subjects that undertake this experiment. The test instrument measures four different brain functions and ideally the test result should be obtained just before the game play session. This is the reason why EEG data of the

aptitude test was recorded. The EEG device was already in place when the aptitude test was taking place, thus their signals were recorded anyway.

The test instrument for measuring learning aptitude was provided by the Cambridge University's Brain Lab. It is available online at https://brainlabs.me. The instrument measures four brain functions:

1. Cognitive
2. Verbal
3. Creativity
4. Logical thinking and reasoning

Each brain functions was measured with a score. These scores can be accumulated over time to monitor changes of the brain performance after every 24 hours. This instrument was a valid and credible instrument and is backed by numerous articles and publications.

For data analysis, raw data out of the EEG device was input and ran into Python codes that applies supervised machine learning to classify the unknown variable. Data from the learning aptitude was also ran with the code even though their result may not be useful for the research's objective. However, when the resulting analysis laid out in a scatter plot graph, a constant pattern of similarities is noticed for all subjects of the experiment.

There are two things that can be observed from these scatter plots. First, for each aptitude tests that measures a specific brain function, their scatter plot is almost unique to each other. The plots shows the emotional valence versus arousal (VA) of the player during each tests. The plots reveals that when a specific brain function is at work, their valence vs arousal is in a specific state. The scatter plots in figure 3 demonstrate one subject's valence versus arousal analysis.

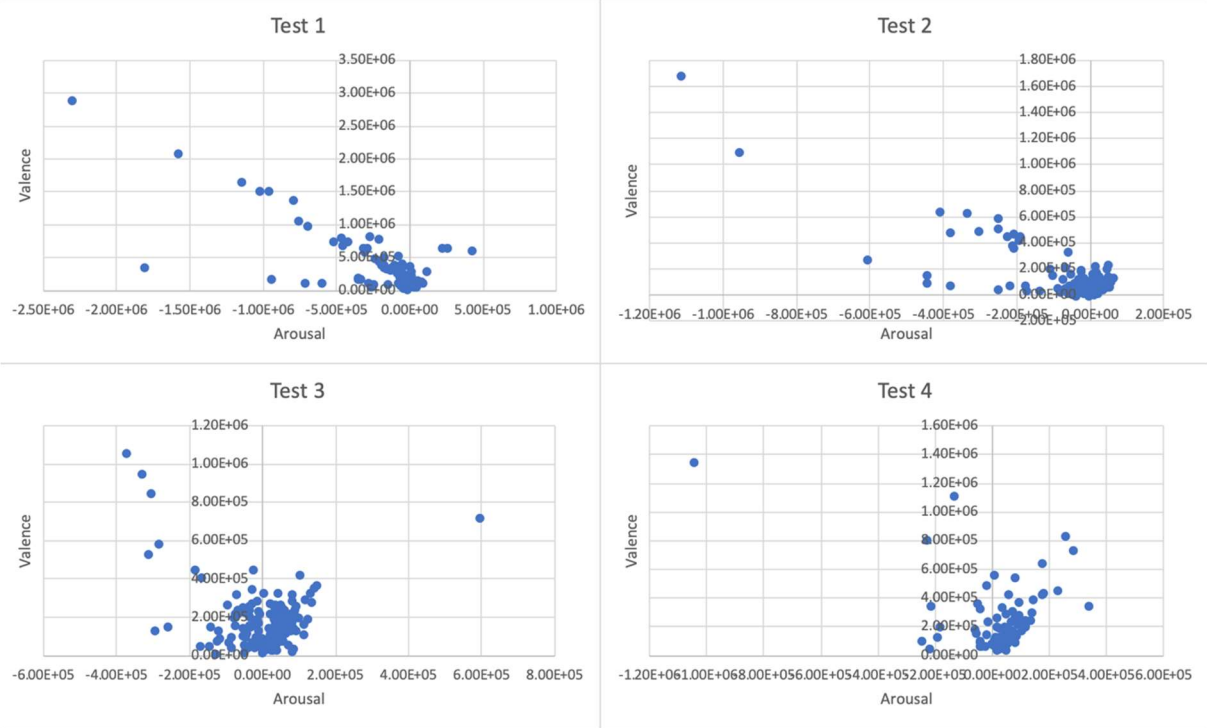

Figure 3. Four scatter plots exhibit unique patterns for each brain functions (cognitive, creativity, memory, and verbal).

