

An Empirical Analysis of Ergonomic Gaming Peripherals Improving Gaming Performance

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Abstract— The gaming industry is a huge industry that is based on creativity and the use of media as well as the latest technology. According to the Entertainment Software Association (ESA) in 2021 more than 227 million Americans playing video games, and 75% of USA households have at least one person who plays games and has a gaming device on their home. The facts mentioned before makes this industry very profitable to enter. In hardware aspect, some company innovates to make a specific device which is used special for gaming needs. This gaming device main selling points is high specification and ergonomics factor for improving gaming performance. Despite the successful sale of this product, many people still doubt the effectiveness of gaming peripheral products to improve gaming performance and whether the higher specification of gaming peripheral can truly improve player performance during gameplay. The Study is based on the effectiveness of peripheral on human perception sensor that can be used in the implementation of ergonomic science / physical engineering or HCI (Human Computer Interaction), namely vision, hearing, and touch. In that case, with qualitative research method (direct observation, interview & simulation) this study found as the result, that was true the gaming peripherals are able to improve the performance of the user, but not for all types of users. The competitive gamer who has high gameplay hours can benefit the most and use maximum potential performance of gaming peripherals.

Keywords— *Gaming Industry, Gaming Performance, Human Computer Interaction, Game Ergonomic, Gaming Peripheral*

I. INTRODUCTION

The gaming industry is a huge industry that is based on creativity and the use of media as well as the latest technology, According to the Entertainment Software Association (ESA) in 2021 more than 227 million Americans playing video games, and 75% of USA households have at least one person who plays games and has a gaming device on their home [1]. The gaming industry has become a more successful industry than other entertainment industries such as film and music industries [2]–[4] The gaming industry is often used as a benchmark in the advancement of cutting-edge technologies because the technology that is used in the game requires high hardware and software computing capabilities to be able to run it [3], [5]. The income of the gaming industry in every aspect

(developers, publishers, players, and manufacturers of gaming hardware) is undoubtedly very high. Based on data from Newzoo's market intelligence game, the total revenue of the gaming industry is expected to grow with a healthy CAGR (2019 - 2024) of +8.7% to reach \$218.7 billion in 2024 [6] the income does not even include profit from gaming peripherals and hardware devices sales. The development of this industry is proceeding massively and dynamic can be seen from the many kinds of research about this industry, the emergence of new elements such as E-Sport that creates some kind of unique new field of opportunities, development of software and hardware which devoted to supporting the industry, and even the opening of new gaming university, HCA all of this will make gaming industry more competitive in the future.

From the beginning, the gaming industry is a creative industry that requires creativity to generate innovative product [7]. Creativity is a must to enter the gaming industry in the future because of its competitiveness that mentions before. The game itself can offer innovativeness and qualities that different to other or mainstream games, the game developer and publisher can offer professionalism, healthy business model and always listen to players demand in designing game product (user-involvement) since developer and publisher is one of contributing factor to purchase a game title [8], [9]. However, the hardware aspect can use performance, features and ergonomics factor as the main selling point to compete.

Ergonomic factors are used to create products that can make its users able to use the product more efficiently and effectively and in accordance with human fit [10]. Ergonomic factors and features which are inherent in hardware/gaming peripherals product is what distinguishes between gaming hardware and common hardware in general. Gaming peripherals such as Razer products have unique features which are supported with higher hardware specifications that are specifically designed to meet gaming needs, for example the special features of gaming mouse devices such as DPI (Dot per Inch), Pooling rate, and Macro Key designed to simplify and assist players with intention of improving accuracy and precision of the inputs. These specifications/features are expected to be an "advantage" for players who have gaming peripherals on various gaming cases, furthermore, that

advantage later can be used as consideration for the user/player adopting the product.

Review is one of the contributing factors for deciding the purchase intention of a specific product, it is also included the intention purchase of gaming product [2], [8], but in interviews conducted on one gaming forums, articles, forum threads and reviewer websites like ign.com and tomshardware.com suggests that some gaming gear features are just a gimmick to drive marketing intention. Based on this case, this study aims to find out, prove and closing the research gap that how ergonomic factor of specific hardware / gaming peripheral can really improve the performance of players in gaming activities not only in experience & performance in terms of comfort, experience and enjoyment [11], [12], but also in the main gaming session performance whether the ergonomic aspect of peripheral gaming can actually increase the performance of the players both in the input and output in terms of vision [13], hearing [13], and touch [10]. The research object which is used in this study is PC gaming hardware which is considered to have many peripheral accessories in order to easier observation.

