SyncPulse: Tension Levels Synchronization in an Interactive Gaming Environment

- Paul Revell -

SyncPulse is a project that explores the synchronisation of in-game events with the tension levels of users in an interactive gaming environment, to assess the effectiveness of altering game events to raise or decrease tension based on a user's physiological state. Developed in the Unity game engine, a horror game was developed that took in the participant's heart rate for the in-game events to be synchronised to it, along with some events that remained consistent across all play-throughs. Some of these events include the player's torch flickering, the playing of 3D ambient sounds and jump scares whenever the user is deemed to be not very tense. The tension levels were inferred via their recorded heart rates which provided a comprehensive understanding of the impact of the game on the user.

The primary objective of the study was to determine the effect of an interactive gaming environment on a user's tension level and to conclude if synchronising events with the user could improve the intended induction or reduction of tension in the user. The results revealed that the majority of participants showed an increase in heart rate after jump scares occurred, indicating that virtual environments can effectively induce tension. In addition to this, it was found that these jump scares had an improved effect when they were created based on the user's tension level rather than predetermined or completely random events. Synchronizing game events to the player's physiological state was therefore found to be an effective method for inducing tension, with the added benefit of ensuring that players with different resting heart rates could experience similar levels of tension.

The study also highlighted other areas that could require further research. For example, the synchronised events were seen to increase the replayability of games that rely on inducing tension in a user - since the effectiveness of tension-inducing elements maintain their effect for longer than those that are pre-determined. For example, a jump scare that is always in the same place will no longer be scary in a second play-through and can therefore reduce the tension and how fun the game is to play.

In conclusion, the study demonstrated the potential of synchronizing interactive environments to induce or reduce tension in players and also provided valuable insights about methods of inducing tension. The findings from this project showcase the psychological and physiological effects of interactive gaming environments and how they can have improved effects when synchronised to players and also showed that some over areas are worthy of further research.

Declaration:

I declare that the material submitted for assessment is my own work except where credit is explicitly given to others by citation or acknowledgement. This work was performed during the current academic year except where otherwise stated. The main text of this project report is 11,628 words long, including the project specification and plan. In submitting this project report to the University of St Andrews, I give permission for it to be made available for use in accordance with the regulations of the University Library. I also give permission for the title and abstract to be published and for copies of the report to be made and supplied at cost to any bona fide library or research worker, and to be made available on the World Wide Web. I retain the copyright in this work.

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0.1 Introduction

Modern games lack the means to take the user's physiological state into account while they play them. This means that games cannot adjust to meet the needs of users with varying baseline tension levels. There is also a lack of understanding of how interactive virtual environments affect users' tension levels, which means that there are some potential risks that should be explored to be mitigated and that games cannot cater to everybody equally. For example, someone may find it more difficult to become tense than someone else and are therefore unable to enjoy the same game as the other.

SyncPulse is an interactive environment that I developed to evaluate the impact of the environment on the user's tension to learn how interactive virtual environments can affect tension and monitor how effectively they can induce tension. SyncPulse is a horror game that can be played by a user while having a heart rate monitor attached to them comfortably on their finger or wrist. The game focuses on getting an understanding of the user's tension level via the heart rate and then synchronising game events such as jump scares, lighting and sounds to the tension level. The purpose is to be

able to record the user's heart rate throughout the experience to gain an understanding of any elements in the virtual environment that were effective at inducing tension and whether or not synchronising the events boosts the effectiveness. Ultimately, the game was able to prove that synchronising events to the tension level of the player is an effective means of improving tension-inducing elements in games. It also highlighted some other benefits, such as the improved replayability of horror games that use tension-synchronising elements.

The most important aims of this project were:

- Build an interactive and responsive virtual environment (the game)
- Adapt the virtual environment that is built dynamically based on the user's tension levels to determine how adaptations can affect the tension level.
- Evaluate the impact of the environment on the user's tension to learn how interactive virtual environments can affect tension and monitor how effectively they can induce tension.

I also had some secondary objectives to help achieve the main objectives.

- Gather and monitor the user's physiological data
- Integrate tension-inducing elements, such as jump scares, within the gaming environment.
- Design the game to be playable with one hand for accessibility.

These objectives allowed me to ensure that I could develop the interactive environment to be effective in showcasing the benefits of synchronising tension levels. In the end, I was able to determine that my project was successful in highlighting the potential advantages of synchronising interactive environments to tension levels, and I was also able to find some other areas worth exploring.

0.2 Literature reviews

In the paper 'Investigating Affective Responses to Video Game Events' by Benjamin James Geelan [2], you can read about an investigation that explored the effective responses to video game events and how Geelan conducted a series of studies aimed at understanding how video game events influence players' emotions.

The thesis paper covers three exploratory studies that were conducted by Geelan, which aimed at developing and applying psychophysiological methods to help understand the influence of in-game events on players' effective responses. Due to the rapid growth of the video game industry, Geelan found great importance in exploring the emotional aspects of video games. In his abstract, Geelan noted that 'The study of emotions and behaviours within video games has been traditionally dominated by subjective and qualitative measures', which he deemed as being very valuable for developing understandings about experiences and behaviours. He did however believe that these methods were generally unable to truly capture the complexity of emotions during dynamic game-play.

Due to his belief that prior methods were inadequate, he wanted to address the gap by using psychophysiology which – at the time of his study – was a growing science that provided quantitative aspects of the human body related to emotions and behaviour. He strongly believed that psychophysiological data was very precise and could provide a reliable set of continuous measurements – but he noticed that there was a lack of research that took advantage of this for exploring real-time game events. He therefore had the primary object of investigating effective responses during video game events using psycho-physiological methods.

Overall, his research had three main objectives:

- Adaptation of Psycho-physiological Methods (to adapt existing psychophysiological methods to measure and analyse effective responses to observed video game events)
- Comparison of Player and Opponent Experiences (comparing events experienced by players and their opponents)
- Exploration of Measurement Effects (to explore the effects of using psycho-physiological equipment)

At the end of Geelan's studies, he was able to make several conclusions about what he had researched. One finding was that, by comparing player

and opponent experiences in real-time, he was able to see how personal and social interactions are strongly coherent with the game experience. His approach led to a deeper understanding of how game mechanics and event interactions can influence a player's emotions.

Another key finding was that participants were seen to be very distracted when they had the measuring tools used on them, for example – having the electrodes applied to them. These distractions revealed some significant changes in the immersion and emotional states of the participants and how physiological measuring devices can impact a gaming experience.

My main takeaway from this research is that I must be very careful to craft an experience that will not be affected by the measuring devices that I plan to use. One way that I can achieve this is through designing the experience to be played with a single hand – which will not have any devices attached to it. My research is also much more focused on the physiological aspects of the experience rather than the person's state of mind and emotions (other than tension).

In the study 'Heart Rate Control of Exercise Video Games' [6], the team of researchers introduced the concept of heart rate scaling in multiplayer exercise video games. Adapting the game environment is something that I wanted to include in this project, so I believe this to be a very valuable research paper that will help me conduct my experiment. The aim of their research was to address the challenge of people with varying fitness levels who want to be able to play fitness games together. In the conventional setup of the game environment, the game would directly rely on the player's fitness level – whilst the heart rate scaling would alter the experience to be more reliant on the effort level instead. The study involved a game experience where players would control the speed of a truck by pedalling on a stationary bike and steering with a game pad. The goal of the research was to enhance inclusivity in multiplayer exercise games.

The primary objective of their research was to implement heart rate scaling in the "Heart Burn" racing game – which involves ranking player performance by awarding their effort in relation to their fitness level. They were able to use heart rate monitoring to scale the game performance based on how the player adhered to their target heart rate. By achieving this objective, they would be able to construct a game where people could play together on an even playing field – no matter how fit they are.

In the chosen game environment, players could control an onscreen truck by pedalling a stationary bicycle and steering with a gamepad. Without any heart rate scaling features, the truck's speed would be directly determined by the speed of the player's cycling. Using the heart rate scaling allowed the player's heart rate to also have an influence over the truck speed – which meant that all players could be on an even playing field no matter how fast they could actually cycle (as long as they put a roughly even amount of effort into it). Through their experimental approach, they are able to quantify the extent to which heart rate scaling can contribute to a more balanced and enjoyable multiplayer gaming experience.

By the end of their experiment, they were able to suggest that their innovative approach to scaling the video game experience to the user's heart rate successfully achieved the primary goal of their study – since they were able to create an inclusive gaming experience that did not rely on the player's fitness level.

One side note here (not mentioned in their study) is that thanks to technology such as Wii remotes and Xbox Kinect, physiological games became popularised to mainstream audiences – where the biggest in-game advantages come from being physically fit. For example, if I were to compete against my younger siblings in a Wii Sports game, I would have a huge advantage over my siblings simply due to the difference in physical ability. I therefore

really believe that this study could really help improve situations like these – where the games could scale to an appropriate level for each player to even out the playing field.

However, one issue with the study is that the idea of using heart rate scaling can be un-intuitive for players to understand and there could be a variety of factors that affect the heart rate, not just the person's fitness level. As I mentioned before, game experiences such as with Xbox Kinect would also not be able to use heart rate to this extent (at least with the current technology that they use – since heart rate CAN be measured with better cameras) – which means that other approaches for how to scale the experiences should be considered. One thing that I think the experiment did not consider in much depth was that many people only play multiplayer fitness games purely to compete with each other to show off their fitness levels, otherwise they would choose a game with more standard controls. In my own experiment, I need to be mindful to take a look at some other ways of altering the experience and not purely rely on the heart rate.

In the study 'Impact of Visual and Sound Orchestration' [3], they explored the emotional impact of horror games. This study heavily relied on using visual elements and sounds in order to alter player experiences. I believe this study will provide me with some insight into how to implement visual and auditory features into my own gaming environment to enhance tension levels. Their study took the already-established horror game 'P.T.' and adapted it to suit their experiment. The study investigated physiological responses via taking galvanic skin response (GSR) measurements and participant-perceived emotions. The idea of this research is to emphasise the importance of context alteration in horror games in order to improve the engagement and emotional impact of the game.

The primary objective of the study was to explore the impact of visual and sound orchestration in horror games – focusing on stress, anxiety and tension levels. The study aimed to identify which visual and auditory effects are the most effective in eliciting stress – which they could determine by taking the GSR measurements as mentioned earlier. The study also wanted to gain an understanding of how context alteration in horror game design can alter the experience – and thus gain insight into how to develop more effective horror games in the future.

Their findings suggest that manipulating the order and combination of visual and auditory effects significantly influences players' emotional reactions to the game experience. The most impactful stress elicitor was found to be sound. This shows me that it is very important to use sound effectively in my own gaming environment.

One issue with the study is that it sheerly focused on the horror game genre, which can limit generalisability for other video game genres – this is an issue I will also have with my own study. Furthermore, the study relied on a fixed-level architecture which can introduce biases that would not be identifiable in the results – which my study will combat by synchronising game events to the tension level. Overall, I believe that this paper has provided me with some insight into some measurements I can take in my own study and also emphasised the importance of auditory effects.

The study 'Death with a Story' [5] explored the impact of adding a storyline to video games (specifically first-person shooter games). The study investigated how adding a storyline could significantly enhance the identification, presence, emotional responses and motivations of its participants. The research also addresses concerns that increasing character identification could potentially lead to violence and heightened aggression for its players – of which the study was inspired. It also recognises how recent video games have evolving narratives in comparison to older video games (of course, this paper was written in 2004 and you can still see today how much video games are evolving to provide players with more powerful stories).

The main objectives of this study were to study the following:

- Investigating how a storyline can influence character identification
- Examine the impact of narrative elements on the sense of presence
- Explore the dimensional aspects of emotional experience in gaming
- Assess the physiological arousal levels of players when exposed to first-person shooter games with and without a storyline, considering implications for desensitisation.

The results of the study show that the presence of a story in first-person shooter games significantly increases player identification, sense of presence, and physiological arousal. The study really conveys how narrative aspects of a video game contribute to the immersion of a video game experience. Whilst this study has limited relation to my own research, it has given me the idea to include some sort of environmental storytelling in the game. It highlights just how effective storylines can be in influencing the player's emotions, so I believe it is very important that I at least consider this for increasing tension.

In the paper 'The Effect of Demanding Mental Tasks on Electrodermal Activity and Heart Rate During Physical Activity: A Pilot Study' [1], they explored a virtual rehabilitation game that incorporated elements controlled via body tracking. They recorded physiological signals, including ECG and EDA, in order to assess the energy expenditure and mental load on the participants.

The utilisation of Arduino for measuring the heart rate in this experiment had several advantages, First of all, Arduino provides flexible functionality and cost-effectiveness in designing custom physiological monitoring systems. Being compatible with various sensors allows the researchers to take any measurement that they deem necessary for their experiment. Furthermore, since Arduino uses open hardware, the researchers can adapt and modify it to be suitable for their study. In this specific study, they also used wireless data transmission over Bluetooth so that they could reduce the discomfort for its participants - which aids in getting accurate and useful data.

In the paper 'Horror game design – what instils fear in the player?' [7], we learn about game mechanics that can be used inside horror games to instil fear in the player. Using a game that they developed themselves, they were able to conduct a study and use recall interviews to find what mechanics can make a horror game scary.

Here are the key elements that they identified:

- **Atmosphere and Immersion**: Creating a scary gameplay experience through environment design, dark corners, and immersive details. Backed up by [5]
- **Auditory Hallucinations**: Incorporating unidentified sounds and music to enhance fear, making the use of headphones crucial. Backed up by [3]
- **Level Structure and Appearance**: Clever placement of furniture and objects that tell a story, facilitating spatial involvement and player immersion.
- **Linear and Open Level Designs**: While not significantly impacting fear, differences in level design styles provide varied player experiences.
- **Fear Build-Up**: Designing levels with a gradual increase in horror elements, aligning with the Ntokos level of fear tool [4].
- **Player Manipulation Patterns**: Incorporating proven horror game design theories, such as the pursue AI pattern and the collection pattern.

- **Strategic Navigation**: Allowing players to strategically navigate levels based on collecting essential items and predicting enemy movements.
- **Darkness and Light**: Effective use of darkness contributes to fear, but prolonged exposure without necessary resources may lead to player frustration.
- **Spatial Involvement**: Creating levels with details that immerse players and prompt them to pay attention to the environment, enhancing the overall horror experience.
- **Use of Headsets**: Emphasising the importance of wearing headsets to fully experience the horror game, particularly in relation to audio elements.

0.3 Methodology

Overview of Gaming Environment Development A Kanban board was used throughout the research project to manage and streamline the workflow. The Kanban method is very strong in terms of efficiency and allowed me to easily plan out the entire project and communicate the tasks that I am completing with my project supervisors. By dividing tasks into different stages, I was able to manage and monitor tasks effectively and with transparency. This board was used to plan our sprints. Each sprint for the game development was 2 weeks long, which included 2 progress meetings to ensure that everything was on track. During each meeting, we reviewed what tasks had been completed and drew tickets from the backlog to be placed on the next sprint section so that we could monitor the progress being made. While a board like this may be deemed unnecessary when a single person is working on a project, we found it very useful to experience what it would be like in a workplace environment with a much larger team.

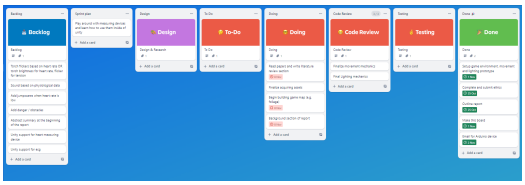

Figure 1: Example state of the Kanban board

To coincide with the Kanban board, the project also made use of a product road-map (namely a Gantt chart) to layout the expected progression of

the project so that tickets could be taken from the backlog appropriately at the beginning of each sprint.

