Creative Technologies Project:
Analysing the use of Biometric Technology in the Field of Games User Research

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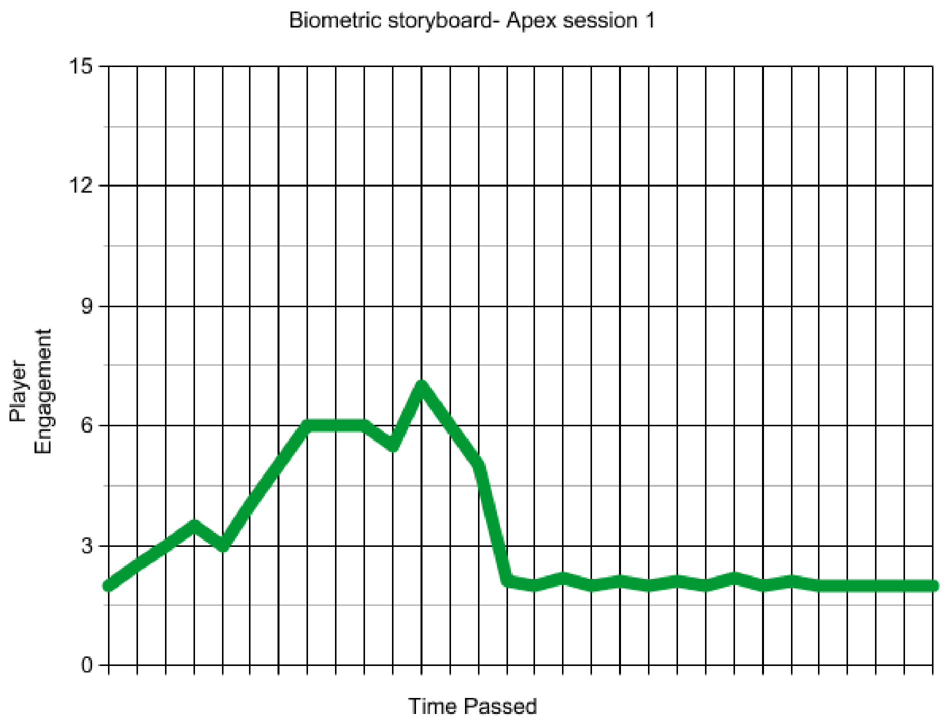

Abstract

This project looks at the use of Biometric Technology in the field of Games User Research (GUR). It looks at the processes of how this technology is used to gain insight into player experience, primarily in relation to the collection and utilization of heart rate (HR) and galvanic skin response (GSR) data. A growing method adopted within the field is to take this data and cross reference it with data gathered from industry standard techniques like interviews and questionnaires, in order to recognize trends and then infer things about the players' experiences. This project replicates this process, in an effort to identify any limitations that the methodology whilst also trying to produce results that show a consistent correlation between different data sources.

Keywords: Games User Research, Heart rate, Galvanic skin response, Biometric Technology

Brief biography

I have always had an interest in analyzing player psychology and thinking about the links between player experience and game design. This project was an opportunity to take a deeper look at the industry practices that take place in this field of study. Github link: https://github.com/pearcejennings

How to access the project

Project files and instructions for use: https://github.com/pearcejennings/Creative-Technologies-Project---Games-User-Research

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1. Introduction

This project examines the field of Games User Research (GUR), which is a field that enables designers to "bring their creations closer to the initial vision of the player experience" (Nacke, 2015, p.63). The methods used within the field involve observing and evaluating player experience in an attempt to improve the quality of a game, which is increasingly carried out these days through the use of Biometric Technology. This technology can be used to gather data during play sessions, that can then be used in conjuction with psycholigical principles to help iterate design. Physiological measurements can be used to give insight to developers about the players experience. Physiological evaluation is rapidly becoming a standard tool in user testing but it has limitations. Biag *et al* (2019, p.2) states "there is no direct relationship between psychological phenomena and physiological processes, only a suggestive one", which is worsened by the fact that "interaction also changes from person to person". It is difficult to draw a definitive link between the two, so this project is focused on replicating some of the methods used in GUR and attempting to find consistent trends amongst the results.

