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Article

Examining the effects of digital gameplay of the racing genre on mood and heart rate

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Abstract
This study aimed to determine racing esport games' effects on the physiological and psychological indices using psychological scales and heart rate monitors. The participants were 10 male university students who did not play games diurnally (mean age ± 20.10, *SD* = 1.10). Participants wore a wristwatch heart rate monitor, and their resting heart rate was measured for 2 min. The duration of the game play was set to 30 min, and their heart rates were continuously measured during play. The changes in the psychological state before and after the game play were then examined using a two-dimensional mood scale-short term. The results showed that the average heart rate significantly increased during gameplay compared to the resting state. As for participants' psychological state before and after the gameplay, the vitality, pleasure, and arousal levels increased while the stability level decreased. These results indicate that gameplay in the racing genre can induce a lively mood and increase the heart rate.

Keywords: esports; racing games; mood; heart rate.

1. Introduction

The size of the sports market is growing annually, and by 2020, the number of esports viewers will grow to 495 million worldwide, while the total revenue will reach one billion dollars (Rietkerk, 2020). Professional leagues for esports have been established, and the number of people aspiring to become professional gamers is increasing every year. In addition to professional players, games have become a popular form of entertainment for people globally and are enjoyed by people of all ages and sex, and studies have shown that they have various effects on players. For example, it has been reported that video games can improve cognitive abilities, and games developed for research purposes have been used to treat diseases (Anguera et al., 2013; Franceschini, Bertoni, Lulli, Pievani, & Facoetti, 2021). Since the demographics of the experimental participants in these studies vary, it is necessary to research a wide range of subjects, from professional to amateur levels, distinguishing their gaming experience.

Although several studies have examined the impact of gameplay on human physiological indicators, there is a limited amount of literature that investigates the impact of esports gameplay from a physiological perspective compared to previous studies of real sports such as soccer (Nicholson, McNulty, & Poulus, 2020). For example, Nicholson et al. (2020) investigated the heart rates of two elite players, aged 18 and 19, while playing League of Legends (Riot Games, 2009), a multiplayer online battle arena game. The results showed that their mean heart rates increased significantly during gameplay compared to at rest. Andre, Valladão, Cox, and Middleton (2019) investigated heart rate in 23 young men (age = 20.7 ± 1.8 years) who played esports for more than six hours per week, using Fortnite (Epic Games, 2017), a battle royale-type game. The results showed that peak heart rate responses during gameplay were significantly higher than peak heart rate responses at rest (120 ± 16 bpm vs. 81 ± 11 bpm).

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These previous studies have studied elite players and light gamers who are regularly engaged in esports games and reported that gameplay improves average heart rate. Campbell, Toth, Moran, Kowal, and Exton (2018) pointed out that while considering game effects, it is necessary to distinguish between the types of video games played and the evidence for their effects. Therefore, when researching esports, it is expected that gameplay's effects on heart rate and mood can be clarified by defining the game genre and attributes of the experimental participants. Similar to the first-person shooter (FPS) and multiplayer online battle arena (MOBA) genres, games in the racing genre require a series of quick and accurate decisions. Moreover, the racing mode has a high perceptual and cognitive load and requires sustained attention while considering the possibility of collisions with many cars. Furthermore, the car racing genre is characterized by the fact that it does not take long to learn the game rules, making it easy for non-gamers with no prior gaming experience to tackle. Moreover, many games in the racing genre do not contain violent depictions, thus, are easily accepted by people of all ages. For these reasons, we chose the racing genre for this study, targeting non-gamers. Leis and Lautenbach (2020) stated that, regarding esports research, not only physiological processes need to be addressed, but also psychological processes. For example, Pallavicini, Pepe, and Mantovani (2021) reported that gameplay was effective in reducing psychological stress, regardless of age.