II. METHODS

This study uses qualitative methods to investigate, collect data and analyze related to exploration whether the use of gaming peripherals can improve performance in gaming session. This method is chosen because the data needed will only be obtained by direct observation of the participants using the problems studied about, simulate cases and interview directly to participants. In the data collection and analysis techniques used data collection techniques proposed by Creswell et al [14]. The research stages is presented in the following Figure 1.

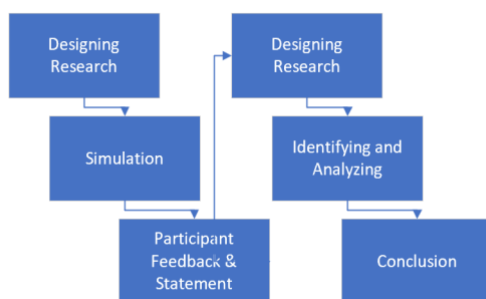


Fig 1. Research Method

The first stage is designing research. This stage contains activities such as literature studies, observing objects and research environment, designing research methodology, research simulation, establishing the needed type of data and other things related to the research. The next stage is the simulation. Simulations are designed to obtain the necessary data through testing against participants with qualitative methods (direct observation, interview) toward object research. Feedback and statements from participants are collected then arranged and cleaned in accordance with the needs of the desired data. The data obtained are further identified and analyzed to explore the fact whether gaming peripherals can affect the performance of players in gameplay. Lastly is the formulation of conclusions from the results of research.

Research object in this research is PC Gaming hardware peripheral input and output. Through simulations conducted by participants of the research object will be obtained facts related to whether there is a performance increase of the player when using gaming peripherals. Participants in this study consisted of 2 types of groups. The first group is a group of competitive gamers with minimum gameplay time in each game tested is 2500 hours of gameplay or 3 years (playing in routine) and have experience participating in the game competition game which is being tested. The second group is a casual gamer group with gameplay time of each game is lower than 500 hours in each game tested, not playing in routine and no experience participating in competition. Each group consists of 5 people (5 casual gamer group and 5 competitive group) for each title of game according to their qualifications mentioned before, with 3 total games used in this testing namely Counter Strike Global Offensive, Player Unknown Battleground (PUBG) and Tekken 7, it makes this research use 30 participant in total (5 casual gamer group and 5 competitive group in 3 games). The purpose of this group division is to reduce potential bias from peripheral performance results which come from gamer familiarity with the research instrument so the result must be divided to ensure the difference score performance occurs is only because of the peripheral device, another reason is to validate if the casual gamer is able to get the same performance because of a different device peripheral.

Before the simulation begins, participants will be given instructions on how to use the features available on gaming peripherals. Participants will perform gaming sessions with fast-paced gameplay genre such as FPS (First Person Shooter) & Action. Fast-paced genres were chosen because these genres were rated to have a positive effect on players [15] such as faster visual reaction times, and improved target localization and mental rotation [16], [17]. This typical game mechanics can lead to improvements in specific motoric skills [18], finally, this type of genre is more easily observed because the motoric movement of the user more explicitly seen including the effect of gaming peripheral usage. The simulation testing will be done with peripherals and without gaming peripherals (standard device) to see the changes that occur because of it and calculate the average difference performance that every user produce between gaming and standard device. Participants were encouraged to give feedback after the simulation in regards to their performance and how they felt while playing the game with and without gaming peripheral. All PC specification is the same in both gaming peripheral and standard peripheral to ensure that the difference result can only occur due to the use of different devices (gaming peripheral vs. standard).

III. RESULTS AND DISCUSSION

A. Peripheral Specification Benchmark

The following are the main specifications of the devices which used in this study shows in the Table 1, Table 2, Table 3, and Table 4. This four-type device is represented human perception sensor that usually used in the implementation of ergonomic science / physical engineering or HCI (Human Computer Interaction) [10], [13], Monitor for vision, Speaker for hearing, Keyboard and Mouse for touch.