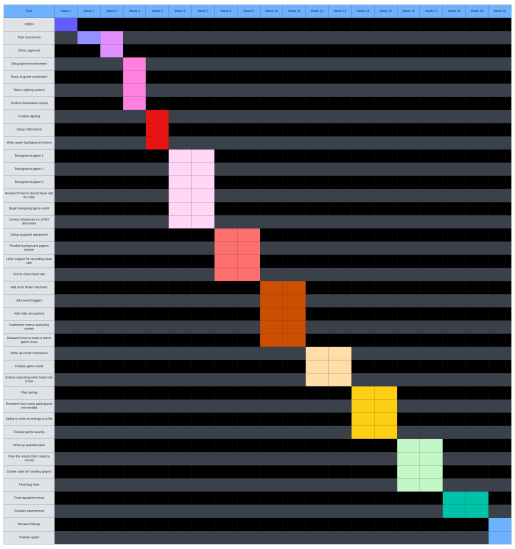

Figure 2: Product Road Map

The figure above shows the product road map and roughly when each feature was added.

To develop the gaming environment, I used Unity. Unity is a very powerful tool that allows rapid development of the environment and is an engine that I have lots of experience using. It also allows reading data from the system input, which is vital for taking in the measurements collected by the Arduino device. Alongside this, we had version control being used during the development. The reasoning for using version control was to simulate a real-life work environment, where version control is vital for working on large projects with numerous teams. Throughout development, I also made use of git for version control to ensure smooth development.

We also made significant use of agile development techniques for this project. The main idea of agile development is to divide projects into small increments, where each sprint leads to a new iteration of the project. It is a very feedback-driven methodology. While agile development is used most commonly in large teams, it can still be an effective approach in a small team in cases where you work closely with a supervisor. Agile methodologies emphasise constant communication and collaboration, where the supervisor is able to provide insights, suggestions, and clarification on priorities, ensuring that the development process stays aligned with the overall goals of

the project. This was very useful in my project as my supervisors were able to guide me along with their expectations so that I could stay on track for completing the key aspects of the project on time. An example of this is that I was tempted to switch out the controls for motion controls, making use of Nintendo Joycon controllers, however, my supervisors were able to rightly steer me away from wasting a large amount of time on something that would not benefit the project in any significant way.

Data collection methods

To gauge participants' responses during gameplay, the study measured heart rate activity of each participant. These methods were found to be effective in a variety of the studies we looked at specifically in the study 'The Effect of Demanding Mental Tasks on Electrodermal Activity and Heart Rate During Physical Activity; [1], although I had to be mindful of not distracting the participant with the measuring equipment, in order to avoid any issues. Heart rate monitoring provided insights into cardiovascular arousal, which is useful for indicating emotional arousal - thus making it a powerful tool for drawing conclusions from the experiment, which also allowed me to tailor the interactive experience to the user and boost the tension when needed. The aim of these measurements was to capture the physical and emotional dimensions of player engagement. I also considered measuring the blood pressure of participants. After conducting my research, I realised that the tools required to measure blood pressure could be very distracting to the participants (for example, having a tight feeling in the arm could significantly impact how comfortable the participant is) and would significantly bias the results that we could draw from the experiment – we therefore ultimately decided to not measure blood pressure. In order to capture the data, I used a small finger scanner for the heart rate. This only affected the participant's usage of a single hand, which did not affect the game experience as it was designed to be playable with a single hand. The scanner could also be attached to the wrist in cases where the participant may prefer not to use their finger, however, it can be slightly more inaccurate using this method so it was important to verify the collected data.

Integration of tension-inducing methods

The interactive gaming environment included a variety of ways of inducing tension. The first noticeable aspect is the usage of environmental storytelling. As soon as the user loads into the game, they can instantly draw some conclusions about the events that must have occurred before the events of the game – and are able to come up with a storyline. This storyline aided in identification, presence, physiological arousal and emotional experience for the participant – which we can see is very effective in raising tension in the research conducted by Schneider [5]. The gaming environment also uses 3D

sound mechanics in order to boost tension – which we found to be a very important aspect of tension thanks to the research conducted by Sarra Graja, Lopes and Chanel [3]. Furthermore, in-game events such as enemy spawns are controlled by the user's physiological responses. Whenever we can determine that they do not feel tense, the game will attempt to raise their tension by throwing obstacles at them and by amplifying the other mechanics such as sound effects. One example of this is that the strength of the flashlight is directly controlled by the heart rate. the faster the heart rate, the stronger the light source, which means that every time the participant begins to calm down, they are suddenly unable to see as much as they previously could - which can cause them to feel more tense and bring up their heart rate once again. Another mechanic is that the user is the player is jump-scared whenever it is deemed that they are not tense enough (this is done through spawning sudden obstacles and also by displaying images - along with audio queues to scare them). We can also take a look at which elements this environment includes that were identified to be very effective tension inducers [7]. Out of the top 10 identified mechanics, our environment uses all 10 of them - so we can be confident that the environment must be able to induce some sort of fear in the participants.

Data Analysis procedures

In order to analyse the data, I used some Python scripts that were capable of reading all of the data files creating some important diagrams and showcasing useful data. These files were named with randomised strings that could be used to link questionnaire answers to the data itself whilst maintaining anonymity - which is very important when you are dealing with physiological data.

0.4 The interactive environment

Controls & Accessibility considerations

As mentioned earlier in the report, ensuring that the game could be playable with a single hand was one of my key objectives. In conjunction with this objective, the game environment can be controlled with a single mouse. To look around the playing field (with the view locked to around 60 degrees in each direction to aid in building tension via the unknown surroundings), the user can simply glide the mouse around in the direction that they wish to look in. To walk forward, the user can just hold the left-click and, finally, the user can hold the right-click to duck. At a minimum, the user can control the game with only 3 fingers which makes the controls very accessible.

In conjunction with this, the user is able to have the heart rate detector

attached to their other hand while playing the game which has minimal distraction and does not get in the way of any of the controls.

Cut-scene

Upon launching the virtual environment, the user is shown an unplayable introduction sequence that introduces them to the in-game world and briefly informs them about what is going on (while keeping the full context a mystery). By the player waking up in a strange cabin with a mysterious wardrobe on fire (and strangely nothing else), the user can gather the fact that whoever they are playing as is in a very strange environment with some unusual events occurring – which aids in building tension through world-building. This was one of the key points in making a horror game scary. The cut-scene then progresses as the player leaves the cabin and walks down to the path where the rest of the game will take place, while finally picking up a lantern with a soft orange tone light emitting from it.

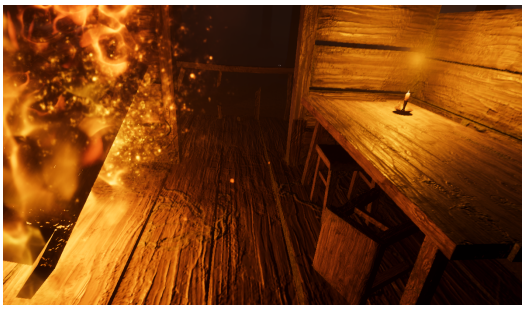

Figure 3: Screenshot from Cut-scene

Figure 4: Starter house (Dev view)

Lighting

Originally, the game was lit by a flashlight that the player held which emitted a white cone of light directly In front of the player. While this concept is very common in other horror games, it turned out to not work very well in this given context. For starters, it means that the player was unable to get the impression of being stranded in the middle of nowhere since they could not see that they were surrounded by trees. Secondly, when close to an object, the harsh white light takes away from the scariness of objects in the environment. To fix these issues, I decided to change the light source to a lantern that emitted a soft orange light around the player, and not just ahead of them. In doing so, the player is now able to feel stranded in the game world and is also able to appreciate the in-game objects more thanks to the softer lighting. In addition to these benefits, there is also the added sound effect of the fire within the lantern which boosts the ambient nose and further builds tension in the user. Furthermore, the sky-box has been carefully designed in great detail to maximise the atmosphere and to match the global lighting settings that I rigorously designed.

Figure 5: Sky-box

Tooltips

To help guide the player, there are various tooltips throughout the game. Firstly, when the cutscene ends, the game tells the player how to walk. Then, upon approaching the fallen tree, the game teaches them how to duck. The final tooltip is shown when the player meets the first static encounter with the enemy which explains to them that they should stop walking immediately when the enemy spawns.

Environmental Story telling

At the beginning of the game, the player witnesses a tree falling down. This is abnormal behaviour that can build tension and cause the user to wonder what their player is going through. There are also several mysterious elements such as wild animals with glowing eyes.

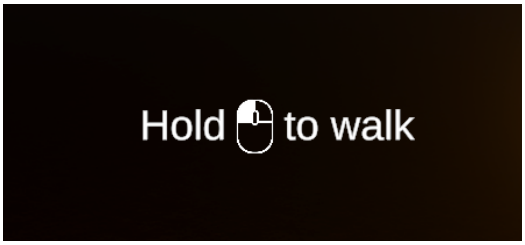

Figure 6: Tool-tip example

Figure 7: Wild deer with glowing eyes

Figure 8: Black cat with glowing eyes (from intro cut-scene)

Sounds

During gameplay, specifically after the second spirit spawns, a variety of sounds play around the player in 3D space. These sounds occur at varying rates based on the player's heart rate. The 3D aspect has been carefully designed to make the best use of the tension-inducing aspects of enigma.

GUI

The user interface shows the user's heart rate at all times. This is to monitor the equipment's functionality during the experiment and also to prompt the participants to be self-aware of the tension that they are feeling - which

should lead to better questionnaire answers.

Figure 9: BPM GUI

Static encounters
Throughout the game experience, there are some static encounters that are the same for every play-through and are completely independent of the physiological status of the user. These have the purpose of guaranteeing at least a few scares to the user and also give me the ability to have a consistent data set across all users to see the effect of a few specific jump scares. There are 3 of these in total, including the tree scene and the first two haunting events. They will also allow me to compare regular events to synchronised events.

Figure 10: First static encounter

Random encounters
As the user plays the game, there are some random events that can occur based on the user's physiological state. Whenever their heart rate is low, they are more likely to have random ambient noises play, their light flickers more and for longer periods of time, and the in-game enemy is more likely to show up. This means that there is a constant building of tension every time the user feels too relaxed. On the opposite end of this, if the user has a high heart rate, then the in-game events are less likely to occur, which is scary in the sense that they wonder why nothing is happening and also gives them the opportunity to rest for a little while. The main scare is the jump scare

from the main enemy. This enemy spawns with a screeching sound and the player's lamp is turned off. The player must stop walking when they see this enemy.

Figure 11: Enemy that spawns in Jump scares

User-based scaling
Since every human has a different range of regular heart rates, it is important that the game does not just use fixed heart rate values for the random encounters, but actually scales to the user. By taking a baseline reading before beginning the experience, the game is able to take an average heart rate throughout the game and determine if the heart rate is high or low for that specific person.

Losing the game
If the player incorrectly moves when the enemy spawns in, they will be greeted with a jump scare and sent to a loss screen which lets them either quit the experience if they feel too scared or try again from a certain point if they want to continue.

Winning the game
Upon reaching the end of the track, the player is instructed to end the game. Initially, I had a jump scare at the end but I ended up removing it due to there being too many static encounters compared to the number of synchronised encounters and also being able to determine the user's heart rate based on the suspense at the end - where they are expecting something to happen at any moment.

0.5 Data Collection and Analysis

Types of analysis
There are two main types of analysis that I will use for this project - quanti-

tative and qualitative. Each of these comes with its own benefits and drawbacks.

Quantitative Analysis

The first main benefit of quantitative analysis is that it allows measurement of the objectives. Since the main measurement is heart rates, which are numerical data, this type of analysis is very powerful for being able to draw conclusions from the data. It also allows for statistical analysis which allows the identification of patterns, trends and correlations within the data. Finally, it allows the participants to be directly compared with each other based on their results.

However, the drawback of this type of analysis is that there is a lack of context in the data, which means that it is difficult to know how the user felt from the data alone - we can only see how their heart rate reacted to the situations. There is also limited emotional insight, where the data could be affected by other factors such as physical activity or distractions.

The environment records the following data that can be used to draw conclusions via quantitative analysis: 1. Heart rate every second during the experiment (records time in seconds against heart rate) 2. Records time stamp (in seconds) when the player encounters an obstacle. Also, note if it was a static (pre-determined) or a random encounter spawned by the tension syncing system.

Qualitative analysis

In order to deal with the drawbacks presented by quantitative analysis, we can use qualitative analysis. The main benefits of this are that we can acquire data about how the participants felt throughout the experience In order to gain a more detailed understanding of the player's emotional journey. It also provides subjective insights that allow us to see how participants felt throughout the experiment and may enable us to draw more conclusions from the data and understand why their heart rate may be what it appeared to be in the data. Finally, we are able to pinpoint the elements in the game that evoked the most fear.

The drawback of this approach is that it can be more time-consuming for both acquiring and analysing the data. Furthermore, since this method is subjective to each participant, the findings may include many contradictions.

Analysis summary

Overall, both kinds of analysis can be used to complete the objective of this study, however they both come with some limitations. To increases the effectiveness of this study, I can combine the important aspects of each and perform both kinds. The qualitative analysis will require some questions to get a deeper understanding of what is going on, so I will ask the participants some questions based on the information I would like to perform qualitative

analysis on.

How similar projects analysed their data

In quantitative research, the sample size is determined by statistical factors to ensure the study has enough power to detect effects. On the other hand, qualitative research aims for data saturation and in-depth exploration, often resulting in smaller sample sizes. In this specific study, it is important to take this into consideration if we will use both kinds of data. Ideally, you would want at least 50 people to get sufficient data to support the objective in terms of the qualitative analysis. Qualitative analysis requires less people but lacks some important data to prove the objective.

Keeping these in mind, I aim to get at least 15 participants on board with the experiment. This number of participants is enough for the quantitative analysis but is not exactly ideal for the quantitative analysis – so I should take this into consideration when making my final analysis. Ideally, I would like to have 50 or more participants, however due to the time constraints and nature of this project it is just not feasible to get that many.

In the study 'Heart Rate Control of Exercise Video Games' [6] they performed the analysis in their experiment by aiming to evaluate the impact of heart rate scaling on the competitiveness of players within their racing game. The study involved examining the results of races under different conditions and categorising them into close and blowout races based on speed differences. Furthermore, they also took engagement scores into consideration and gathered feedback and preferences from the participants.

***Strengths*:**

- Detailed Analysis: They considered both the overall results and also broke down the analysis into specific types of races. This allowed for a deeper understanding of the impact of HR scaling in different scenarios.
- Participant Feedback: The study incorporated participants' statements, giving qualitative insights into their experiences and preferences, contributing to a more comprehensive evaluation.
- Engagement Scores: The inclusion of engagement scores provided additional metrics to assess players' experiences under different conditions, contributing to a more holistic evaluation.

***Weaknesses*:**

- Sample Bias: The study primarily involved young and fit participants from the university population, potentially limiting the generalisability of the findings to a more diverse population. The bias may have influenced the observed race characteristics.

- Limited Duration of Experiment: Participants performed only two races under each condition, making it challenging to draw conclusions about the long-term effects of HR scaling, particularly on the potential reduction of the disheartening effect of repeated losses.

- Heart Rate Calculation Limitations: The use of predicted maximum heart rate based on a linear formula and the measurement of resting heart rate at the beginning of the experiment may introduce inaccuracies. The study acknowledged potential variations in resting rates that were not considered.

Overall, their analysis was strong but imitations such as sample bias, short experiment duration, and potential inaccuracies in heart rate calculations should be considered when interpreting the findings. These findings can be used to inspire my own analysis methods. They combined qualitative and quantitative analysis to make conclusions about varying parts of their experiment, for example, the engagement scores and the actual heart rate findings use each of the methods to analyse them.

This study also emphasises the importance of having varying types of participants to avoid any sample bias. I can use this in my own experiment by ensuring that I get at least half of the participants from diverse backgrounds and age groups.

In the paper 'The Effect of Demanding Mental Tasks on Electrodermal Activity and Heart Rate During Physical Activity: A Pilot Study' [1], the researchers used the "Kruskal-Wallis" test (which compares medians of three or more groups) to detect the differences in-game statistics, kinetic power and physiological signals during the rest and activity. They used this test across different segments and focused on the initial and final 90 seconds of stressful activity periods. For the physiological signals, percentage significance was calculated for each variable, which they used linear regression on to find trends that highlighted the cognitive load's effects. Overall, the analysis was able to identify the impact of cognitive demand of physical activity and physiological responses.