2. Project overview

An Arduino board is the primary piece of technology that was used in the project as a way of collecting data. Two sensors, a Heart rate (HR) sensor and a Galvanic skin response (GSR) sensor, were connected to the microcontroller.

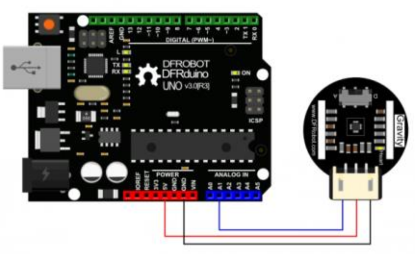


Fig 1: Diagram of HR sensor connected to Arduino style board (seeed wiki)

A sketch was then created to read the data from the sensors, using code collated from the Seeed wiki and Arduino's online resources (Seeed's wiki, 2020). The production of sweat in the eccrine glands acts as a variable resistor for the GSR sensors, so as sweat rises in a gland, the resistance decreases. This data can then be used to determine arousal in participants (Singh, 2013), in a way that is low cost and non-intrusive. For HR, the sensor detects heartbeats and then emits signals at an equivalent rate, which can then be used to determine a person's heart rate over time.

The other half of the project is the Unity end, which collects the data from the Arduino via the serial port. This data is processed in script and a value is then produced which is plotted on a modified version of a biometric storyboard. The project was originally going to have the Unity end be directly integrated with a Unity based game but due to the circumstances at the time involving Covid-19, no testing involving multiple users could take place which meant a few key aspects of the project changed. Due to the lack of multiple users to test on, the focus of testing became testing one user with various games. This meant that triple A titles were used, none of which of course could be directly integrated with the serial port system. Another result of this, was the questionnaire aspect that was originally going to be implemented being removed. Initially, an iGEQ survey was going to be taken for each user and then cross referenced on the storyboard along with the biometric data. The *In-Game Experience Questionnaire* (iGEQ) is a simple self-report method used for gathering information about a player's experience (IJsselsteijn, 2013). It is a form of feedback that has been tested various times within experiments that involve psychophysiological measures (Nacke, 2009). This was unfortunately not feasible with just one test subject, and any attempt to give personal feedback for sessions would only incur bias on the results.

3. Direction and development

The direction of the project has changed a great deal throughout. There was always an interest in using biometrics in conjunction with games in some regard, but there was an initial crossroads of what route to go down. There were thoughts originally of potentially incorporating biometric technology into a playable experience, for instance a horror game that reacts to the players physiological state. It became evident very quickly that this would be a difficult project to carry out, as it would entail a whole host of ethical issues when conducting player testing. So, after researching how biometric technology is commonly used within the context of gaming (Ekman *et al* 1983), it became clear that the field of GUR would be an incredibly interesting area of study to base the project off of.

It also became apparent very quickly, that it is a field that is inherently opened ended in its attempt to inform upon player experience. One of the main appeals that the project had, was using some of the practices within GUR to help evaluate and iterate upon a games design, particularly by drawing conclusions about the players emotional state during given moments of gameplay. However, upon further reflection it was evident that this direction for the project had too wide a scope. GUR is obviously suggestive in its nature but especially when trying to draw links between a player's physiological state and what emotions they might be feeling. There is of course a great deal of credibility to this area of study and it is slowly being supported with more and more psychological basis within the field (Soares, R, 2016) , so it has remained an active line of thinking when carrying out the project but not the main focus. Instead the focus was refined to take on a more deductive approach and was reduced down two main aspects; replicating the process of user testing, then analysing and evaluating the consistency of the physiological data produced.