TABLE I. MONITOR SPECIFICATION

No	Monitor Specification	Category	
		Gaming	Standard
1.	Name	Asus ROG Swift PG27UQ	Asus VN247H
2.	Size	27 Inch	24 Inch
3.	Panel	IPS	TN
4.	Resolution	3840x2160p	1920x1080p
5.	Refresh Rate	144hz	60hz
6.	Response Time	4ms	5ms
7.	HDR Support	Yes	No

TABLE II. KEYBOARD SPECIFICATIONS

No	Keyboard Specification	Category	
		Gaming	Standard
1.	Name	Razer Blackwidow Chroma	Logitech K120
2.	Type	Mechanical	Membrane
3.	Actuation Force	50 gram	+/- 35 gram
4.	Travel Distance	4.0 mm	+/- 3.0 mm
5.	Actuation point	1.9 mm	+/- 3.0 mm
6.	Durability	60 Million Keystroke	10 Million Keystroke
7.	Macro	Yes	No

TABLE III. MOUSE SPECIFICATION

No	Mouse Specification	Category	
		Gaming	Standard
1.	Name	Razer Naga Molten	Logitech M90
2.	DPI	5600 Adjustable	1000 Non-adjustable
3.	Pooling Rate	1000hz Ultrapolling / 1ms	-
4.	Sensor	3.5G Laser Sensor	Standard Optical Sensor
5.	Macro	Yes	No
6.	Total Button	17 (+ scroll wheel)	3 (+scroll wheel)

TABLE IV. HEADSET SPECIFICATION

No	Headset Specification	Category	
		Gaming	Standard
1.	Name	Razer Kraken 7.1	Logitech H151
2.	Sensitivity (Headphone)	118 dB	122dB +/-3dB
3.	Sensitivity (Microphone)	-38 ± 3 dB	-44dBV/PA +/- 2.5dB.
4.	Frequency response (Headphone)	12 Hz – 28.000 Hz	20 Hz s/d 20.000 Hz
5.	Frequency response (Microphone)	100 Hz – 10.000 Hz	100 Hz s/d 6.500 Hz.
6.	Impedance	32 Ohm	22 Ohm

On paper, the hardware specifications of gaming peripherals are indeed higher than standard devices, but the purpose of this study is to find out if the higher specification of gaming peripheral can truly improve player performance during gameplay, so that will indicate the usage effectiveness of gaming peripheral product is able to improve gaming performance.

B. Simulation Result

1) Visual

Down below are the raw feedback & statement regarding performance comparison of the display monitor in and post-simulation combined.

1. Setting preset

- Both run at max graphics quality setting
- Both run at maximum supported resolution (Gaming Monitor: 3840x2160p | Standard Monitor: 1920x1080p)
- Both FPS capped at 140
- Both running same game: Counter Strike Global Offensive

2. Result

The average competitive gamer participants said that their gameplay feels very smooth when the use of gaming monitor than a standard monitor, in addition, they feel that the movement is more responsive, clearer color and they can easily see when the difference object popping, example, it was easier to see the enemy hiding in the dark areas. Although they are not sure they feel the shot more easily hit the target when using a gaming monitor. They feel comfortable when using both gaming and standard monitor.

The casual gamer participants said that their gameplay feels very smooth when the use of gaming monitor than a standard monitor, the color more vibrant. Regarding the responsiveness, they are not sure but they feel actually the same. They feel comfortable when using both gaming and standard monitor.

3. Analysis

Both groups of participants feel that gameplay runs very smoothly on gaming monitor because although the game runs

on the same FPS on both devices (140 fps), but the standard monitor cannot display the entire frame rendered by GPU (Graphical Processor Unit) due to the maximum refresh-rate of the standard monitor is only 60Hz, in another case, gaming monitor is capable to display the entire FPS which is rendered by the GPU because the maximum refresh rate of gaming monitor is 144Hz. The higher or better monitor refresh rate (Hz) the better its output performance [19].