***Strengths*:**

- Detailed Experimental Design: The study is well-structured, outlining the experimental setup, tasks, and data collection methods. The inclusion of three activity blocks with varying difficulty levels allows for a comprehensive exploration of the relationship between cognitive load and physical activity.

- Quantitative and Physiological Measures: The researchers collect a diverse set of data, combining quantitative game statistics, kinetic power

estimates, and physiological signals (ECG and EDA). This approach enhances the depth of the analysis, providing insights into both behavioural and physiological aspects.

- Statistical Analysis: Robust statistical methods, such as the Kruskal-Wallis test, are employed to analyse the data. This enhances the reliability of the findings by identifying significant differences across levels and blocks.

***Weaknesses*:**

- Small Sample Size: The study's sample size is small, with 27 participants, and the exclusion of two individuals further limits statistical power. The study acknowledges this limitation, categorising itself as a pilot study.

- Lack of Control Group: The absence of a control group hinders the ability to establish causal relationships. A control group engaged in a different activity, or no activity would provide a baseline for comparison.

- Limited Generalisability: The participants are healthy volunteers, potentially limiting the generalisability of the findings to individuals with specific rehabilitation needs. Including a more diverse participant pool, especially those with rehabilitation requirements, could enhance external validity.

Overall, limitations in sample size, lack of a control group, and potential generalisability issues should be considered when interpreting the results. However, this paper emphasises the importance of ensuring that I have some sort of control group. In this regard, I may want to consider giving some people a version of the game with no adaptations and analysing how different the results are compared to the people who had the full version of the game. However, this would require at least 25% more participants to ensure a decent balance and may not be feasible within the time limit.

Both studies note the weakness of their small sample size. They had 24 and 27 participants respectively. Due to this, I should try to get as close to 20 as possible (at the minimum) to be able to draw any conclusions from the experiment at all.

Final questionnaire questions (excluding demographics):
Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

Useful for pinpointing specific aspects of the adaptive environment that contribute to tension regulation or distraction. This question is also for my personal development for potential future projects.

To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? Useful for exploring the relationship between immersion and dynamic environmental changes in the context of tension regulation.

Before the virtual experience, how would you rate your baseline tension level? (please choose one) Useful for establishing a baseline and understanding participants' initial tension levels before exposure to the virtual environment.

During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response? Useful for identifying critical moments of tension variation and linking them to emotional responses during the virtual experience.

Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary. Useful for understanding both the stress-inducing and stress-alleviating elements within the virtual environment.

On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? Useful for summarising and quantifying the overall subjective impact of the interactive virtual environment on tension levels.

Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe. Useful for identifying potential negative aspects or discomfort caused by dynamic changes in the virtual environment.

Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience? Useful for linking subjective experiences with objective physiological responses to the virtual environment.

Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain. Useful for evaluating the impact of adaptive features on the user's enjoyment of the virtual experience.

There is also an attention check question to ensure that we can trust the responses from the participants. This questionnaire was shared with participants via the Qualitrics platform to ensure anonymity.

0.6 Results

Result formats
There are a variety of ways that I was able to format the data in order to be able to draw conclusions from it. I will outline the methods here:

Tables: Tables are very useful for reporting the overall results for the users, whereas diagrams may be messy to showcase the information. I can use tables to summarise the mean heart rates of participants and to showcase the varying tension levels numerically. I can also use these to get an idea of the trends within the data, which can be backed up by looking at the other data formats. Due to tables not taking up too much space, I can also showcase the whole data set with them in this report - as opposed to the graphs which take up too much space to showcase all of them.

Line-graphs: Line graphs can be used to plot heart rates over time and to highlight any key events that occurred during the play-throughs, which allows me to see the impacts of each type of event and to visually see if they were effective or not. Overall, they provide a clear visualisation of the impact of events on the participants' tension levels which helps me achieve my objectives.

- X-axis: Timestamp
- Y-axis: Heart Rate
- Points: Heart rate measurements
- Lines markings: Events (colour-coded for sounds, static and non-static scares)

Histograms: Histograms can be used to plot the frequency of the different heart rates that participants had during their play-throughs. This allows the distribution and variability of heart rates to be visually assessed and can convey the effectiveness of tension increases (where the mean heart rates can be seen very clearly, unlike the tables).

- X-axis: Heart Rate
- Y-axis: Frequency
- Bars: Heart rate frequency

Difficulties in analysing the results
Due to the nature of the game, every participant experienced events occurring

at varying in-game times. For example, one user might have taken 60 seconds to reach the first static encounter - whilst another may have had the same encounter after 40 seconds. This means that I cannot simply plot one huge graph of everyone's heart rates since they all span over different time lengths. In order to solve this issue, I can abstract data around key events. For example, I can look at a 10-second time frame surrounding each encounter so that I can see the effect that the encounter had.

Another issue is that due to the idea of synchronising game events to each participant, they each had different numbers of encounters with the main enemy in the game. This implies that I cannot just plot every time frame around encounters for all users evenly and I must take this into consideration when analysing the results.

The final issue that I have faced is the idea of in-game deaths. Upon dying, the user starts again from the beginning and has to face the static encounters again. Due to this, the participants who experienced at least one death became accustomed to the static encounters and were less prone to tension increases from the same events, which could have affected their results. To solve this, I could stitch their results together after their death and remove the events that had already occurred - but I did not want to impact the results too much so I included this as a separate analysis at the end.

Average heart rates

Here is a table that shows the mean heart rates for each participant and their mean heart rate increase:

Participant ID	Mean Heart rate (bpm)	Mean Heart rate increase	Standard deviation of increase
87823	81.8	5.6	2.41
44103	66.9	6.41	3.368
26296	83.2	2.8	1.737
88134	74.0	6.3	4.891
15745	82.2	7.4	7.186
32696	73.6	5.83	2.273
90926	72.3	6.9	3.883
12102	90.5	5.6	1.999
61105	83.4	5.9	3.576
24719	81.6	8.7	4.865
85551	90.9	2.1	3.965
62579	78.9	5.9	3.242
37228	78.2	9.6	4.409
14509	86.1	4.5	1.384
26279	74.0	-2.2	2.414
40310	93.4	7.1	1.749
95067	63.5	2.8	2.14
28479	60.6	10.1	3.229
89981	85.2	7.21	4.917
55030	62.5	7.1	2.867

Table 1: Results summary

One form of analysis that we can do on the data is looking at the standard deviation of the heart rate increase after events occur. Standard deviation is a measure of the dispersion or spread of a dataset. For this experiment, a lower standard deviation indicates that the heart rate values are closer to the mean, suggesting less variability in heart rate and a higher standard deviation indicates that the heart rate values are more spread out from the mean, suggesting greater variability in heart rate.

For example, a standard deviation of 4 means that the heart rate increases around 4 beats per minute (bpm) above the mean heart rate. Overall, this means that the higher the deviation rate is - the more affected the participant was.

Average heart rates to Number of encounters

Here is a table that showcases the number of encounters that participants had, along with their mean heart rate increases of the 3 static encounters versus their random encounter heart rate increases.

Mean Heart rate (bpm)	Number of random Encounters	Mean heart rate increase (Static)	Mean heart rate increase (Synced)
60.6	3	8.3	11.5
62.5	4	7.6	7.9
63.5	4	3.1	3.1
66.9	3	6.3	6.9
72.3*	2	7.0	6.2
73.6	2	5.75	7.5
74.0	3	7.0	7.6
74.0	3	-2.2	-1.2
78.2*	2	11.0	9.0
78.9	2	7.2	8.8
81.6	3	9.0	9.8
81.8	0	5.2	N/A
82.2	2	7.3	7.5
83.2	3	2.0	2.7
83.4	2	5.3	6.5
85.2	1	8.8	9.0
86.1	1	4.8	5.6
90.5	2	4.3	7.0
90.9	0	2.75	N/A
93.4	0	8.3	N/A

Table 2: Heart rate to number of encounters & Static vs Dynamic

* case where the dynamic events were less effective - only 2 out of 20

Number of encounters to heart rate

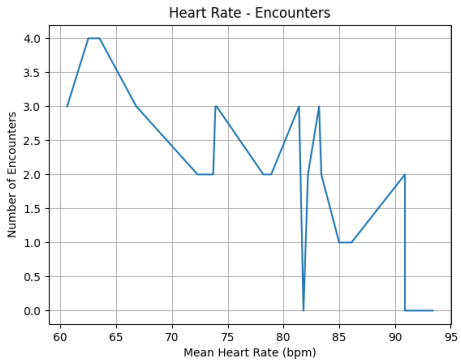

Figure 12: Heart rate to number of encounters

Line graph example (the rest are in the appendix)

As mentioned previously, these line graphs can be used to determine the differences in heart rate at each type of event. This example shows slightly less tension in replayed events and how the heart rate increases after the dynamic encounters.

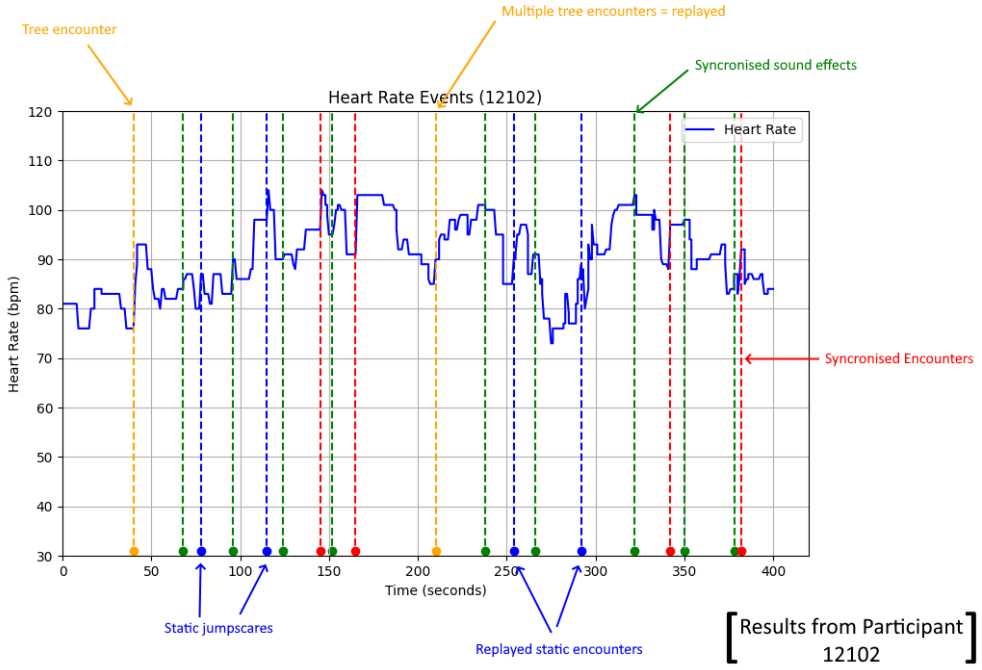

Figure 13: Line graph example

Histogram example

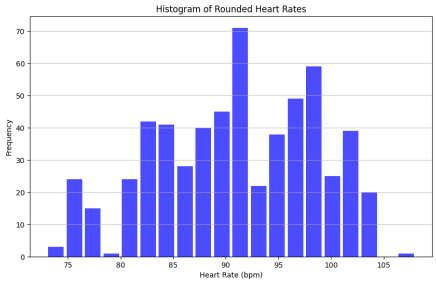

Figure 14: Histogram example

This histogram plots the frequencies of each heart rate for a participant.

Questionnaire answers summary

Ages The participants had varying backgrounds across all different ages.

Figure 15: Ages

How frequently do you play video games?

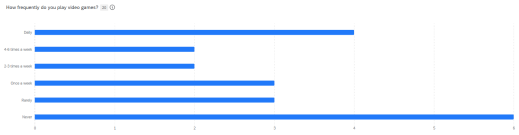

Figure 16: Video game frequency

The participants are highly diverse in terms of video game experience, which is good for getting a broad view throughout the analysis.

How frequently do you play horror games

Most participants rarely or never play horror games. This means that most

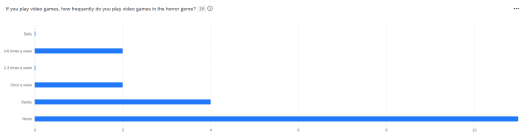

Figure 17: Horror game frequency

of them should not be accustomed to jump scares and we can hopefully get a more accurate picture of how they affect people's tension.

Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

Some of the most important answers were that the wires for the heart rate monitor were distracting, the controls were easy and the jump scares were

highly effective.

To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels?
The mean was 8.11 out of 10 for this question, which implies that the majority of participants felt immersed in the experience.

Before the virtual experience, how would you rate your baseline tension level? (please choose one)
All but one participant claimed to be relaxed before the study started. The that was not relaxed may have slightly biased results in the experiment.

During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?
Many participants mentioned that they felt tense during the jump scares. Some other answers included the cutscene (which 2 people said), the animals in the scene and that the felt tense in between jump scares.

Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.
Every single participant mentioned jump scares in their answer to this question. Some other answers included the lighting, being able to see your heart rate, the falling tree, the environment itself and the lamp flickering.

On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels?
The mean for this one was 8.37, meaning that most people believed that the environment was effective in affecting their tension levels.

Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.
All participants said no.

Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?
Most responses mentioned their heart racing and sweating, with a few claiming that they did not notice anything and one person saying that they felt

nervous.

Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.
Some participants said that the wires took away from the experience a little and the rest were either unsure or believed that it made the game more fun/scary. I believe that this question was a little misunderstood and I could have phrased it better in order to get more clear answers.

Attention check

Figure 18: Attention check

One participant was not reading the questions properly, so I will ignore their responses in my analysis.

Response quality
I am unsure what this means, but Qualitrics seems to believe that the re-

Figure 19: Response quality

sponses are all of high quality. Discarding the person who failed the attention check, I agree with this.

0.7 Analysis

Mean heart rate increases

Overall, the majority of participants *did* indeed show an increase in heart rate around the jump scares present in the virtual environment, with the mean heart rate increase for all of the participants being 5.96 bpm. While it is true that they did have increases in heart rates, they did not increase quite as much as I had expected after seeing heart rate increases in other experiments as high as 30 bpm. The reason for this is most likely due to the length of the experiment, which I will discuss in more detail in the limitation section.

It is also important to note that the majority of participants claimed to be quite calm and free of tension during the experiment, which is very important in the opening sequence for recording the baseline tension level - meaning that the results are more likely to be accurate for a broad number of aspects.

From the results, we can therefore conclude that virtual environments do have the potential to induce tension in players.

Standard Deviation of Heart Rate Increase

Similarly to the increases in heart rate, the mean standard deviation of the heart rate increase was 3.3 bpm, which is slightly lower than the mean increases. There are a variety of reasons for this, such as the players remaining tense after jump scares - so their heart rate may remain slightly higher than their usual resting heart rate throughout the experiment which can make the standard deviations slightly lower than the increases. However, in the results, you can see how the main spike of heart rates after jump scares did not last very long themselves - with heart rates dropping as quickly as 3 seconds after the event occurred.

From this, we can conclude that tension spikes can last a very short amount of time, but they have longer-lasting effects after the initial spike that can lead to a consistently higher heart rate. This further proves that virtual environments can have an impact on tension levels.

Demographics

Despite there being a wide range of ages in the participants that took part in the experiment, there was no clear evidence to suggest that age has an effect on tension levels in this experiment. This is most likely due to the way that the game balances itself to match the state of the user, which mitigates the differences in baseline tension levels. However, I did notice that the elder participants had a lower average heart rate overall. I could not draw any conclusions from the other demographic questions due to time constraints.

Heart-rate increase of Static vs Synchronised Events

The data indicates that the synchronised events were slightly more effective than the static encounters. There are several possibilities for this. For example, some participants remarked that the statically placed encounters were quite obvious and that they were able to brace themselves for the scare. To further prove this hypothesis, some of the questionnaires also mentioned that they did not feel scared by the first few encounters and became much more scared as the experiment continued. This could also be attributed to the increased levels of immersion as time went on.