However, there are only a few reports on moods esport gameplay induce since it is difficult to ascertain quantitative data. Although mood changes during gameplay can be estimated by analyzing heart rate variability, the use of a subjective psychological state rating scale provides a better grasp of the psychological state. In this study, we used the two-dimensional mood scale-short term (hereafter referred to as TDMS), a psychological scale developed by Sakairi, Soya, and Kizuka (2009). TDMS can measure both the negative and positive psychological states through self-monitoring of a subject's psychological state (mood). Additionally, TDMS is based on a theoretical model in which mood is a two-dimensional structure comprising two orthogonal axes: arousal and pleasure. Mood is the affect of relatively long duration and low intensity, while emotion is an affect of relatively long duration and high intensity (Arimitsu, 2002). Therefore, the TDMS measures body-induced mood rather than stimulus-responsive emotion, which is an appropriate scale for examining the relationship between physiological states, behavioral responses, and psychological states. In addition, the TDMS has the advantage of measuring mood in a short period of time (one minute), thus placing less burden on the experimental participants. However, only a few studies have used the TDMS to investigate gameplay's effects on human mood.

In light of the above, it is important to use both indices together to examine the physiological and psychological changes in humans caused by gameplay. Therefore, the purpose of this study was to clarify the effects of gameplay in the racing genre on non-gamers heart rates and mood.

2. Methods

2.1. Participants

The experimental participants were 10 healthy male university students (Age: 20.10 ± 1.10 years old, Height: 170.40 ± 4.74 cm, Bodyweight: 63.90 ± 4.70 kg; Mean value ± Standard deviation), and were non-gamers with less than one hour of gameplay time per week. Participants were informed of the study's purpose, content, and risks (orally and in writing), and written consent was obtained. We also explained that they could withdraw from the experiment at any time. Approval was obtained from the institutional review board of Kyushu Sangyo University (No.2021-00002, May 20, 2021). After the completion of the experiment, the participants were given a book card worth 3000 yen as a monetary reward.

2.2. Method for measuring and evaluating heart rate during gameplay

An optical heart rate (OHR) monitor, Polar A370 (Polar Electro, Kempele, Finland), worn like a wristwatch, was used to measure the heart rate during gameplay. The device was fitted just below the Ulnar styloid process on the dominant and opposite arms. The device's heart rate measurement range was 30–240 bpm.

2.3. Methods for measuring and assessing psychological state

The TDMS developed by Sakairi et al. (2009) was used to measure the psychological state (mood) before and after gameplay. The TDMS is a psychological scale written in Japanese, based on a two-dimensional (arousal × pleasure) mood model, which can easily measure the fluctuation of the psychological state. Participants were asked to respond to eight items expressing their psychological state using a six-point scale ranging from "0: not at all" to "5: very much so." Based on the results, the factor scores for vitality (4 items: -10 to +10 points) and stability (4 items: -10 to +10 points) were calculated. In addition, using the scores of vitality and stability, the pleasure level (vitality + stability: -20 to +20 points) and arousal level (vitality - stability: -20 to +20 points) were calculated to measure the four types of psychological states. The psychological states indicated by the scores on each scale are as follows:

1. Vitality level: The level of psychological state (activation) with high vitality and low vitality as the two poles. A positive score indicates a state of energy and liveliness, while a negative score indicates a state of lethargy and listlessness.
2. Stability level: The level of psychological state (relaxation) with high stability and low stability as the two poles. A positive score indicates a relaxed and calm state, while a negative score indicates an irritable and nervous state.
3. Pleasure level: The overall pleasure level of the psychological state, with pleasure and displeasure being the two extremes. A positive score indicates a positive and pleasant mood, while a negative score indicates displeasure and a negative mood state.
4. Arousal level: The overall level of arousal of a psychological state with extremes of high arousal and low arousal. A positive score indicates high arousal and energetic mood, while a negative score indicates low arousal and a listless mood state.

2.4. Adopted Game and Driving simulator

The participants in the experiment had no experience with the racing game employed in this study, Gran Turismo Sport (Sony Interactive Entertainment Inc., 2017). Gran Turismo Sport is a highly competitive esports title and has also been selected for the Olympic Virtual Series-Motor Sports event. Gameplay conditions were standardized among the participants. The course used was "Northern Isle Speedway," and the car model was the "Mitsubishi Lancer Evolution Final Edition Gr.B. "

The experiment used a fixed simulator consisting of a 29-inch display (TOSHIBA 32S20, Japan), a distance-adjustable gaming chair (Playseat Evolution Alcantara, Netherlands), and a steering wheel game controller (Logitech G29-LPRC-15000d, Logitech, USA). When the participants sat in the driving seat, their eye height was adjusted to be at the midpoint of the display.