Second, when these scatter plots are superimposed or combined into a single plot, it resembles the pattern of the game play emotional state. The plots in figure 3 are used again for demonstration and the result can be seen in figure 4.

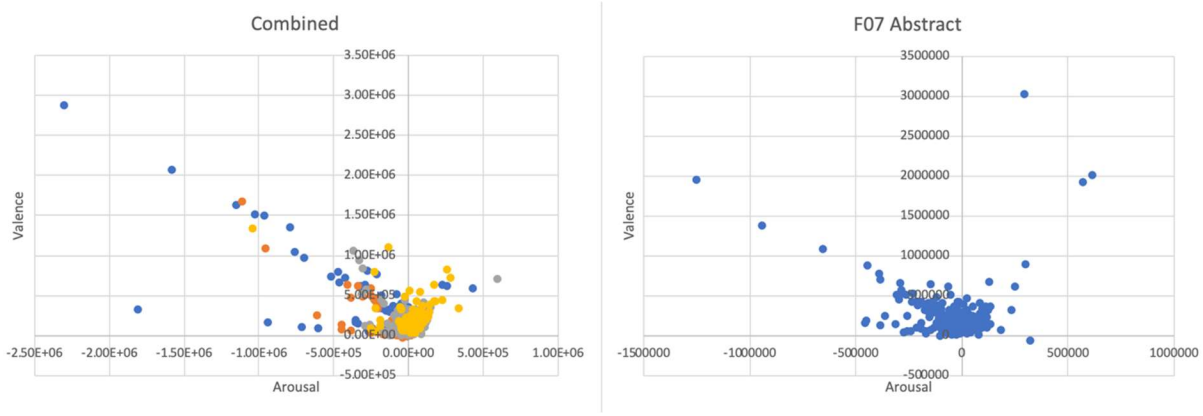

Figure 4. Combined aptitude test VA plots (left) versus gameplay VA plots (right).

The similarities are obvious when they are seen in visual observation. At this point, it is tempting to converge into a conclusion that four different components of the brain functions are present in a game that were not designed to stimulate any of those functions at all.

One might say that this finding is obvious since the brain have to work using all of its function all the time. But to what degree? Aptitude test results measure varying result of the brain performance. And in this experiment, the same subject may only shows not all of the brain's function when playing a different video game. This can be observed in figure 5.

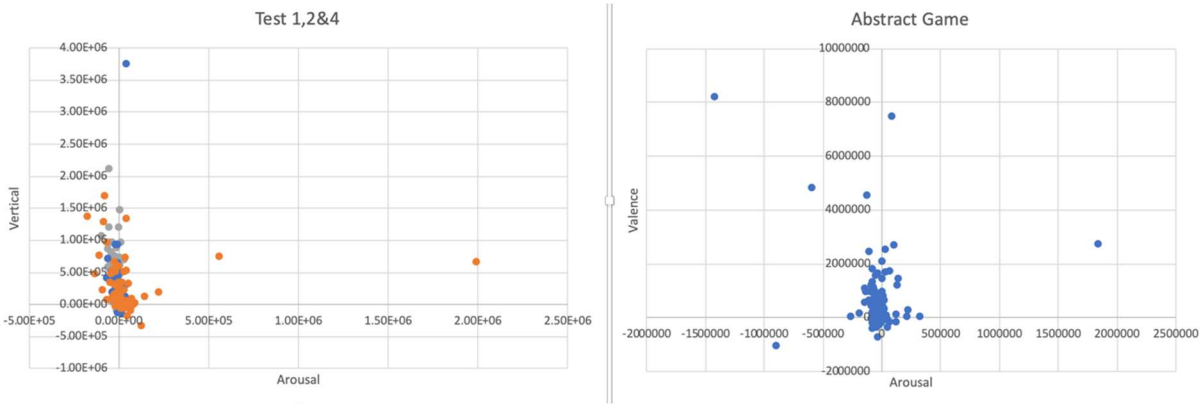

Figure 5. Aptitude tests 1, 2, and 4 (left) resembles scatter plot of gameplay of an abstract design scatter plot (left) when combined.