As we can see in the results, the static encounters had a mean static increase of 6 bpm, whilst dynamic encounters had a mean of 6.6 bpm (a 10% increase). Overall, ensuring that scares are unexpected is crucial for inducing tension in players - and I believe that allowing a game to predict if a user is braced for a scare can be a very effective tool for ensuring this. Therefore, dynamically synchronising game events with the player can be a very powerful tool for inducing tension.

Effectiveness of synchronised events

Since the game events were synchronised differently for each participant, participants had varying numbers of encounters with the main enemy. We can see in the data that participants with fewer encounters generally had a higher mean heart rate than those with many encounters - where the line graph trends towards 0 as the heart rate increases, which shows that the mechanics that I implemented worked as intended and we can therefore conclude that I was able to successfully build an environment that synchronises to the player as intended. I can also include that the synchronised events are around 10% more effective than static events in raising tension as mentioned in the previous section.

Overall, consistent heart rate increases across most participants indicate that a person with a high resting heart rate and a person with a lower resting heart rate can both enjoy the game equally and experience the same level of tension - which highlights one key advantage of synchronisation which we also saw in some of the other studies. In contrast to this, a game that is not synced to the player may see the effectiveness of encounters significantly reduced. Therefore, synchronising events with the user is an effective method for inducing tension.

Effectiveness of sources of tension increases

One of the things that I researched before developing the environment was the different ways of making a game more scary. I used my findings when developing the environment to improve the effectiveness of the tension-inducing elements. Unfortunately, the effects of some elements were not possible to record data for so I can only make conclusions about the elements that could be recorded or that participants mentioned in their questionnaire answers.

Firstly, the *ambient* sound effects that I included in the game seemed to have little to no impact on the user's heart rates. By looking at the line graphs with the sound effect time stamps on - you can see that there is no noticeable difference in the heart rates for most users. However, there was one particular sound effect that I noticed while conducting the experiments that did seem to scare people a little. There was also one participant who mentioned it in their questionnaire. The "look behind you" sound effect seemed to genuinely scare some users. When this sound effect played, many of the participants attempted to look backwards and then realised that it was impossible to do so in this game - which I believe is what made this scary. These sound effects were synchronised to the heart rate in the same way as jump scares, but I believe that they may be more effective if they are strategically placed in places that the environment exemplifies. Just like how that particular sound was scarier because the environment would let the user turn around, I believe that you can place sounds in places such as different rooms from the player in games in order to make it tension-inducing since it is impossible for the player to see what made that sound at the time. These findings are further proven by the paper that delved into how sound can be used to persuade people's emotions.

The effects of world-building are one thing that could not be analysed from the game data, but the effectiveness can be implied from the participant questionnaire answers. Some of the participants made remarks such as the animals with the same glowing eyes as the monster were quite scary and the idea of that was quite mysterious and unsettling. There were also remarks about the beginning of the game being very mysterious with people wondering what was going to happen and what could have happened beforehand. One key element was the lighting itself, with everything being difficult to see other than the monster itself. This means that the jump scares in the game had an increased effect due to the environment surrounding them and it is therefore important to note the importance of the environment.

The most effective source of tension was by far the jump scares. These are the only noticeable events that notably increased tension in the data. Since we also found that synchronised scares were more effective than strategically placed / static encounters, it is clear that these can have a greater impact when synced to the player's physiological state. Unlike the sound effects, they were consistently effective and improved the experience as a whole.

The loss of effectiveness on subsequent attempts

One thing that I learned was that players who had to reattempt the game had lower heart rates in their second play-through. Namely, they were almost completely unaffected by the static encounters on their second play-through and had lower heart rates throughout the entire introduction section. How-

ever, the random synchronised encounters were seemingly *not* impacted by this. The conclusion that I can draw from this is that synchronising with the user instead of having scared in the same place can also boost replay ability and prevent the deterioration of tension inducers inside the virtual game.

Therefore, I can conclude that having game events synchronise with the user can also be effective in maintaining tension across multiple play-throughs of the game. This potentially opens the doors to improving the replayability of horror games drastically - since currently people can often only play through a horror game a single time with it being scary. I believe that further research on this fact could be beneficial for many game designers.

Further Questionnaire analysis

There are some things that I learned from the questionnaire answers that the other analysis sections did not cover, so I will briefly detail them here.

Firstly, the participants seemed to find the world around them to be quite spooky - which means that I was successful in developing a "scary" environment. A number of participants also found the mechanic of standing still to ward off the enemy as an effective tension inducer - with one participant remarking "It was very scary to see the monster in front of me". This reassured me that I did a good job in developing the jump scares.

Another important thing that some participants claimed was that they felt involved in the story and were bewildered at the beginning trying to figure out what was going on inside the burning building. This is good to hear because the story was important and I did not have enough time to create an entire backstory for the character, but I was still able to achieve the immersion that I was aiming for.

Arguably the most important question in the questionnaire was when the participants were asked to describe moments when they felt tense. All participants remarked that the jump scares were the key aspect that made them feel tense, and some mentioned the tree at the beginning slowly falling was mysterious and made them feel tense from the beginning. They also found the lighting to be quite spooky, which falls in line with the other studies that I researched that claimed lighting is very important for immersion and boosting tension,

Some participants claimed that the equipment was a bit distracting, which is unfortunate since I tried my best to avoid this with the accessibility features. If I were to repeat the study, I would definitely put further research into other ways to record heart rate without detracting from the experience - most likely with a smartwatch or a sensor attached to the mouse.

Overall, the responses in the survey were very useful for discovering the strengths and weaknesses of my study and have given me great insight into potential improvements that I could make if I were to explore this topic

further in the future. I also felt quite relieved to see that the short horror game that I made seemed to be somewhat effective in inducing tension and I was glad that the participants appreciated different aspects of it.

0.8 Conclusion

In conclusion, the objectives of the study were to evaluate the effectiveness of different tension-inducing elements in a virtual environment (which became a horror game) and to assess how synchronising game events to the user's tension level can further improve the effectiveness of the mechanics.

In the created environment, the jump scares were the most effective sources of tension, which showed significant evidence of increasing the heart rates of the majority of participants. In addition to this, we found that synchronising the game events to the player's physiological state proved to improve the effectiveness of tension-inducing elements by both maintaining their impact throughout the game and also ensuring that players with different resting heart rates could experience similar levels of tension - which we also saw in the other studies. Furthermore, the synchronised events were able to help prevent the scares from becoming ineffective in replays of the game - thus improving the replayability of the game. We can also see in many cases that the participants' heart rates increased throughout the play-throughs which means that the experience was able to build tension constantly.

Overall, this research provides valuable insights into the effects of video games on players' tension levels and also highlights how synchronising events inside of the environments can improve the effectiveness of the tension-inducing elements. Future studies could focus on trying to use physiological synchronisation to improve the replayability of games with a focus on inducing tension, like horror games, and to create more immersive and engaging experiences for the players. Furthermore, I can envision this technology excelling in mobile games in cases where users are wearing smart watches or even in Virtual Reality games where the headsets could be capable of recording physiological data. An example of this could be a horror game that spawns tension-inducing games in the line of sight of the player with the eye-tracking technology on high-end headsets.

0.9 Further Limitations

In addition to the small sample size (as mentioned earlier), another limitation of this experiment is the time length of the experiment itself. For a

player to be able to fully immerse themselves in the game world, you would expect them to need to play the game for at least 15 minutes for maximum impact of horror elements. Since this experiment takes around 4 minutes to complete, the player may not be as affected by the horror aspects as they could have been with longer time. This unfortunate limitation is due to the short development time and the short amount of time that I had to conduct the actual experiments, which meant that I had to make a shorter game. This also results in many scares in a short time which can be expected and thus decreases the tension in the user.

0.10 Ethical Considerations

All data collected in this experiment was stored securely and anonymously to ensure that no participants could be identified. Furthermore, all participants were informed in detail that the game would not be suitable for any persons with known heart conditions and were also told that they could end and leave the experiment at any time if they felt uncomfortable. Please see the attached ethics document for more details.

Furthermore, the questionnaire was built to not allow any responses without consent. Any time the user did not consent, they would be removed from the survey. You can view the survey here:
`https://standrews.eu.qualtrics.com/jfe/form/SV_2lgvJ5Slo6NhRxY`

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[7] Tobias Årnell and Nikola Stojanovic. Horror game design – what instills fear in the player? : A study on the effects of horror game design theories and level design patterns on player behaviour in a horror environment., 2020.

0.11 Appendices

The game can be run via the included executable file on a Windows device. This .exe file can be found in the Unity build folder. I have left the game in a state that is playable without the equipment in case you would like to try the game out (with some predetermined heart rate numbers). If you were to connect the correct equipment then the game will detect this and switch to normal operation. All data is stored inside the records folder. If you would like to see how certain aspects of the game work, you can see the included C# scripts inside of the project folder.

The Unity scripts folder contains a copy of the scripts used inside the Unity project. The project folder itself contains 51,119 Files - so I am not able to share the entire game along with its assets and packages, which is why I chose to just share the scripts and the executable. The most important functions are in the heart rate controller and serial reader - note some functions may appear to not be linked to the other functions because they are called from in-game trigger events.

The scripts used to analyse the data are included in the "scripts" file, with the data itself being stored in the "data" folder. These are written in Python.

University of St Andrews | FOUNDED 1413

School of Computer Science Ethics Committee

03 November 2023

Dear Paul,

Thank you for submitting your ethical application which was considered by the School Ethics Committee.

The School of Computer Science Ethics Committee, acting on behalf of the University Teaching and Research Ethics Committee (UTREC), has approved this application:

Approval Code:	CS17308	**Approved on:**	03.11.23	**Approval Expiry:**	03.11.28
Project Title:	SyncPulse: Tension Levels Synchronization in an Interactive Gaming Environment				
Researcher(s):	Paul Revell				
Supervisor(s):	Abd Alsattar Ardati and Xu Zhu				

The following supporting documents are also acknowledged and approved:

1. Application Form
2. Participant Information Sheet
3. Participant Consent Form
4. Participant Debrief Form
5. Participant Advert
6. Sample Questions

Approval is awarded for 5 years, see the approval expiry data above.

If your project has not commenced within 2 years of approval, you must submit a new and updated ethical application to your School Ethics Committee.

If you are unable to complete your research by the approval expiry date you must request an extension to the approval period. You can write to your School Ethics Committee who may grant a discretionary extension of up to 6 months. For longer extensions, or for any other changes, you must submit an ethical amendment application.

You must report any serious adverse events, or significant changes not covered by this approval, related to this study immediately to the School Ethics Committee.

Approval is given on the following conditions:

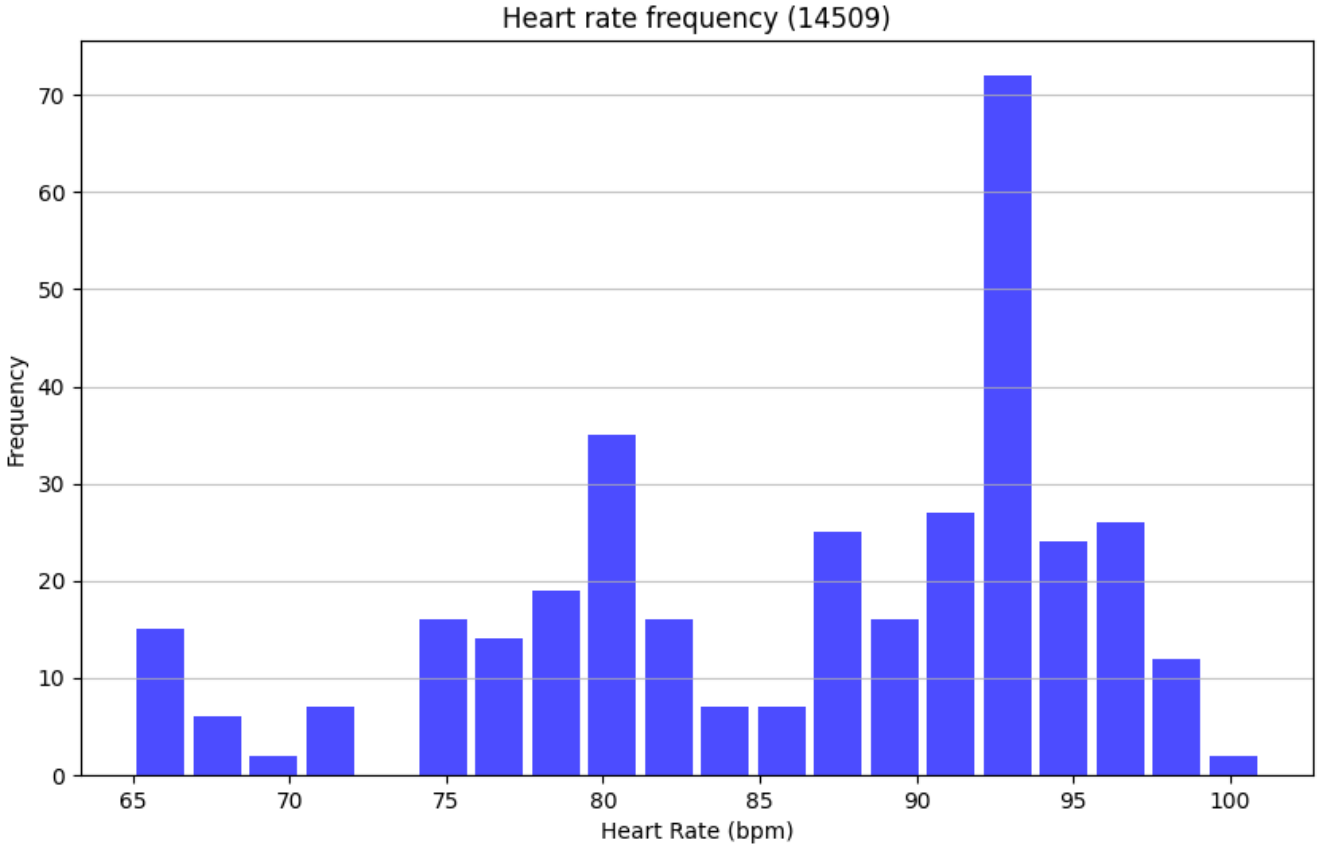
- that you conduct your research in line with:
  - the details provided in your ethical application
  - the University's Principles of Good Research Conduct
  - the conditions of any funding associated with your work
- that you obtain all applicable additional documents (see the 'additional documents' webpage for guidance) before research commences.

You should retain this approval letter with your study paperwork.