The research carried out for the project showed that cross referencing different data sources yielded more success when trying to correlate trends within the results (Drachen *et al*, 2010). So, this is why it was decided that both heart rate data and skin resistance would be used. It was also decided that for HR, the average HR per minute, HRV and covariance would be calculated to have more data points to correlate between. Of course, it was important that the suggestive nature of everything was kept in mind, but this did not mean absolutely nothing could be inferred from these trends. Say for instance there was a spike/drop in a player's GSR and HR, then it does not necessarily mean that that moment had an emotional reaction, it just means it had an impact of some kind. It was found in research (Drachen,A, *et al* 2010), that the more definitive conclusion to be drawn about a player's experience was their overall engagement. If a player has a spike in their physiological state, then it can be defined as a moment of arousal. The fewer of these drastic spikes there are, then generally, the more engaged they are during a session. Of course, this is not true in a lot of modern genres of games, like battle royals and team-fight based games, where there are big high heart rate inducing periods of gameplay, and then periods of nothing happening. Since the project changed to using different games as the varying factor, it was important to have predisposed ideas of what the results might look like for each game. And this is where originally where the questionnaires would have come into play; to try and inform upon those moments of arousal.

4. Technical implementation

From a technical perspective, communicating between Arduino and unity has been the main obstacle. The serial port is the most common way that data is sent between Arduino and Unity. It requires the data to be displayed in a string to then be read properly in script. Arduino can only receive constant data from one pin at a time, so the sketch was constructed to read two different sensors at intervals between one another with such a short time between readings that it is not noticed. Due to the fact that two sensors are being used, the data of each cannot be constantly fed to Unity as it would cause the serial port to overload, which was one of the issues come across when trying to feed data through. The script in Arduino and Unity is therefore set up so that there is a slight delay in between live data and that which was being sent to unity. The system in Unity also works using a handshake and ping structure, which was based off of modified code from the Ardity package (Ardity, 2019). Arduino sends data to the com port, which unity then reads and sends a ping back to Arduino to let it know to send the next batch of readings.

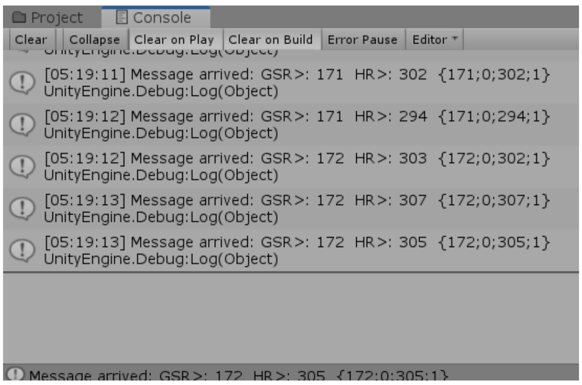


Fig 2: Screenshot of debug logs from Unity system

Due to the types of data being used, readings are pinged every second. Anything less is not needed due to the regularity of heart beats. Research was done to interpret the messages of the sensors and turn those signals into useful data points:

The GSR sensor measures skin resistance (ohms) not conductivity, so it is calculated using this formula (Seeed wiki, 2020):

- ((1024+2*Serial_Port_Reading)*10000)/(512-Serial_Port_Reading)

Average heart rate and HRV, is measured using BPM and IBI (in milliseconds):

- The time between each beat is called an "R-R interval" or "inter-beat interval (IBI)

This is mainly done through the sketch within Arduino, but the data is also handled in C# script. Every time data is collected and run through the algorithm, the system saves the resulting value for both GSR and HR related data and plots a collated value for player engagement on the storyboard at the end. To view the live data during the sessions, the serial plotter within Arduino was used.