As in Figure 4, Figure 5 shows another subject's similarities of valence versus arousal scatterplot between aptitude tests and playing a video game. Only this time, only three brain functions are apparent. However, when the subject played another similar game but with a different design style, the scatter plot only reminiscent to only one of the brain functions, as can be seen in Figure 6.

These scatter plots are based on the emotional valence versus arousal data. Thus, it is not a concrete correlation between design styles in video games and learning aptitudes. However, Figure 5 and 6 both reveals as if it can be assumed that different games lit up different aspect of brain functions. The same experiment but using the aptitude tests as the machine learning model may provide a more solid evidence of this assumption.

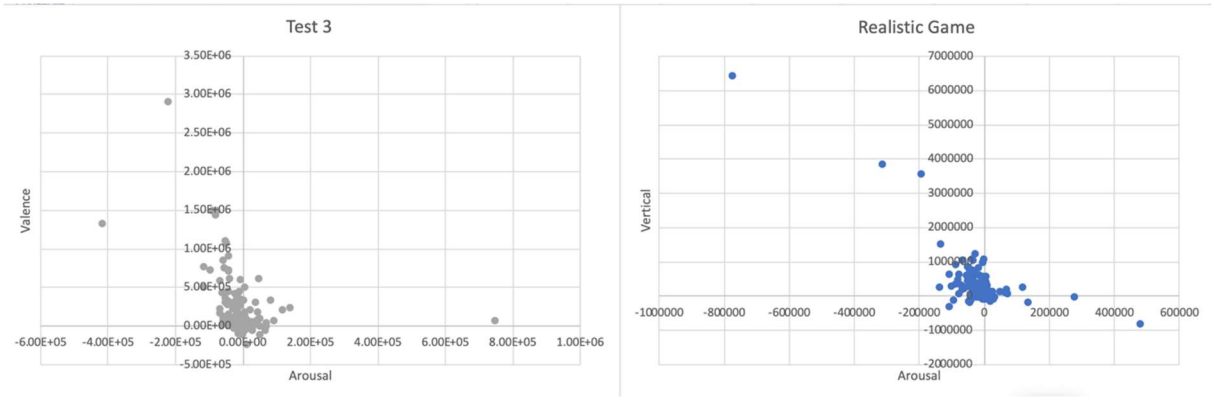

Figure 6. Only one of the aptitude test resembles the gameplay of a realistic game. The other patterns from other tests seem absent.

4. A Hypothesis For A Conclusion

The distribution of the valence and arousal signals from the EEG signals provided by the emotional scatter plots exhibit clear visual correlation between brain functions and video games designs. It is amazing to see that multiple brain functions indeed respond to video games that are not even designed to stimulate them. Unfortunately, the lack of quantitative analysis and statistical correlation means that it is not a concrete proof. This is due to the following:

a. The research was not designed to reach this conclusion and it is actually outside the research scope. It is merely a bonus discovery during data analysis.
b. The scatter plots similarities are only visual. No statistical correlation has been done to confirm this claim yet.
c. A more accurate research design is needed to verify this finding. Instead of emotional valence and arousal model, a specific computational model of the brain functions can be applied in the machine learning process.

Despite the above, the findings can be synthesized into a hypothesis for future research: Specific cognitive and learning aptitude functions of the brain are present and respond in varying degrees in a video game that are not even designed to stimulate them. Each brain functions emits unique EEG signals and they are possible to be correlated with video game designs. The brain's cognitive, creative, memory, and verbal functions may each be individually stimulated by the visual elements of the game. This includes design styles, colors, textures, shapes, and other design elements.

The idea of having fun and entertaining activities that simultaneously improve learning potential may not be a far-fetched concept after all. While this paper cannot give a concrete proof and concludes the presence of brain functions within a video game that was not designed to stimulate them, the trace of evidence can at least be observed visually in the research this paper discusses. And that trace is hard to ignore.