Yours sincerely,

Wendy Boyter

SEC Administrator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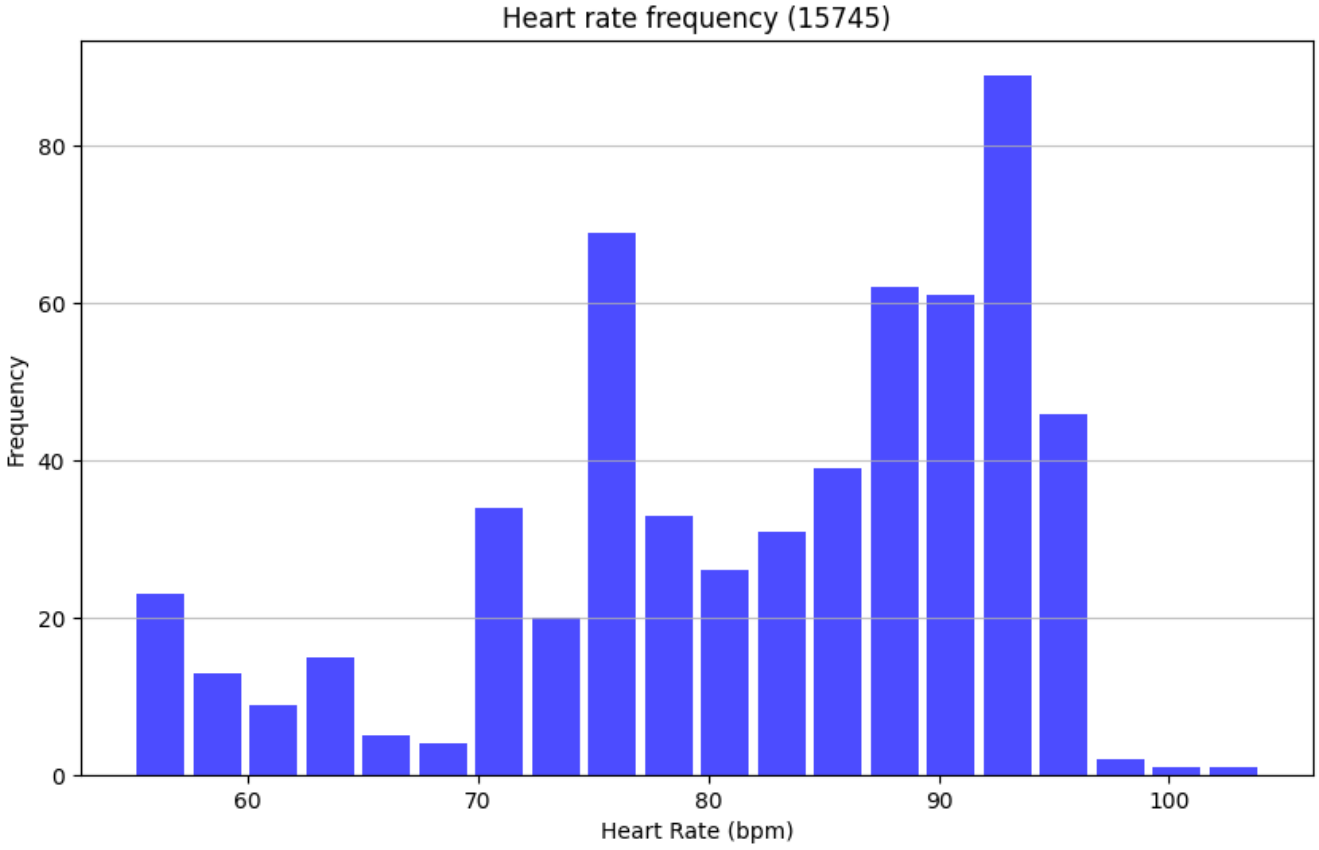
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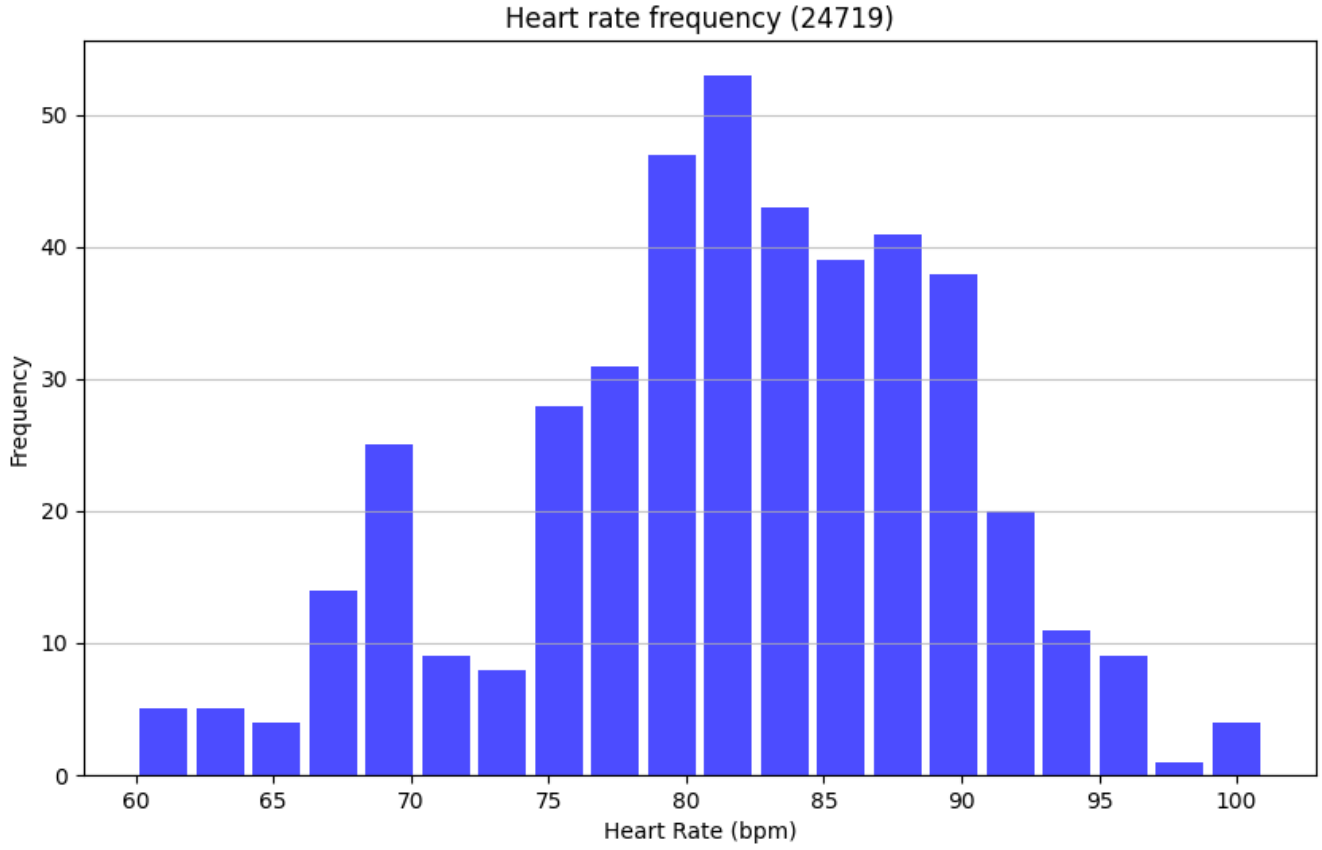
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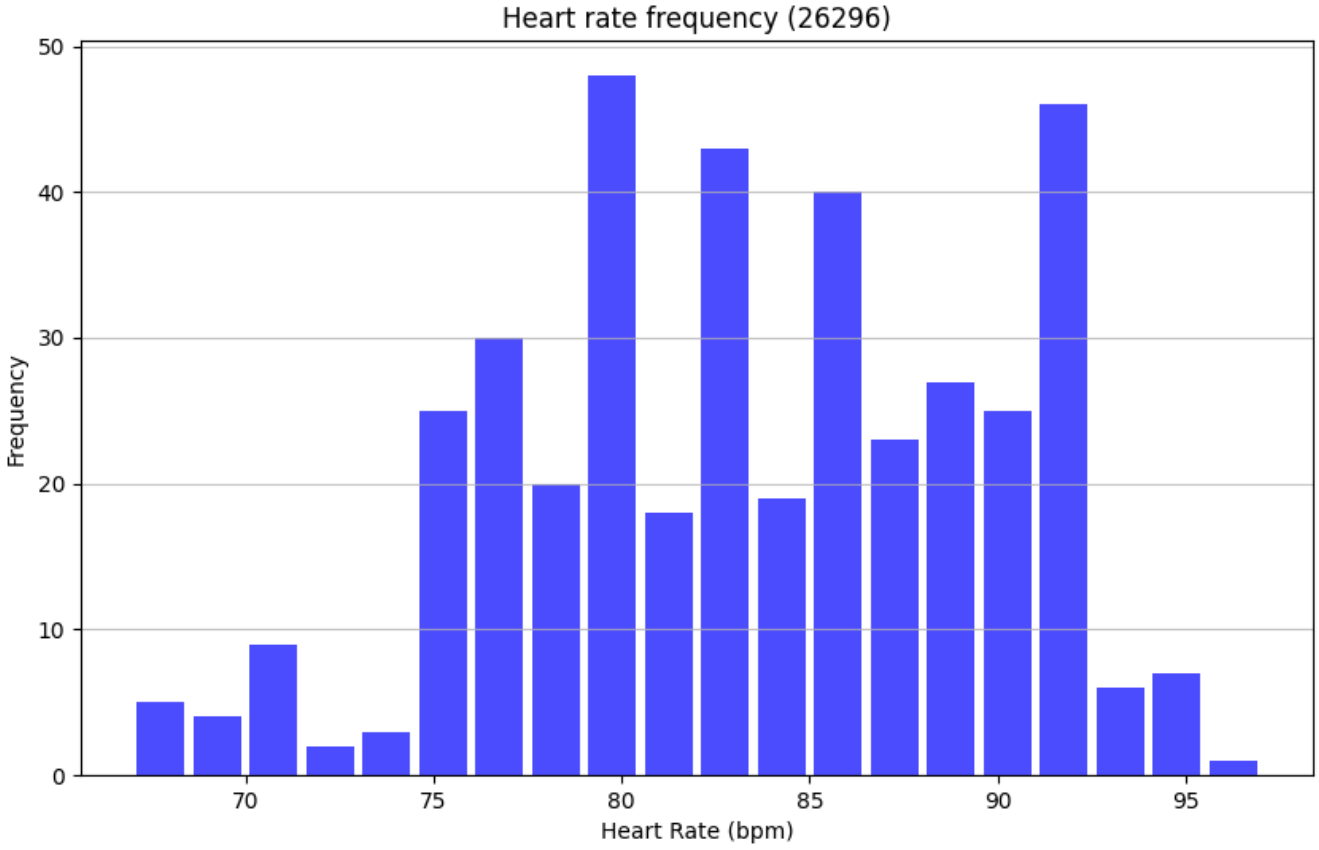
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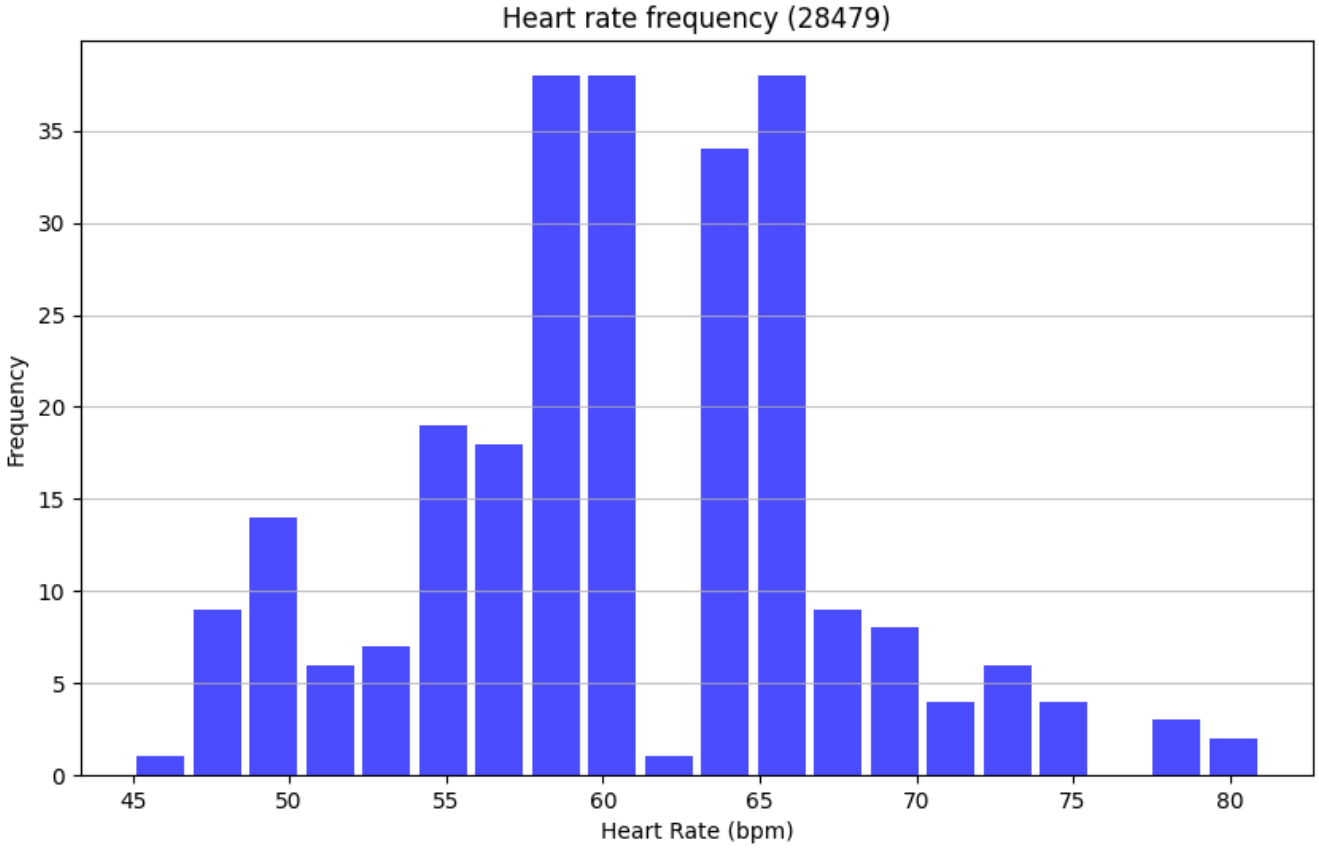
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Heart Rate (bpm)