The average competitive gamer group participant states that the gaming monitor has more saturated and clearer colors therefore they are able to see the objects on the screen more clearly rather than the standard monitor. Similar statements were also said by casual gamer group that the color of the gaming monitor is more vibrant. Both statements are because the HDR (High Dynamic Range) feature on the gaming monitor. HDR has an effect on accurate rendering and illumination, typically, also a larger range of colors than conventional standard dynamic range [20], [21] therefore it's making the picture and color richer on the gaming monitor. Figure 2 shows the non-HDR vs HDR Image.



Fig 2. Non-HDR vs HDR Image (Image by: Florante Ancheta)

Although they are not sure about the statement, the average competitive gamer participants say that their shots are easier hit on enemies' target when using a gaming monitor. Technically a monitor with a high refresh rate can display more frames in 1 second than a low refresh rate. Examples of frame movement from A to C. There are 3 columns (A, B and C) 1 column represents 1 refresh rate, and 1 column can be occupied by 1 frame. Monitor with a lower refresh rate, in this case, only able to display 2 Hz (2 frames) therefore, that only the frames in A and C are displayed, the B frame is skipped. The monitor with a high refresh rate, in this case, can display 3 Hz therefore that all frames are displayed (A, B and C) therefore that high refresh rate monitor users can see the movement from A to C earlier when the frame in B is displayed even though the beginning frame and the final frame are occur at the same time. Besides more Hertz in 1 second, the response time on the gaming monitor is 4ms while the standard monitor is 5ms. Lower the response time is faster the execution [22]. Figure 3 shows higher refresh rate monitor can display denser frame, the picture looks slightly faster on higher refresh rate monitor (the object passes middle white line).



Fig 3. The Difference Between 60, 120, 144 and 240 Hz Monitor

2) Hearing

The average feedback against hearing performance.

1. Setting preset

- Both run same sound setting preset (maximum setting)
- Both running same game: Player Unknown Battleground & Counter Strike Global Offensive

2. Result

The average competitive gamer participants said that the sound quality produced by gaming headset is better than a standard headset. In gaming session, the bass effect is very clear and deep making the sound effect on firing and explosion feels more realistic. They can pinpoint clearly where the sound comes from for detecting the enemy locations. Lastly, noise cancelation by headset foam on the gaming headset is really good, and bad for standard headset. Mic quality slightly better on the gaming headset because the volume of sound produced a little louder. Gaming headset mic tone is deep, the standard mic is high pitched but overall, both have good sound clarity.

The average casual gamer participants said that the sound quality produced by gaming headset is better than a standard headset. They are able to pinpoint where the sound comes from. Two participants feel that gaming headset bass is too heavy. For mic quality average casual gamer participants prefer gaming headset mic due to more sound sensitivity.

3. Analysis

Both competitive gamer and casual gamer group participants have similar opinions. In the context of performance improvements in gaming sessions and ergonomics, there are 2 important points gained during interviews they are sound round localization and ergonomic foam design for noise cancelation. The 7.1 sound round is able to enrich received information with hearing by adding spatial audio for localization. This spatial audio can create immersive 3D Sensation experience [23], which is good for gamers to be able to pinpoint location by sound and it's able to improve gameplay experiences and accuracy.

Noise cancelation is better on gaming headset because of ergonomic foam design. This design enables all parts of ears to be submerged within the foam, making the sound more focused.

3) Touch (Mouse)

The average feedback against touch performance (mouse).

1. Setting preset

- DPI Setting = 900, 1800, 2700

- Mouse Acceleration = 0
- Both running same game: Counter Strike Global Offensive (Weapon Course), Tekken 7.

2. Result

The average competitive gamer participants say on a 1080p monitor they can use all three DPI presets pretty well, although they take a while to get used after switching the preset DPI mouse, while at the 2160p resolution they feel DPI 900 is too slow and interfere with the aiming process. According to them, 1800-2700 DPI is the best choice for 2160p resolution.

The average casual gamer participants say at 1080p resolution, the best DPI is 900, while 1800 and 2700 DPI are too fast for them and disrupt their performance, while at 2160p resolution the best DPI according to them is 1800, 900 DPI is too slow and 2700 is still considered too fast for them. Table 5 shows the average performance of mouse from touch category.