2.5. Procedures

Participants first entered the experimental room and filled out questionnaires about their demographics and gameplay experiences. To stabilize the readings, the participants were reminded not to speak or move their bodies significantly during the experiment. Next, to minimize the influence of the mood state of the experimental participants, they were seated in a chair for 5 min and asked to rest with their eyes open. Then, a heart rate monitor was attached, and the resting heart rate was measured in the open-eyed state in the sitting posture for 2 min. Subsequently, the current mood (psychological state) was measured using the TDMS. After the TDMS measurement was completed, the participants were seated at the car racing gameplay seat, and the game rules were explained. The game duration was 30 min. Simultaneously as the start of the gameplay, heart rate monitoring measurements were started. The heart rate measurement was terminated concurrently at the end of the gameplay, and TDMS was immediately conducted to measure the mood of the experimental participants after the gameplay.

2.6. Analysis

We utilized a paired t-test to compare the mean and peak heart rates at rest with the mean and peak heart rates during gameplay. To confirm the changes in the psychological state before and after gameplay, the scores for vitality, stability, pleasure, and arousal calculated by TDMS were analyzed using a paired t-test.
Subsequently, to clarify the intercorrelations for heart rate and mood indices, the correlation coefficients (Pearson’s product-moment correlation coefficients) were calculated and compared between rest and gameplay conditions changes in measures. Finally, race records recorded at the end of gameplay were employed as game performance to examine the relationship between physiological and psychological indices.

IBM SPSS Statistics software (version 28.0) was used for all statistical analyses. The significance level was set at 5%. A standardized measure was used to calculate the effect size, which did not vary with sample size. In addition, the effect size of Cohen's d index (d) was calculated using unbiased variance to estimate the population value.

3. Results

3.1. Gameplay's effects on heart rate

To determine the effect of 30 minutes of gameplay on heart rate, the average heart rate at rest was compared to the average heart rate during gameplay. The results showed that the heart rate during gameplay (M = 91.20, SD = 7.05) was significantly higher than that during rest (M = 73.30, SD = 11.17) (t(9) = -5.10, p<.001, d=1.87) (Figure 1a). Similarly, there was a significant increase in peak heart rate during game play (M = 108.40, SD = 11.87) compared to that at rest (M = 82.10, SD = 10.34) (t(9) = -5.19, p<.001, d= -2.36) (Figure 1b).

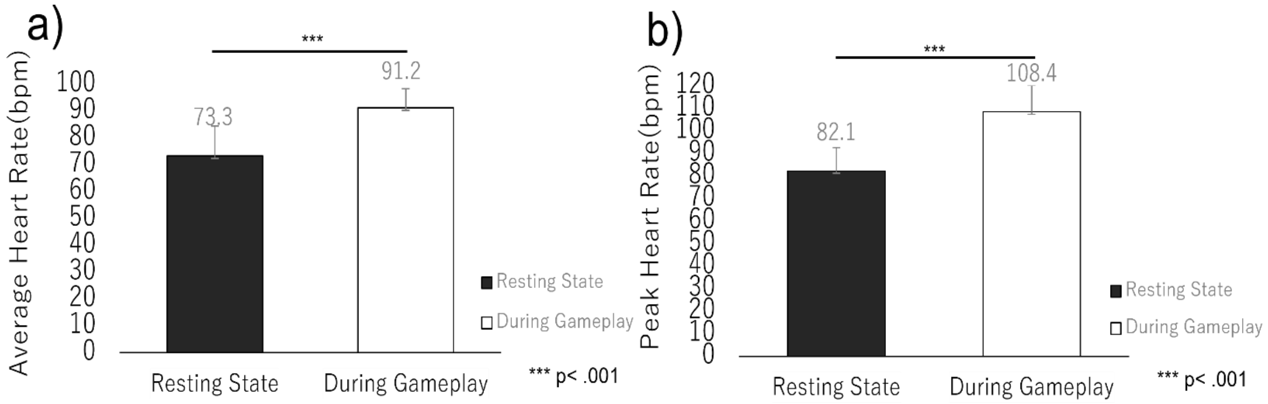

Figure 1. Comparison of Mean Heart Rate (a) and Peak Heart Rate (b) in Resting and Gameplay Conditions. The error bars represent standard deviations of the mean, ***= p< .001 between conditions.