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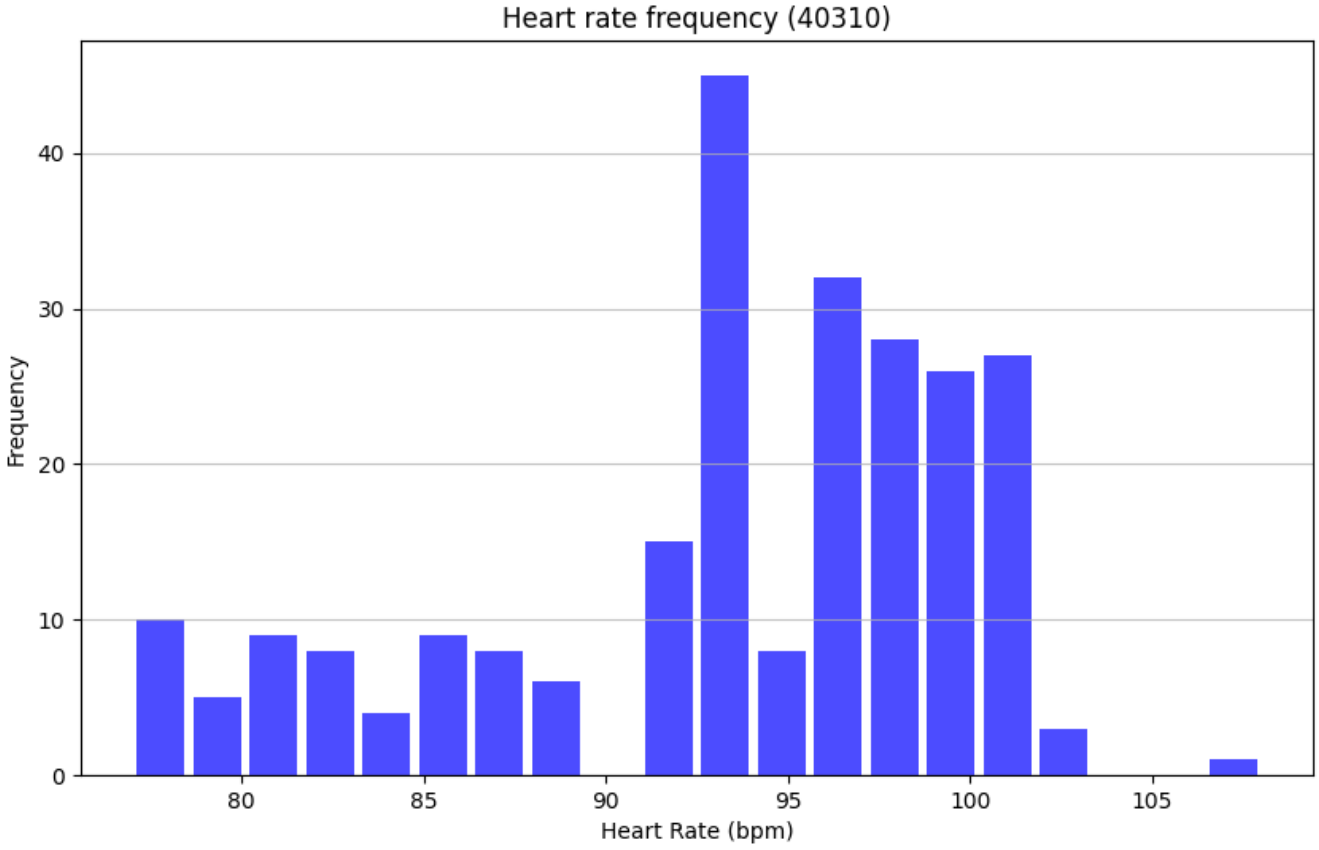
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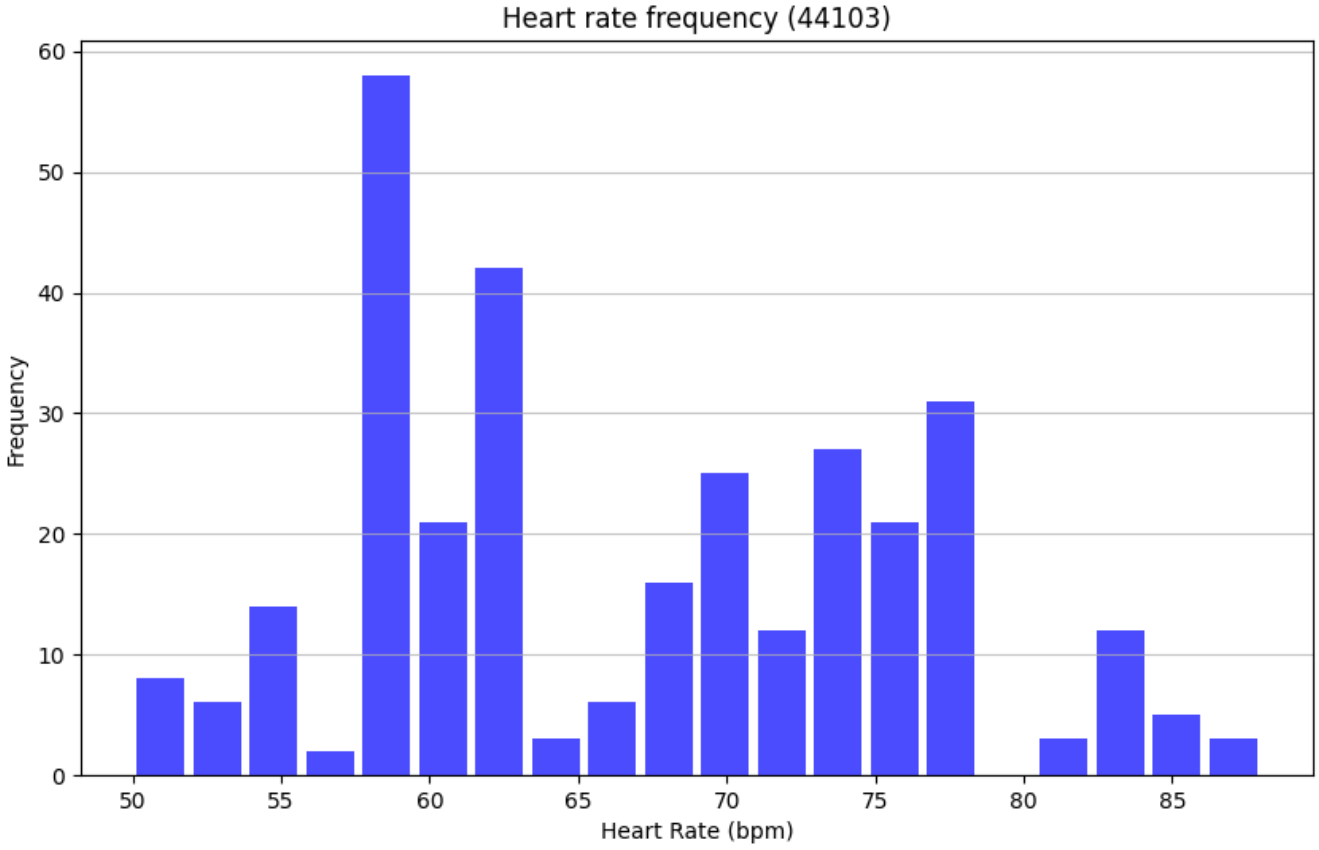
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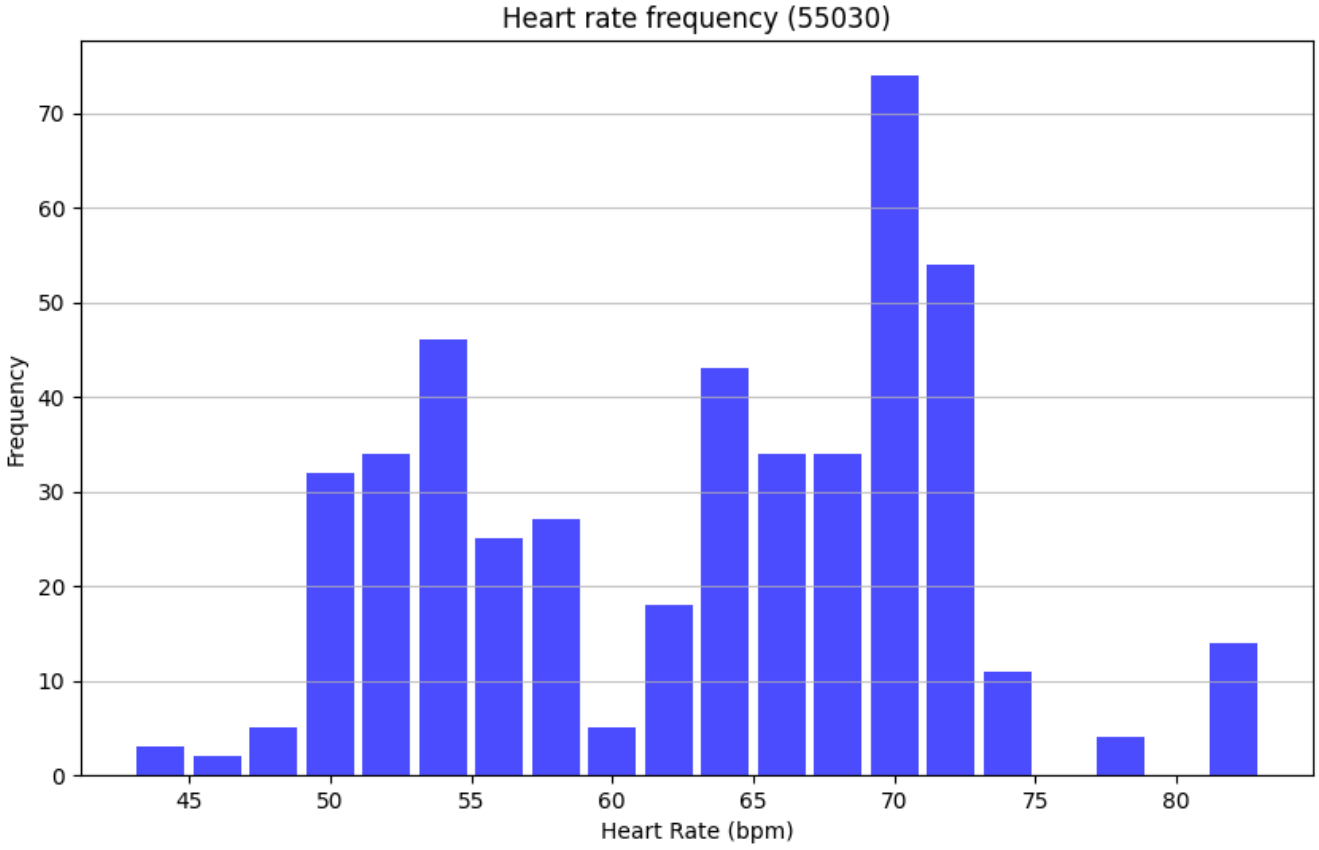
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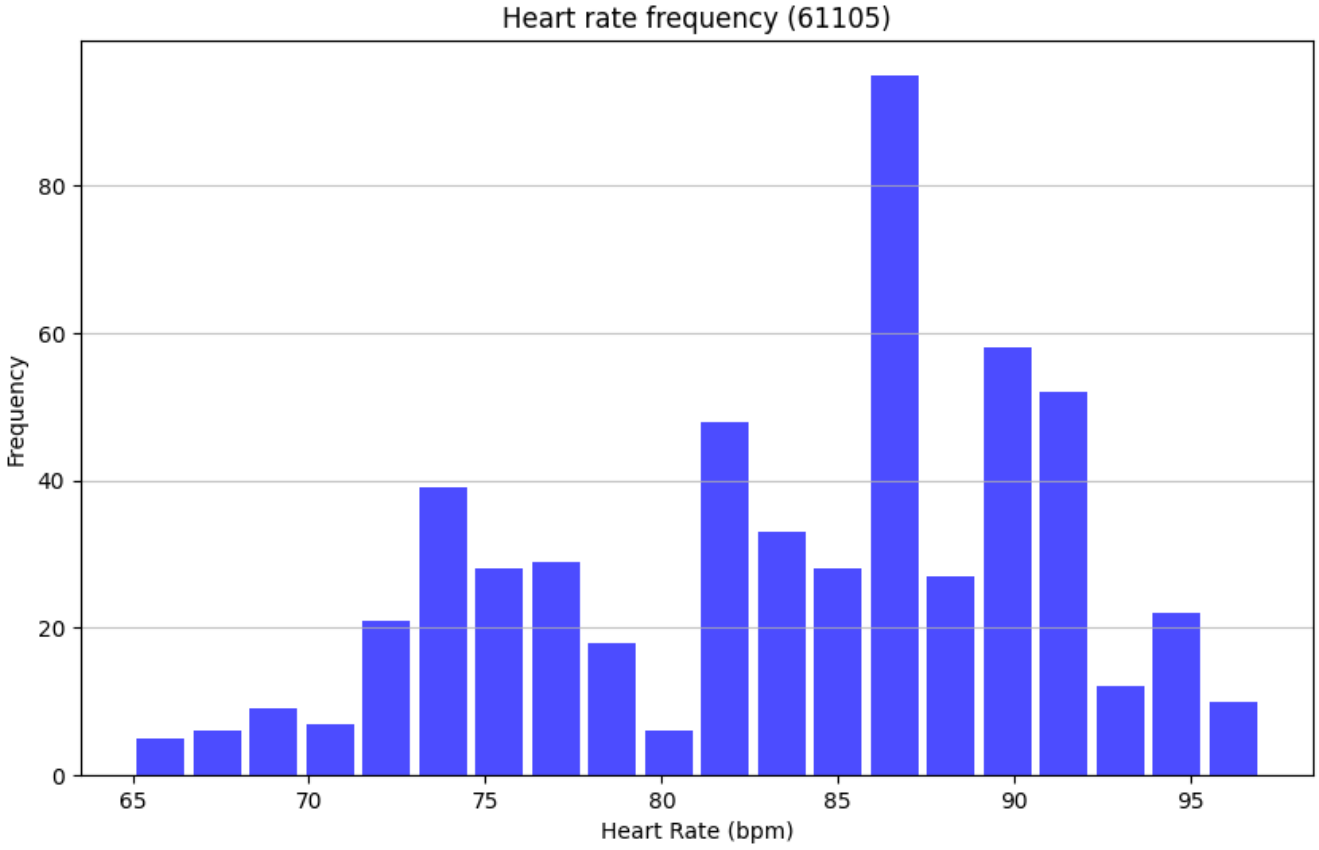
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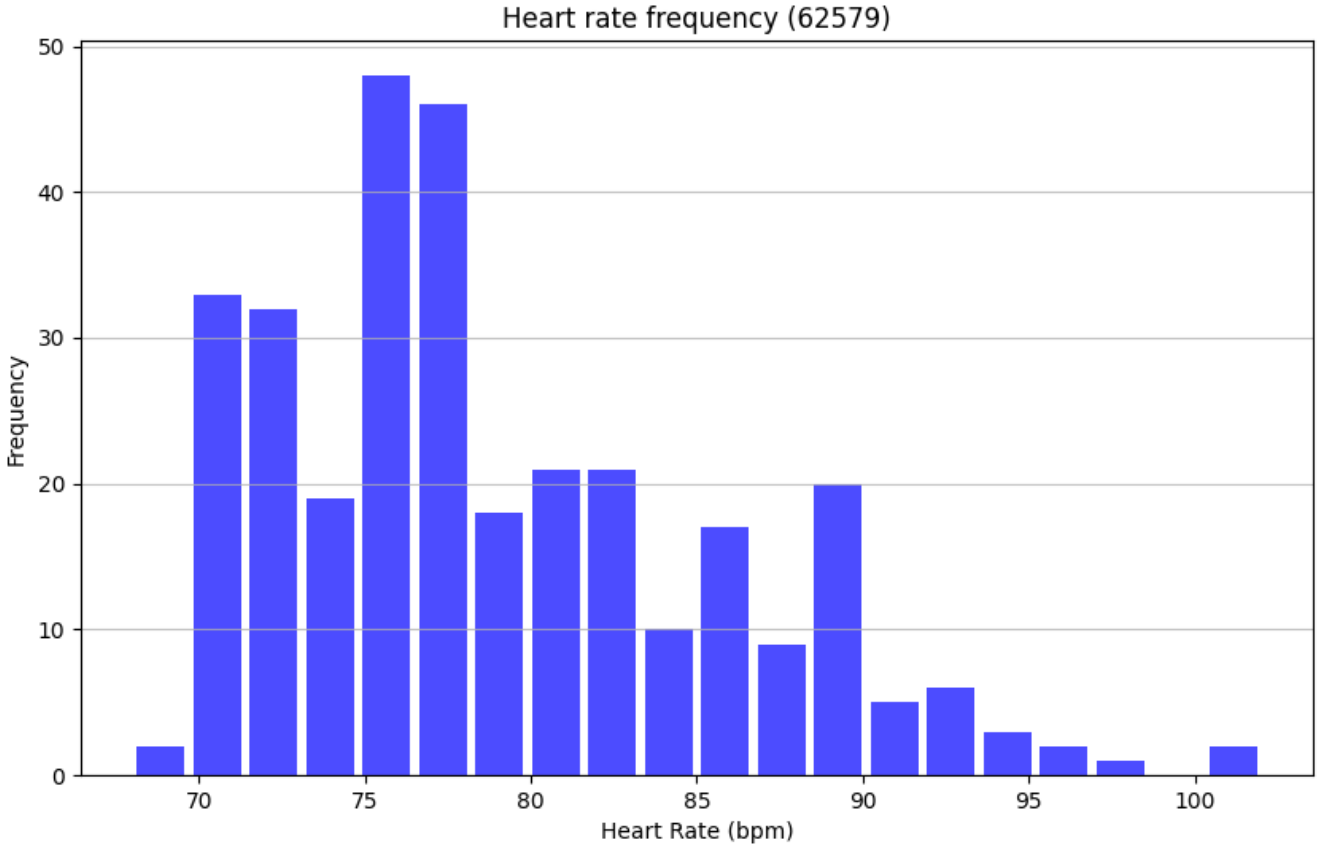