TABLE V. MOUSE AVERAGE PERFORMANCE RESULT

No	Resolution/ DPI	Average Time to Complete Weapon Course	
		Competitive Gamer	Casual Gamer
1.	1080p – 900 DPI	33.2 seconds	44.6 seconds
2.	1080p – 1800 DPI	30.5 seconds	47.2 seconds
3.	1080p – 2700 DPI	32.4 seconds	54.6 seconds
4.	2160p – 900 DPI	37.6 seconds	46.4 seconds
5.	2160p – 1800 DPI	32.6 seconds	43.8 seconds
6.	2160p – 2700 DPI	32.2 seconds	51.2 seconds

*Fast is Better

3. Analysis

The data obtained through interviews compared to the data obtained from direct observation (completion of weapon course mode) is already linear, it can be seen that the best dpi preset according to the respondent has been directly proportional to the speed completion of the weapon course mode. When compared to the standard mouse performance (1000 dpi) then most likely the results will not be much different from 900 dpi. The dpi is already optimal enough for general gaming usage in 1080p.

4) Touch (Keyboard)

The average feedback against touch performance (keyboards).

1. Setting

Participants are asked to type a continuous recurring sentence for 20 minutes quickly and constantly without deleting if the sentence is wrong. Both running same application/game scenario: Microsoft Word & Tekken 7

2. Result

The average competitive gamer participants say the typing experience feels better on the mechanical keyboard (gaming keyboard), typing with the tactile keyboard makes all the inputs seem more precise than the keyboard membrane (standard keyboard), furthermore on the keyboard membrane typing sometimes not registered very well, sometimes they have to press more than 1 times or press with more force for input registered. Overall they feel that the mechanical keyboard is better when used in continuous use.

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3. Analysis

Gaming keyboard like Razer Blackwidow keys is designed in more rectangle shape rather than square shape it reduces tendon travel. Figure 4 shows about the razer keystroke graph.

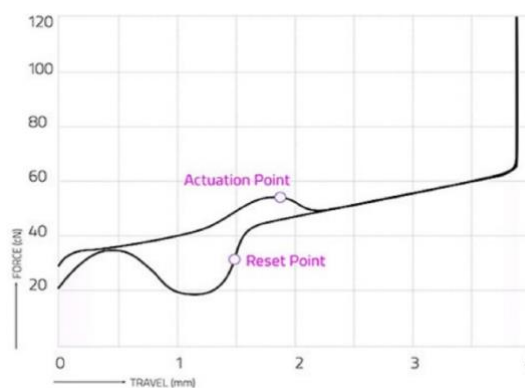


Fig 4. Razer Keystroke Graph

On the figure 4, mechanical keyboard which tested, the input will be registered when a pressure of 50 gram is applied on the keycaps in 1.9 mm travel distance and input reseted just when we release the power to 30 gram to the button keycaps trough 0.4mm. There is no need to press all the way down to the bottom up-to 4.0 mm travel distance for input registered like membrane keyboard, making input registered faster and need less force on mechanical keyboard and improving word per minute typing and vice versa [24].

In the Table 6 can be seen performance and efficiency of the macro usage in gaming keyboard or gaming mouse to execute combo in an action game. Macro can be created to combine the sequential execution set of button sequence with just a single trigger button.

TABLE VI. PERFORMANCE AND EFFICIENCY OF THE MACRO USAGE IN GAMING KEYBOARD OR GAMING MOUSE TO EXECUTE COMBO IN AN ACTION GAME

No	Keystroke for 1 Combo	Macro Time Efficiency			
		Competitive Gamer		Casual Gamer	
		Execution (Without Macro)	Execution (With Macro)	Execution (Without Macro)	Execution (With Macro)
1.	4	1.29 seconds	0.2 seconds	1.99 seconds	0.4 seconds
2.	8	2.66 seconds	0.2 seconds	4.33 seconds	0.4 seconds
3.	12	3.90 seconds	0.2 seconds	6.21 seconds	0.4 seconds
4.	16	5.17 seconds	0.2 seconds	9.01 seconds	0.4 seconds

In the table above can be seen performance and efficiency of the macro usage in gaming keyboard or gaming mouse to execute combo in an action game. Macro can be created to combine the sequential execution set of button sequence with just a single trigger button.