3.2. Comparison of psychological state (mood) before and after gameplay

To clarify the changes in the psychological state before and after gameplay, vitality, stability, pleasure, and arousal levels in the TDMS were analyzed. Table 1 shows that the vitality, pleasure, and arousal levels were significantly higher after the gameplay than before. Contrarily, the stability level scores were significantly lower after gameplay than before. Figure 2 also shows the characteristics of the psychological state on a two-dimensional graph using the vitality and stability scores before and after gameplay. Before the gameplay, the vitality score was (M = -2.40, SD = 3.47) and the stability score was (M = 7.90, SD = 1.97), indicating a psychological state suitable for rest. After gameplay, the vitality (M = 6.50, SD = 2.59) and stability (M = 3.50, SD= 4.45) scores indicated that the psychological state was suitable for activity.

Table 1
Changes in Psychological State Before and After Gameplay

	Before Gameplay		After Gameplay				95% CI		Cohen's
	M	*(SD)*	*M*	*(SD)*	*t* (9)	*p*	*LL*	*UL*	*d*
Vitality level	-2.40	(3.47)	6.50	(2.59)	-7.62	<.001	-11.54	-6.26	-2.88
Stability level	7.90	(1.97)	3.50	(4.45)	2.76	.02	0.80	8.00	1.29
Pleasure level	5.50	(3.54)	10.00	(3.86)	-4.10	.003	-6.98	-2.02	-1.21
Arousal level	-10.30	(4.40)	3.00	(6.18)	-5.18	<.001	-19.11	-7.49	-2.49

Note. M= Mean; SD= Standard Deviations; N = 10; Cl = Confidence Interval; LL = Lower Limit; UL = Upper Limit.

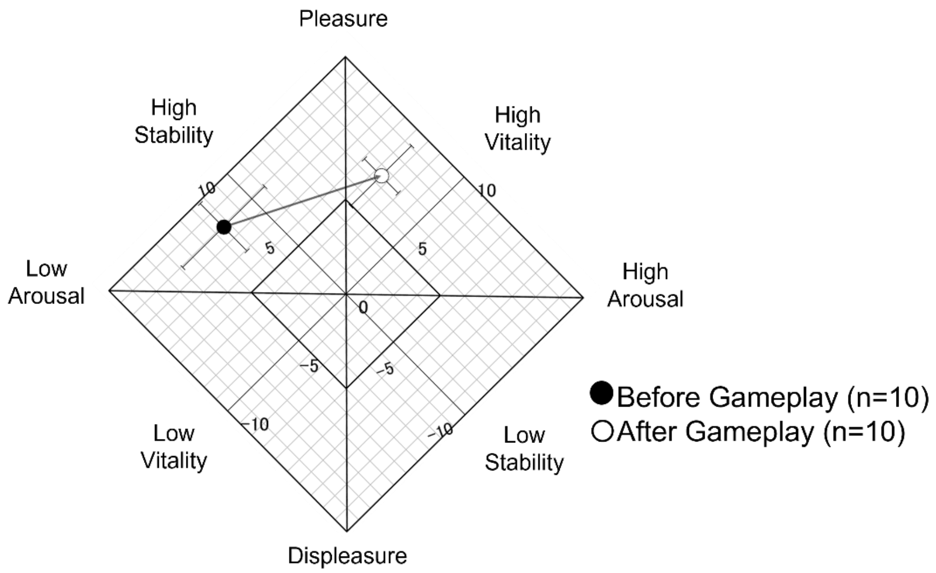

Figure 2. Mood changes before and after gameplay. The mean values of the Vitality and Stability scores of the groups before (black circles) and after (white circles) gameplay are plotted as psychological states. The error bars on the Stability and Vitality axes indicate the standard deviations of the mean.