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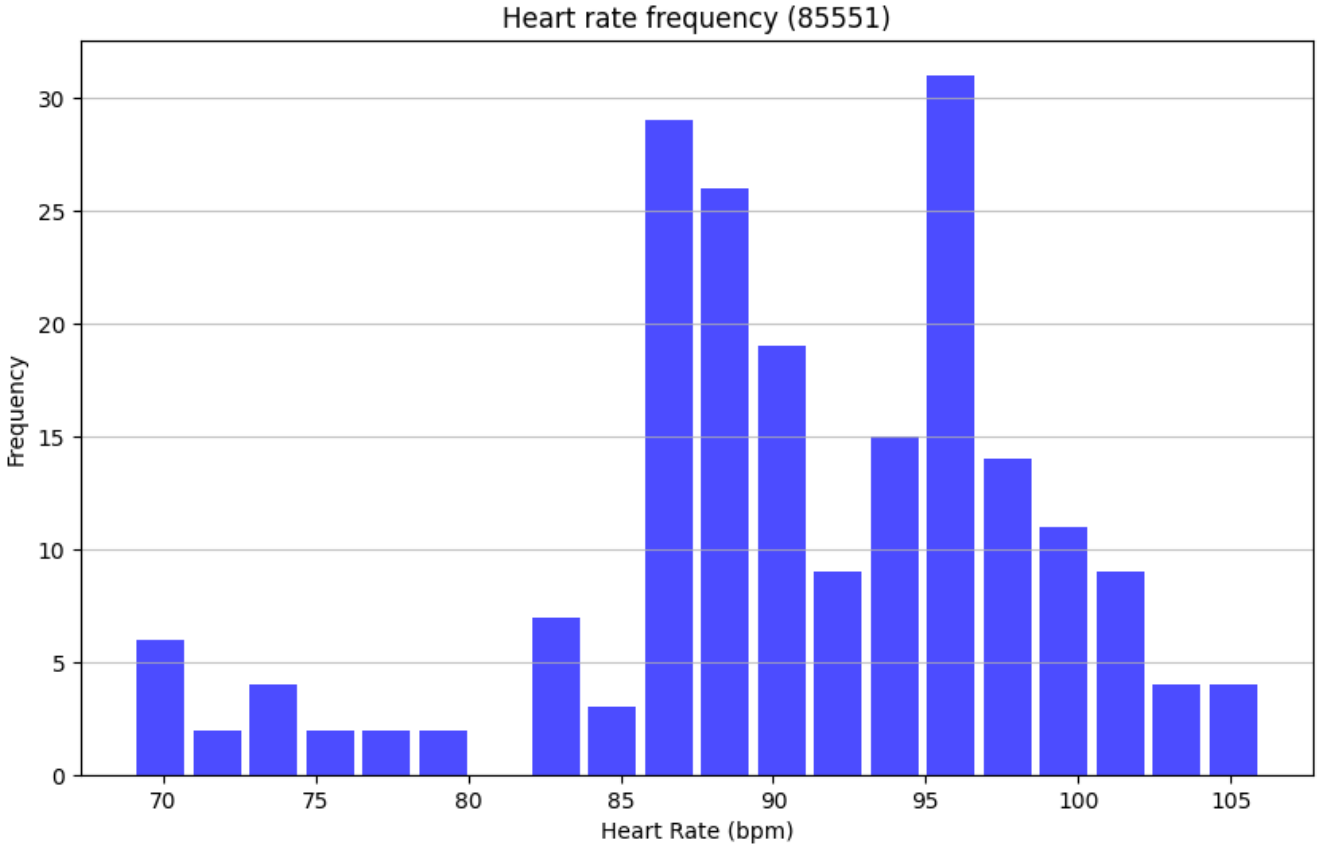
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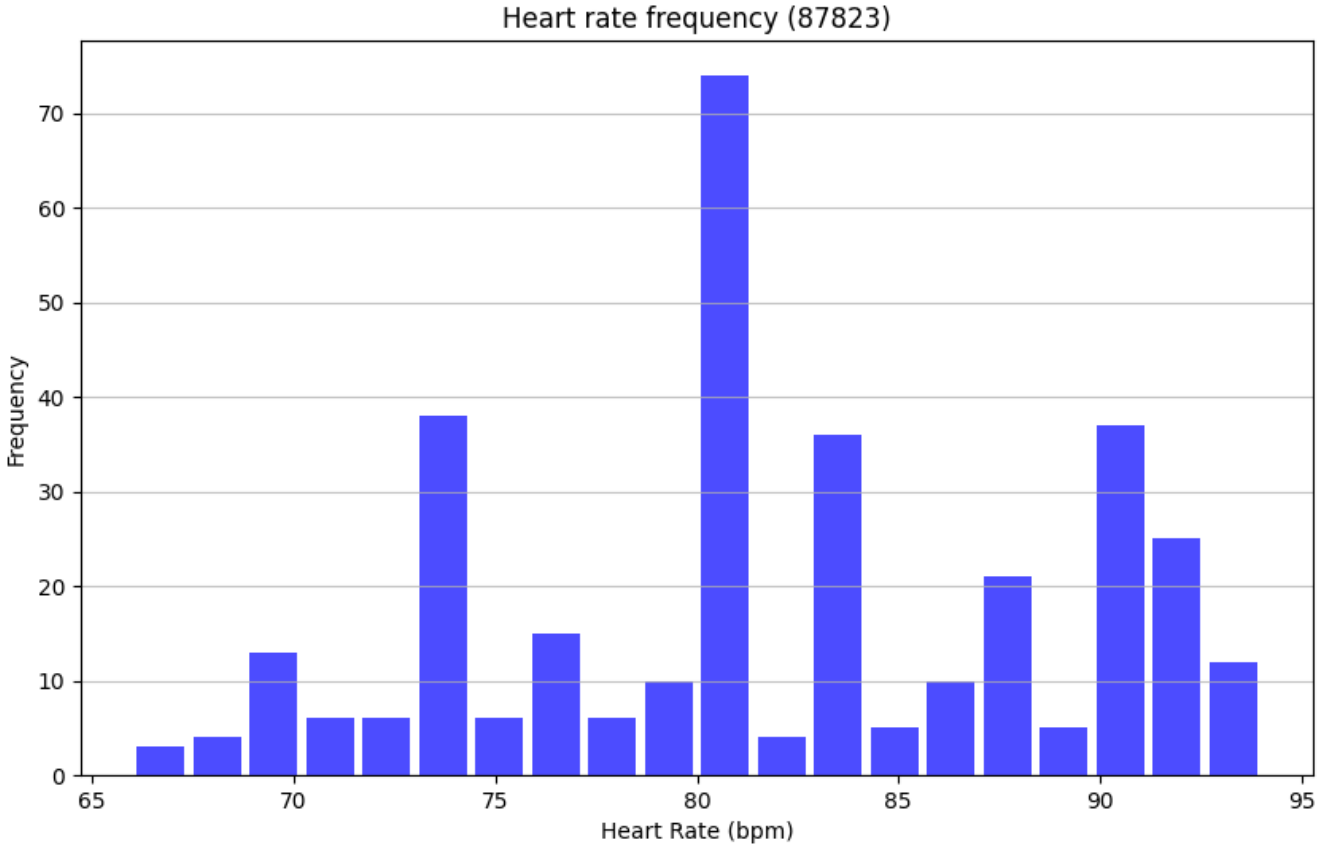
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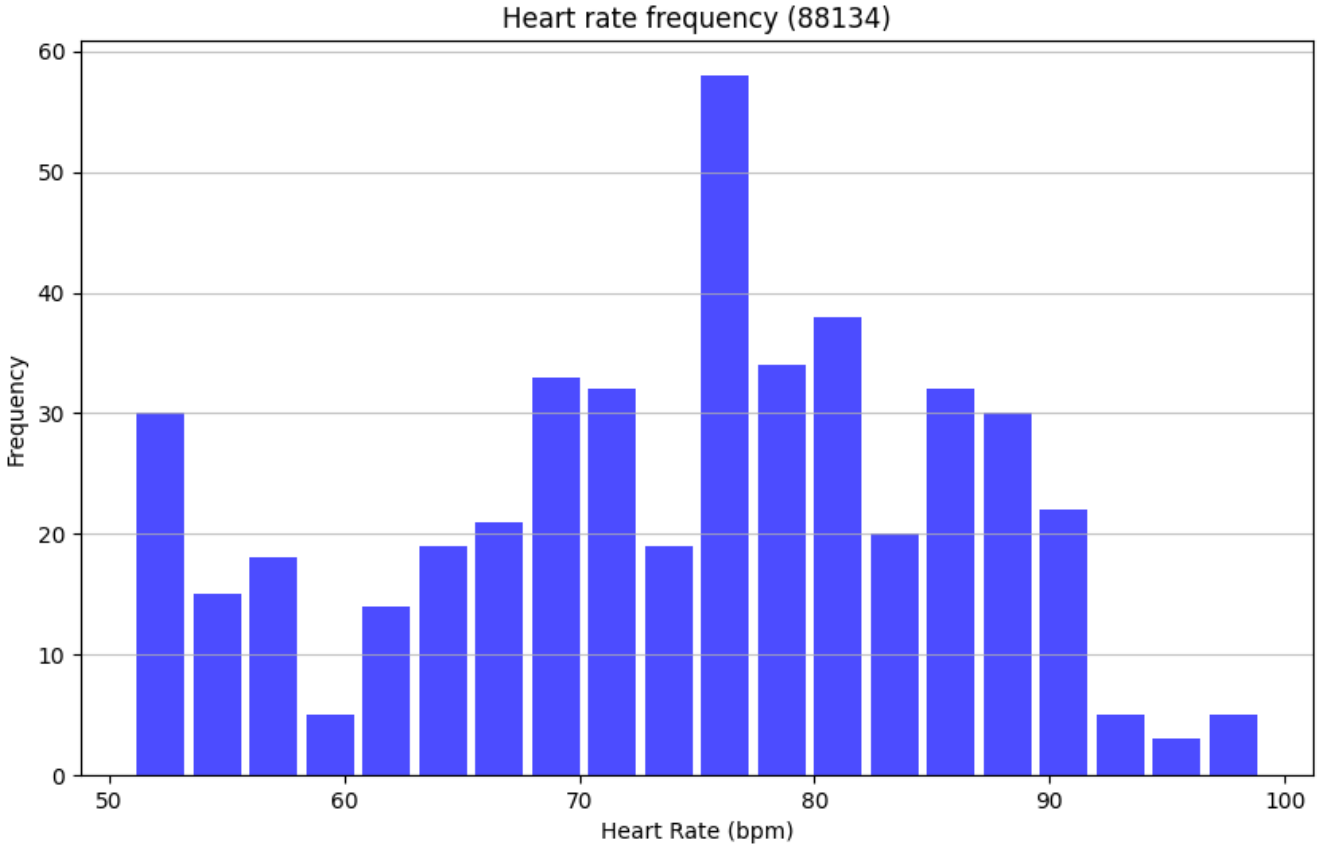
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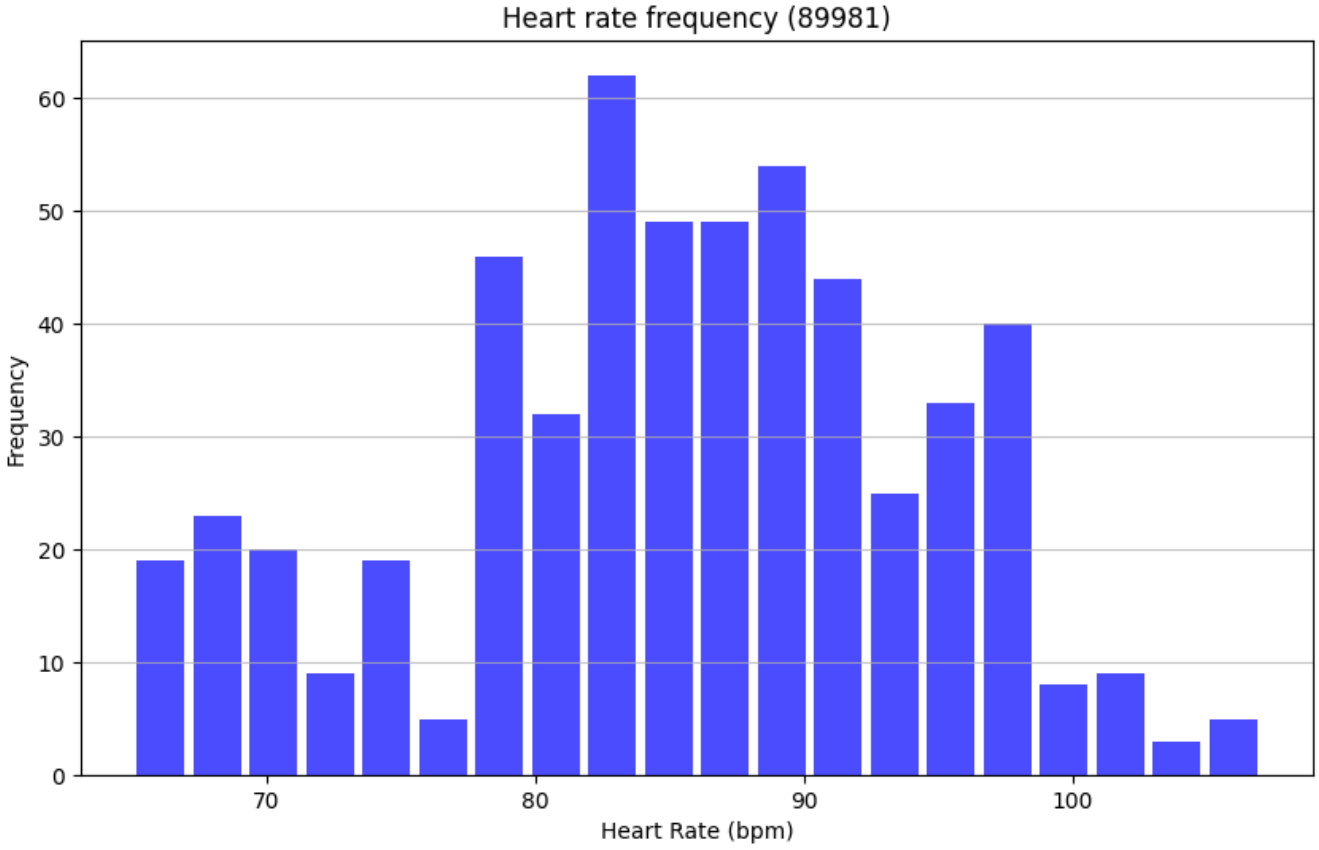
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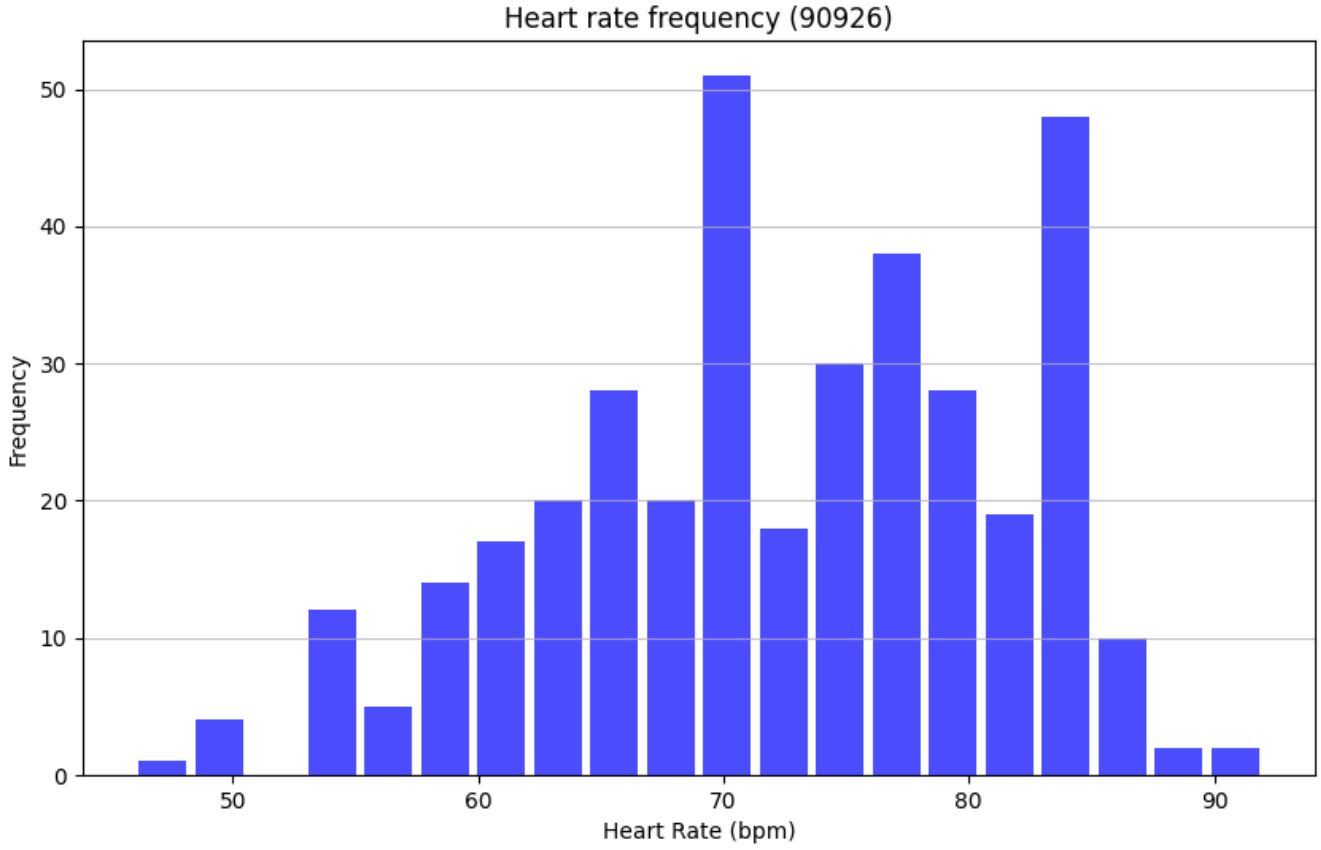