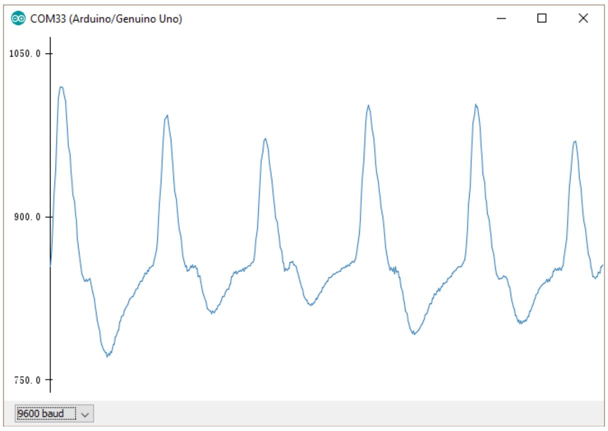


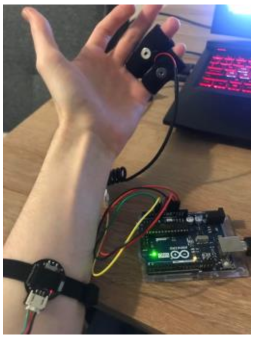
Fig 3: Screenshot of Arduino Serial Plotter

Creating a storyboard from the data was one of the key issues of the project. Data needed to be presented in a way that would allow easy comparison of results from the testing sessions. As discussed in the research report, previous storyboards used within GUR studies have been used as a baseline for this project. To visually present these storyboards, Unity plugins were used that take the engagement values and plot them on a timeline of the session. The plugin takes the engagement value from script and plots it each time a new reading is generated. This is slightly different from the original plan for storyboarding, as it collates both values into one. This was done after further looks at previous projects that did the same.

5. Testing

Testing was core to the project, and it was also understandably an area that caused some of the greatest issues. Obviously, the subject of testing itself changed due to the current circumstances, but most of the logistical issues faced were present throughout the project. The physical aspect of the sensors themselves for instance, often caused a lot of inaccuracy in early testing. Even the slightest movement would cause spikes in the readings, so it was decided any games used had to be playable with a controller, and the GSR finger sensors had to be placed on the fingers cupping the bottom of the game pad. As for the HR sensor, it was used on the wrist instead of the finger to alleviate any misreading from movement.

Fig 4: Demonstration of sensors being worn



The tech itself does still have some limitations that had to be kept in mind during testing. For instance, the GSR sensor seems to have issues when drawing very long forceful breaths. The readings drop, as expected, but then keep falling and register no resistance data of any kind for a few minutes. In testing this meant that long drawn out breaths were to be avoided, to stop this issue ruining any sessions.

Another critical aspect of testing was the privacy and handling of data. Obviously in the end, only one test subject was used, but before the current circumstances came about, preparations had to be made for user testing. A form had to be created for anyone who was going to take part in user testing, that informed them of what kind of data was going to be collected and how that data was going to be handled. On top of this, precautions were taken to protect people's privacy in regard to storing data from the sessions. Due to the nature of how results were visualised, raw data did not need to be kept after the storyboard for that session was created, so any raw data after this was automatically deleted. A person's raw physiological data could be used to inform upon their health, so ensuring it was not stored after testing alleviated any concerns related to personal data. This was eventually not needed as a feature, due to lone test subject also being the one carrying out the project.

6. Results

The system that was created was tested on one user in three different games. The focus of genres was FPS titles, but all with very different overall styles of gameplay: Overwatch, Apex Legends and Call of Duty Modern Warfare.

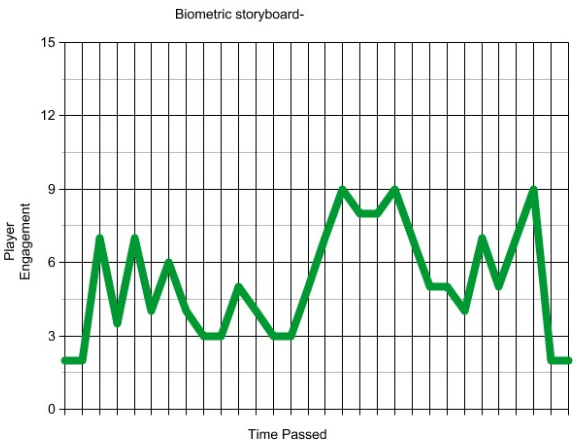


Fig 5: One of the final session storyboards

The results from Apex Legends highlighted a few different trends. Notably player engagement would understandably drop when there were no enemies nearby, but aspects like the sound of gunfire would cause spikes in these times. During team fights themselves, player engagement would maintain a very high value, and this is seemingly the case across all the sessions that took place.