3.3. Relationship between heart rate and mood index and game performance

When the amount of change between resting and gameplay was calculated for the 1–6 measurement items shown in Table 2, no correlation was found between heart rate and the four mood indices obtained by the TDMS.

Table 2
Summary of the Interrelatedness of Heart Rate and Mood Indices by the Amount of Change Between Conditions

Measure (Variation between Conditions)	1	2	3	4	5	6
1. Vitality	–	.73	.24	.90**	-.035	-.36
2. Stability	.73*	–	-.48	-95**	-.19	-.39
3. Pleasure	-.24	-.48	–	-.19	.046	.035
4. Arousal	-.90**	.95**	-.19	–	-.13	-.40
5. Average HR	-.035	-.19	.046	-.13	–	.64*
6. Peak HR	-.36	-.39	.035	-.40	.64*	–

Note. Each index represents the amount of change between resting and gameplay conditions. $N = 10$; HR = Heart Rate. *p<.05; **p<.01.

The mean and standard deviation of the game performance (race record) of each experimental participant were M=178.92(sec), SD=4.74, respectively. Note that the smaller the value of the race record, the higher is the performance. In conjunction with the results in Table 2, we examined the relationship between the performance data and the heart rate and mood indices and found no relationship between these variables.

4. Discussion

This study aimed to clarify the effects of playing esport-racing games on the physiological and psychological indices of non-gamers. In terms of physiological indices, both mean and peak heart rates were significantly higher during gameplay than while resting. One possible reason for this result is the influence of the game genre. Gran Turismo is a race with 19 computer machines in which a single mistake in pedal operation or steering wheel operation is likely to cause a crash or cause the player to go off course and lose position. Therefore, games of this type require a high level of action, similar to FPS games, MOBA games, and fighting games. The action here refers to the level of game operation, and action video games are characterized by transient events, speed in terms of moving objects, high perceptual and motor load, and an emphasis on peripheral processing (Bavelier & Green, 2019). Wang and Perry (2006) reported a significant increase in heart rate and other parameters before and after gameplay using a fighting game in 21 boys aged 7 to 10 years. Thus, the results obtained in this study are consistent with those of previous studies in similar fields.

Skoluda et al. (2015) stated that heart rate is a parameter that responds quickly when physiological and psychological stressors are encountered. It has also been reported that heart rate measurement can estimate arousal on a calm-excited axis (Drachen, Nacke, Yannakakis, & Pedersen, 2010). However, with only heart rate data, it is difficult to estimate whether the psychological state during gameplay was displeasure arousal or pleasant arousal. Therefore, we used a psychological scale to understand the mood generated by the increase in heart rate due to gameplay. We examined the changes in the mood before and after gameplay using a simple psychological state measurement scale (TDMS) and found that arousal, pleasure, and activity levels were higher after gameplay. These results suggest that gameplay induces a lively and energetic mood and a positive state of arousal. Although the stability scores decreased, the post-gameplay scores were in the positive range (M=3.50, SD=4.45), suggesting that the participants changed from a high pleasure and calm state before gameplay to an area of normalcy (Sakairi et al., 2009). This may have been influenced by factors such as the need for sustained attention required by racing games.

To visualize the characteristics of the psychological state at the time of measurement and understand the direction of change in the psychological state before and after gameplay, the results obtained by TDMS were plotted on a two-dimensional graph. From the direction of the arrows shown in Fig. 2, it can be confirmed that before gameplay, the psychological state was high in stability and slightly low in vitality, but after gameplay, the mood changed in the direction of increasing vitality. In other words, 30 minutes of gameplay changed the mood from one suitable for rest to one suitable for the activity, indicating gameplay's activation effect. Mood induced by gameplay can be an important factor in structuring an effective intervention program. This is because gameplay is an efficient method of inducing positive mood and active states, and positive emotional changes due to gameplay enhancing cognitive performance (Franceschini et al., 2021). Therefore, intervention in gameplay before or during cognitive tasks such as work or study may lead to improved work efficiency. In the future, it will be necessary to examine the duration of mood induced by gameplay.