C. Discussion

Research which conducted to explore the impact of the use of gaming peripherals has found some evidence that some of the features and specifications of gaming peripherals are able to improve performance in some cases of gaming. Details will be shown in the following Table 7 below.

TABLE VII. RESEARCH RESULTS

No	Ergonomic Aspect Domain	Evidence	Improvement/ Gaming Advantage
1.	Visual	Gaming monitor with 144 Hz refresh rate is able to display more frames than standard monitor.	Smoother gameplay, denser frame rate make picture displayed on the screen looks slightly faster therefore can improve player reaction time.
		Gaming monitor have lower response time than standard monitor make picture execute from processing (GPU &	Improve response time when gaming making player reaction time faster.

CPU) to display in monitor faster.

Gaming monitor equipped with High Dynamic Range make picture clearer, more saturated, darker black and brighter white.

Eye care support, low blue light, flicker free, anti-glare and ergonomic stand design.

Game graphic prettier, player easier to spot an object, improving player accuracy and awareness.

Comfortless, save for eyes make player more durable and able to play longer.

2. Hearing

Gaming headset has 7.1 Chanel Sound round localization

Foam ergonomic design make good noise canceling abilities on gaming headset.

Player able to pinpoints enemies or object with sound. Increase player accuracy and awareness in specific game with support 7.1 channel.

Sound delivered more focused to the player.

3. Touch

Macro support available on the mouse and gaming keyboard

Ergonomic design on gaming mouse and keyboard

High customizable DPI on gaming mouse.

Player input execution time faster.

Player durability when playing games increased.

Player can move faster on bigger resolution screen.

To make the results unbiased, this study summarizes and formulates all statements and opinions, both objective and

subjective, and then concludes them in a conclusion that represents all participants, after that the conclusion is triangulated to find out whether the statement has sources / data that can strengthen the interpretation. As the result, the most hardware advantage will mostly benefit on competitive gamer side rather than normal casual gamer user. This is because competitive gamer is accustomed to play game. Competitive gamer will have faster visual reaction times, target localization awareness and mental rotation [15], [16] Overall competitive gamers have better specific motoric skill [17] to be able to fully use all advantage from gaming hardware than normal casual gamer user. Lastly this research found some gimmick hardware features. An overly high dpi on mouse is not recommended if player using low resolution to play. Rather than improving its most likely will complicate and decrease player performance during gameplay. High dpi is recommended when player play in high resolution or multiple screen at once. All of this fact implies that gaming peripherals are specific devices for specific people not for everyone to be able to utilize its maximum potential performance. The other gimmick is RGB backlit lightning. For supporting player gameplay in dark environment, it's enough if using standard non RGB and slightly dimmed backlit. The RGB lighting sometime distracting player from monitor when the room is very dark, rather than improving distraction can lead to decrease performance during gameplay.

IV. CONCLUSION

As the conclusion, the gaming peripherals in ergonomic factor / aspects on human perception sensor namely visual (monitor), touch (mouse & keyboard) and hearing (headset) are able to improve the performance of the user in gaming session, but not for all type of users. The competitive gamer who has high gameplay hours can benefit the most and use maximum potential performance of gaming peripheral. It is true that some specific features on the gaming peripheral are rather gimmicky than improving the performance. That feature is most likely implemented for marketing purpose.

Some of the gaming devices through the research are seen to have excellent capabilities that can even help in activities other than gaming such as using short actuation point that is owned by mechanical keyboard to speed up the typing process and help in long session typing work, low sensitivity on gaming headset can be used to hear low-frequency sound that is useful in video/audio editing process, a macro key can be used to store frequently used shortcuts when using a computer.

For future work, the researchers would like to recommend conducting another study with a larger respondent sample size including with professional e-sport team player input. In addition, the researchers would also recommend to use more peripherals for each type of ergonomic factor and a wider variety of peripheral model / brands. Future research may use other method to shows different perspective in result like using ANOVA method to benchmark the result come from casual vs competitive gamer with more quantitative approach. More varied and relevant information or feedback extracted from respondent research object would lead to achieve more perfect results and also reducing bias.

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