Fig 6: Screenshot of gameplay alongside live data

In instances when the user died, player engagement would consistently drop to near zero, but would have massive spikes the moment before this happened. These general trends remained consistent amongst all the sessions and the only varying factor was how engaged the player was during 'downtime'. Whenever there were no fights, GSR levels generally steadily increased which implied a consistent level of tension in the players physiology. Of course, this cannot directly speak upon the players mindset, but it's is something to note that heart rate was only really affected by direct contact with other players.

The Overwatch sessions demonstrated the most consistent set of results. Overwatch's gameplay is based off of team-fights, which leaves gaps in combat every time the teams are not engaging. Initially it was expected that the players engagement would drop in these times, but in fact it maintained a steady level. The HR of the player would obviously increase a great deal when team-fights were underway, but even when nothing much was happening on screen, the trend across all session was that the player's physiology was consistently elevated.

Call of Duty demonstrated a varied set of results. As expected, the player's engagement spiked a great deal whenever any enemy was present, but this was often not clear from the gameplay on screen alone. There was an overall increase in engagement as the sessions went on, however the results themselves demonstrated no clear trends for how each session affected the players physiology. One of the issues with the lack of direct player feedback from users, was the fact that identifying triggers in the gameplay and relating them to the spikes in engagement was a lot harder. With there only being one user, there was obviously a fair amount of bias in the results, due to the subjective nature of how one person might engage with these games. Players having different physiological reactions to a game is an inherent part of this type of testing, especially due to the influence that indivdual bodily health can have on results (Biag *et al*, 2019). There is also the fact that these are games that the test subject had consistently played a great deal, so their physiological reaction to them could very well have been influenced by their previous experiences. It was also clear in live data results, that there was still an issue with delay in the system. Sometimes there were also clear random spikes that were not related to gameplay due to issues mentioned earlier regarding the players movements on the controller affecting the sensors.

7. Conclusion and recommendations 200

The project overall was fairly successful at replicating the kinds of methods found within GUR. In that same respect, the common problems that can come from user testing were also prevalent throughout, and the attempt to find consistent trends among sessions was not as easy as initially hoped. There were potentially not enough testing sessions for each game and there could have also been a few more different games tested to offer even more results. However, there were still certain markers found in the results, involving engagement in relation to combat and player death, both of which are reasonably intuitive. There could have been improvements made in the systems functionality, but the streaming of data between the com port and unity was relatively successful. If testing had taken place with multiple users, then the project would have most likely produced results that would have ideally shown more consistency.

8. References

Ardity website, *Ardity* (2019). Available from: https://ardity.dwilches.com/ [Accessed 6 April 2020]

Baig, M., Kavakli, M. (2019) A Survey on Psycho-Physiological Analysis & Measurement Methods in Multimodal Systems. [online] *Multimodal Technologies and Interaction*. 3(37) pp 1-20 Available from: https://www.mdpi.com/2414-4088/3/2/37 [Accessed 12 April 2020]

Drachen,A., Nacke, L., Yannakakis, G., Pedersen, A. (2009) Psychophysiological Correlations with Gameplay Experience Dimensions. [online] *Sandbox '10 Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games*. pp 1-4 Available from: https://arxiv.org/ftp/arxiv/papers/1004/1004.0243.pdf [Accessed 20 April 2020]

Drachen,A., Nacke, L., Yannakakis, G., Pedersen, A. (2010) Correlation between heart rate, electrodermal activity and player experience in first-person shooter games. [online] *Sandbox '10 Proceedings of the 5th ACM SIGGRAPH Symposium on Video Games*. pp 49-54 Available from: http://www.hci.usask.ca/uploads/176-DrachenNackeetal_Correlations.pdf [Accessed 13 April 2020]

Ekman, P., Levenson, R.w., Freisen, W.V. Automatic nervous system activity distinguishes among emotion. *Science. 10*, pp. 1208 (1983)