Acknowledgement

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References

[1] Alvarez J, Djaouti D, Ghassempouri R, Jessel J-P and Methel G 2006 Morphological study of the video games *3rd Australasian Conf. on Interactive Entertainment* December 2015 pp 36–43
[2] Ashinoff B 2014 The potential of video games as a pedagogical tool *Frontiers in Psychology* **5** September DOI: 10.3389/fpsyg.2014.01109

[3] Benlamine M S, Dombouya R, Dufresne A and Frasson C 2017 Game experience and brain based assessment of motivational goal orientations in video games *Lecture Notes in Computer Sci. (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 10512 LNAI* pp 118–32 DOI: 10.1007/978-3-319-67615-9_11
[4] Blacker K. J, Curby K M, Klobusicky E and Chein J M 2014 Effects of action video game training on visual working memory *J. of Experimental Psychology: Human Perception and Performance* **40(5)** pp 1992–2004 DOI: 10.1037/a0037556
[5] Boot W R and Hommel B 2015 Video games as tools to achieve insight into cognitive processes *Frontiers in Psychology* **6(3)**
[6] Bunian S, Canossa A, Colvin R and El-Nasr M S 2018 Modeling Individual Differences in Game Behavior using HMM *Preprint Arxiv: abs/1804.00245*
[7] Chandra S, Sharma G, Salam A A, Jha D and Mittal A P 2016 Playing action video games a key to cognitive enhancement *Procedia Computer Sci.* **84** issue May pp 115–22 DOI: 10.1016/j.procs.2016.04.074
[8] Franceschini S *et al* 2017 Action video games improve reading abilities and visual-to-auditory attentional shifting in English-speaking children with dyslexia *Scientific Reports* **7(1)** pp 1–12 DOI: 10.1038/s41598-017-05826-8
[9] Gori S *et al* 2016 Dyslexia prevention by action video game training: behavioural and neurophysiological evidence *J. of Vision* **16(12)** 489 10.1167/16.12.489
[10] Järvinen A 2002 Gran stylissimo: the audiovisual elements and styles in computer and video games *Computer Games and Digital Cultures Conf.* pp 113–28 DOI: http://dx.doi.org/10.1177/1468796811398833
[11] Keo M 2017 *Graphical Style in Video Games*
[12] Khairuddin R N H R, Malik A S and Kamel N 2014 EEG topographical maps analysis for 2D and 3D video game play *2014 5th Int. Conf. on Intelligent and Advanced Systems: Technological Convergence for Sustainable Future ICIAS 2014 – Proc.* DOI: 10.1109/ICIAS.2014.6869517
[13] Kuk K, Jovanovic D, Jokanovic D, Spalevic P, Caric M and Panic S 2012 Using a game-based learning model as a new teaching strategy for computer engineering *Turkish J. of Electrical Engineering and Computer Sciences* **20** (SUPPL.2) pp 1312–31 DOI: 10.3906/elk-1101-962
[14] McMahan T, Parberry I and Parsons T 2015 Evaluating electroencephalography engagement indices during video game play *Proc. of the Foundations of Digital Games Conf. 2015*
[15] Palaus M, Marron E M, Viejo-Sobera R and Redolar-Ripoll D 2017 Neural basis of video gaming: a systematic review *Frontiers in Human Neuroscience* **11** issue May DOI: 10.3389/fnhum.2017.00248
[16] Poels K, Hoogen W van den, Ijsselsteijn W and de Kort Y 2012 Pleasure to play, arousal to stay: the effect of player emotions on digital game preferences and playing time *Cyberpsychology, Behavior, and Social Networking* **15(1)** pp 1–6 DOI: 10.1089/cyber.2010.0040
[17] Rapeepisarn K, Wong K W, Fung C C and Khine M S 2008 The relationship between game genres, learning techniques and learning styles in educational computer games *Edutainment 2008* pp 497–508 DOI: 10.1117/12.958586
[18] Schneider E, Wang Y and Yang S 2007 Exploring the uncanny valley with Japanese video game characters *Digital Games Research Association (DiGRA)* 546549
[19] Sharan L, Neo Z H, Mitchell K and Hodgins J K 2013 Simulated motion blur does not improve player experience in racing game *Proc. of Motion on Games* **149** pp 149–54 DOI: 10.1145/2522628.2522653