As described above, gameplay in the racing genre can induce an active mood with little physical activity; however, it should not be used as a substitute for actual physical exercise. Sousa et al. (2020) reported that esports is different from true aerobic exercise because they are less strenuous and more prone to physiological changes caused by stress hormones secreted by the adrenal glands. Therefore, it is important to consider the synergistic effects of gameplay and exercise on mood when using exergaming genres that involve physical activity, such as dancing and fitness. Moreover, physically disabled people who face difficulty part-taking in physical activity in their daily lives may find it effective to use games for relaxation and activation while considering the game genre.

In the racing game used in this study, as in FPS, MOBA, fighting, and action games, if the concentration is lost even for a short period, game performance drops significantly. Conversely, role-playing games and simulation games allow players to play at their own pace and in a relaxed mood. Therefore, racing games are considered to use different levels of cognitive skills compared to role-playing and simulation games. Based on these considerations, it will be possible to adjust one's mood to a desirable state by selecting and using games that are more suitable for different purposes, such as relaxation and activation, by investigating the effects of gameplay on one's mood and taking into account differences in game genres and content.

Previous studies have reported an increase in heart rate due to gameplay, but it was unclear whether this was necessarily due to changes in mood. In the context of our study, the bivariate correlation did not show a statistically significant association between our heart rate index and mood index measures. However, we considered the research significant in that we examined the relationship between the two variables using psychological scales in combination.

Furthermore, no association was found between game performance and the mean or peak heart rate in the non-gamers included in this study. Additionally, the gameplay of the racing genre tended to induce a lively and active mood, regardless of the superiority of performance. This may be since non-gamers felt excited and energized by the first game they played. In the future, differences in gaming skill levels and gaming experience should also be considered. If you are a professional esports player, the standard deviation in the amount of change in heart rate may be smaller if you play a game that you are familiar with and played regularly. On the contrary, it is possible that players with higher skill levels may have higher readiness than beginners and may experience greater fluctuations in the heart rate because they are more focused and engaged in the game. The accumulation of data on these points will contribute to the development of research on esports.

This study has some limitations. First, we need to compare the physiological and psychological indices of the experimental participants according to their different attributes (sex, skill level, game genre preference, and game genre). Avid players, such as participants in esports competitions, may have different changes in physiological and psychological indices during gameplay. This is in comparison to non-gamers in order to compare with their usual performance. Moreover, examining the effects of the differences in game genre preferences would allow for more effective use of esports for mood change. Finally, in this study, since the open-eyed sitting state was used as the resting state (baseline), physiological and psychological changes from the baseline could also occur simply by doing something (e.g., watching a TV screen). Therefore, by collecting heart rate data during TV screen viewing, we can refer to the physiological and psychological changes that occur due to race gameplay. In the future, a control group with a sufficient sample size should be established to examine these points.

5. Conclusions

In summary, this study investigated the effects of racing games on heart rate and mood in non-gamers. The results showed that gameplay increased the overall heart rate and peak heart rate during gameplay compared to the resting state. Furthermore, a psychological scale was used to examine the changes in the mood before and after gameplay, and the results showed that arousal and pleasure levels increased after gameplay, indicating esports' activation effect. The results obtained in this study contribute to the initial understanding of racing-game esports' effects on physiological and psychological states, such as mood.

These findings are also expected to be utilized for the health management of game players, the number of which will continue to increase in the future. Future studies examining changes in physiological and psychological indicators during gameplay should accumulate data that clearly distinguish the differences in the attributes of the participants, game genres, and the amount of time spent in gameplay.

Author Contributions

Conceptualization, R.F.; methodology, R.F., G.H.; software, R.F.; validation, R.F.; formal analysis, R.F.; investigation, R.F.; G.H.; resources, R.F.; data curation, R.F.; writing—original draft preparation, R.F.; writing—review and editing, R.F.; visualization, R.F.; supervision, G.H.; project administration, R.F.; funding acquisition, G.H.; All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

No potential conflicts of interest are disclosed.