IJsselsteijn, W. A., de Kort, Y. A. W., & Poels, K. (2013). The Game Experience Questionnaire. [online] Eindhoven: Technische Universiteit Eindhoven. https://pure.tue.nl/ws/portalfiles/portal/21666907/Game_Experience_Questionnaire_English.pdf [Accessed 12 April 2020]

Nacke, L. Games User Research and Physiological Game Evaluation. (2015) In Drachen, A., Mirza-Babaei, P., Nacke, L. (2018) *Games User Research*. Oxford University Press. pp 63-86

Seeed wiki, *Grove- GSR Sensor* (2020). Available from: https://wiki.seeedstudio.com/Grove-GSR_Sensor/ [Accessed 12 April 2020]

Singh, Navjot. (2013) *Arousal Level Determination in Video Game Playing Using Galvanic Skin Response.* [online] MA, Department of Electrical and Instrumentation Engineering, Thapar University. pp 1- 62 Available from: https://pdfs.semanticscholar.org/d65c/af1945183f379140a2680b6ee8d34d746ffb.pdf [Accessed 17 April 2020]

Soares, R., Siqueria, E., Miura, M., Silva, T., Castanho, C. (2016) Biofeedback Sensors in Game Telemetry Research. [online] In *SBC Proceedings of SBGames.* pp 81-88 Available from:http://www.sbgames.org/sbgames2016/downloads/anais/157482.pdf [Accessed 14 April 2020]

9. Bibliography

Sarter, F., Papini, G., Cox, L., Cleland, J. (2018) Methodological Shortcomings of Wrist-Worn Heart Rate Monitors Validations. [online] *Journal of Medical Internet Research*. 20(7), pp 1 Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6048383/ [Accessed 13 November 2019]

Project Log

Pearce Jennings 16000680	Analysing the use of Biometric Technology in Games User Research		
Date of the week	Tasks set for the week (bullet points)	Brief summary of outcomes achieved, research or practical aspect completed	Questions arising and/or tasks to be taken forward
23/01/2020	-Refine storyboard	The storyboard was refined	What exact form will storyboards
30/01/2020	-Work on system	The system was developed further	Narrow the scope for this kind of project
07/02/2020	-Improve demo based on feedback	Feedback was implemented	Ensure demo is used as a baseline

14/02/2020	-Sort Ardunio issues with delay	Arduino and sensors sorted	How long should the delay be?
21/02/2020	-Start developing test factors	Research around UX was done	How does this research influence the direction of the project
29/02/2020	-Further research around GUR	Limitations with the UX testing process were identified	How will these limitations be avoided
04/03/2020	-Start looking at forms for testing	Forms were written out	What things might I a have missed from the forms?
11/03/2020	-Start refining the final version of the system	Started finalising the systems structure and communication over com	How will the storyboards be integrated with Unity
18/03/2020	-Get forms signed	Forms were signed	Will Covid- 19 affect the project?
25/03/2020	-Adapt the project to not have multiple test subjects	Changed the varying factor to different games	Start testing
20/04/2020	-Carry out testing and write final report	Testing was done and report was finalised	

Project Timeline

October	Final proposal to be submitted by 10/10/2019 Order Biometric Tech Begin research into how to program the tech in Unity Research biometric data in relation to patterns of engagement and principles related to HUR	4 days 1 day 7 days 6 days
November	Begin designing the system Install SDK's Start implementing the system within Unity Pre-alpha testing	10 days 2 days 15 days 4 days
December	Write up and evaluate testing Redesign aspects of the system based on testing Implement changes in the design of the system Work towards Alpha build Alpha testing	2 days 4 days 5 days 8 days 5 days
January	Write up and evaluate testing Redesign aspect of the system based on testing Implement changes to the design of the system Work towards Beta build	2 days 5 days 4 days 14 days
February	Source out group of developers for role suited testing Beta test the system Write up results and evaluate Potentially implement extra features into system such as the eye position time lapsing	5 days 10 days 3 days 12 days
March	Optimise all aspects of the system and continue testing when possible	30 days
April	Write up report Sort out submission Hand-in 23/04/20	19 days 3 days