Institutional Review Board Statement

The study was conducted according to the Declaration of Helsinki, and approved by the Institutional Review Board of Kyushu Sangyo University (No.2021-00002, May 20, 2021).

Informed Consent Statement

Informed consent was obtained from all participants involved in the study.

Data Availability Statement

The datasets generated for this study are available on request to the corresponding author.

References

Andre, T., Valladão, S., Cox, D., & Middleton, D. (2019). Heart Rate Response During Esport: Fortnite. *Medicine & Science In Sports & Exercise*, Suppl.*51*(5), S22.

Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., ... & Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature*, *501*(7465), 97-101. https://doi.org/10.1038/nature12486

Arimitsu, K. (2002). Research on affect with questionnaire Past and Future. *JAPANESE JOURNAL OF RESEARCH ON EMOTIONS*, *9*(1), 23-30. https://doi.org/10.4092/jsre.9.23

Bavelier, D., & Green, C. S. (2019). Enhancing attentional control: Lessons from action video games. *Neuron*, *104*(1), 147–163. https://doi.org/10.1016/j.neuron.2019.09.031

Campbell, M. J., Toth, A. J., Moran, A. P., Kowal, M., & Exton, C. (2018). eSports: A new window on neurocognitive expertise?. *Progress in brain research*, *240*, 161-174. https://doi.org/10.1016/bs.pbr.2018.09.006

Drachen, A., Nacke, L. E., Yannakakis, G., & Pedersen, A. L. (2010, July). Correlation between heart rate, electrodermal activity and player experience in first-person shooter games. *In Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games* (pp. 49-54). https://doi.org/10.1145/1836135.1836143

Franceschini, S., Bertoni, S., Lulli, M., Pievani, T., & Facoetti, A. (2021). Short-term effects of video-games on cognitive enhancement: The Role of positive emotions. *Journal of Cognitive Enhancement*, 1-18. https://doi.org/10.1007/s41465-021-00220-9

Leis, O., & Lautenbach, F. (2020). Psychological and physiological stress in non-competitive and competitive esports settings: A systematic review. *Psychology of sport and exercise*, *51*, 101738. https://doi.org/10.1016/j.psychsport.2020.101738

Nicholson, M., McNulty, C., & Poulus, D. (2020). Letter in response to review: More physiological research is needed in Esports. *International Journal of Esports*, *1*(1), 1-6. Retrieved from https://www.ijesports.org/article/31/html

Pallavicini, F., Pepe, A., & Mantovani, F. (2021). Commercial Off-The-Shelf Video Games for Reducing Stress and Anxiety: Systematic Review. *JMIR Mental Health*, *8*(8), e28150. https://doi.org/10.2196/28150

Rietkerk, J. (2020). *The global esports audience will be just shy of 500 million this year* [PDF file]. Retrieved from https://newzoo.com/insights/articles/newzoo-esports-sponsorship-alone-will-generate-revenues-of-more-than-600-million-this-year/

Sakairi, Y., Soya, H., & Kizuka, T. (2009). *Two-Dimensional Mood Scale TDMS guide*. Aiemuefu Co., Ltd.

Skoluda, N., Strahler, J., Schlotz, W., Niederberger, L., Marques, S., Fischer, S., ... & Nater, U. M. (2015). Intra-individual psychological and physiological responses to acute laboratory stressors of different intensity. *Psychoneuroendocrinology*, *51*, 227-236. https://doi.org/10.1016/j.psyneuen.2014.10.002

Sousa, A., Ahmad, S. L., Hassan, T., Yuen, K., Douris, P., Zwibel, H., & DiFrancisco-Donoghue, J. (2020). Physiological and cognitive functions following a discrete session of competitive esports gaming. *Frontiers in psychology*, *11*, 1030. https://doi.org/10.3389/fpsyg.2020.01030

Wang, X., & Perry, A. C. (2006). Metabolic and physiologic responses to video game play in 7-to 10-year-old boys. *Archives of Pediatrics & adolescent medicine*, *160*(4), 411-415. https://doi.org/10.1001/archpedi.160.4.411