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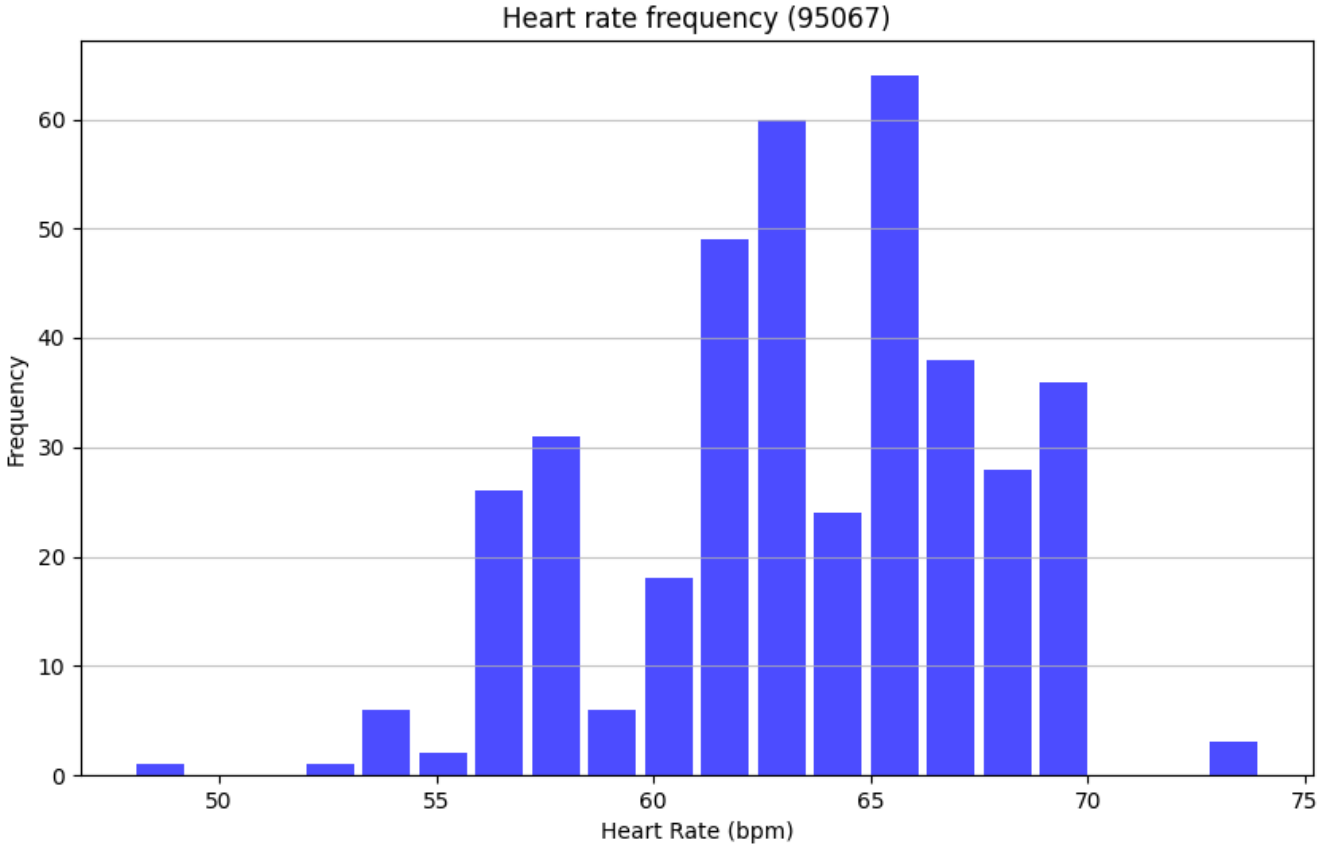
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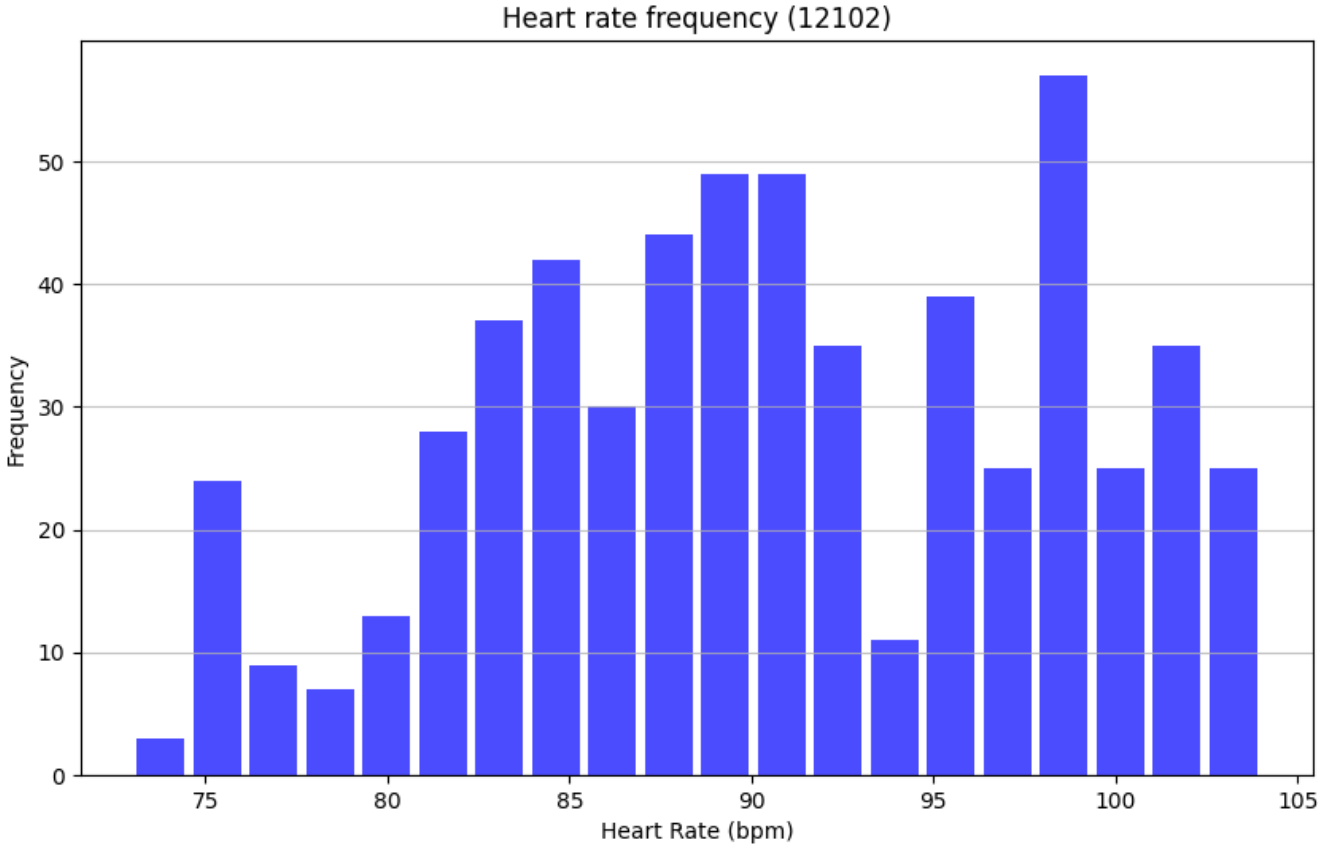
Heart Rate (bpm)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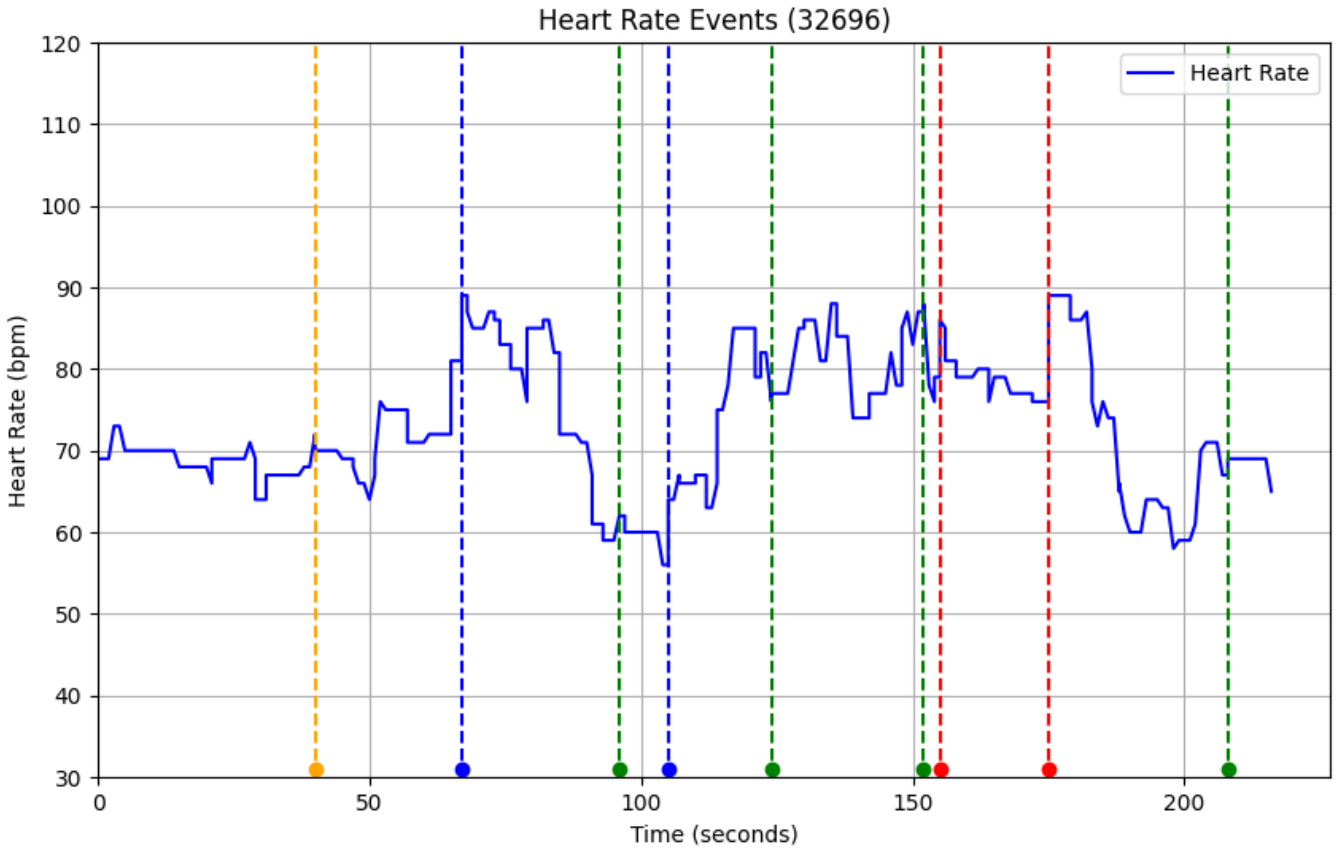
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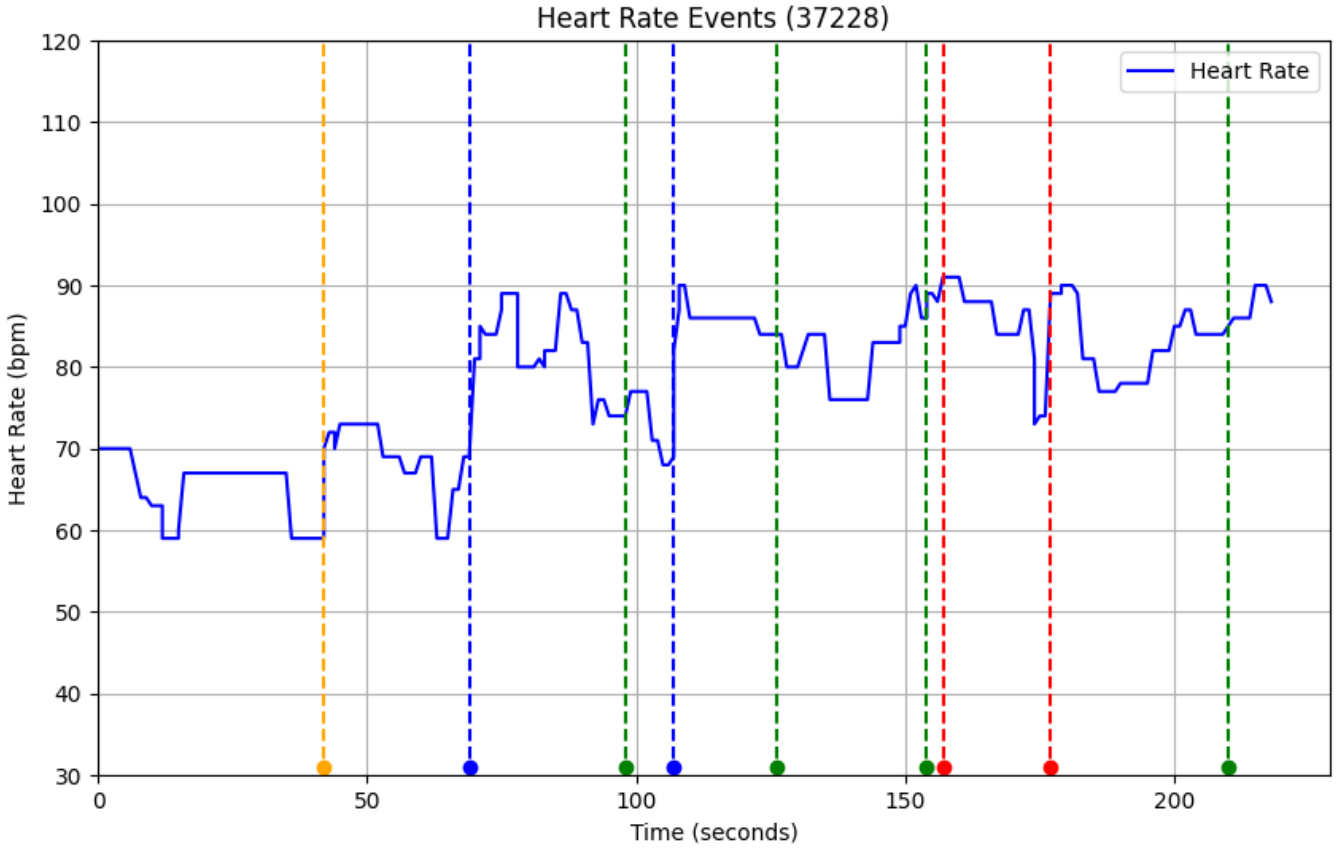
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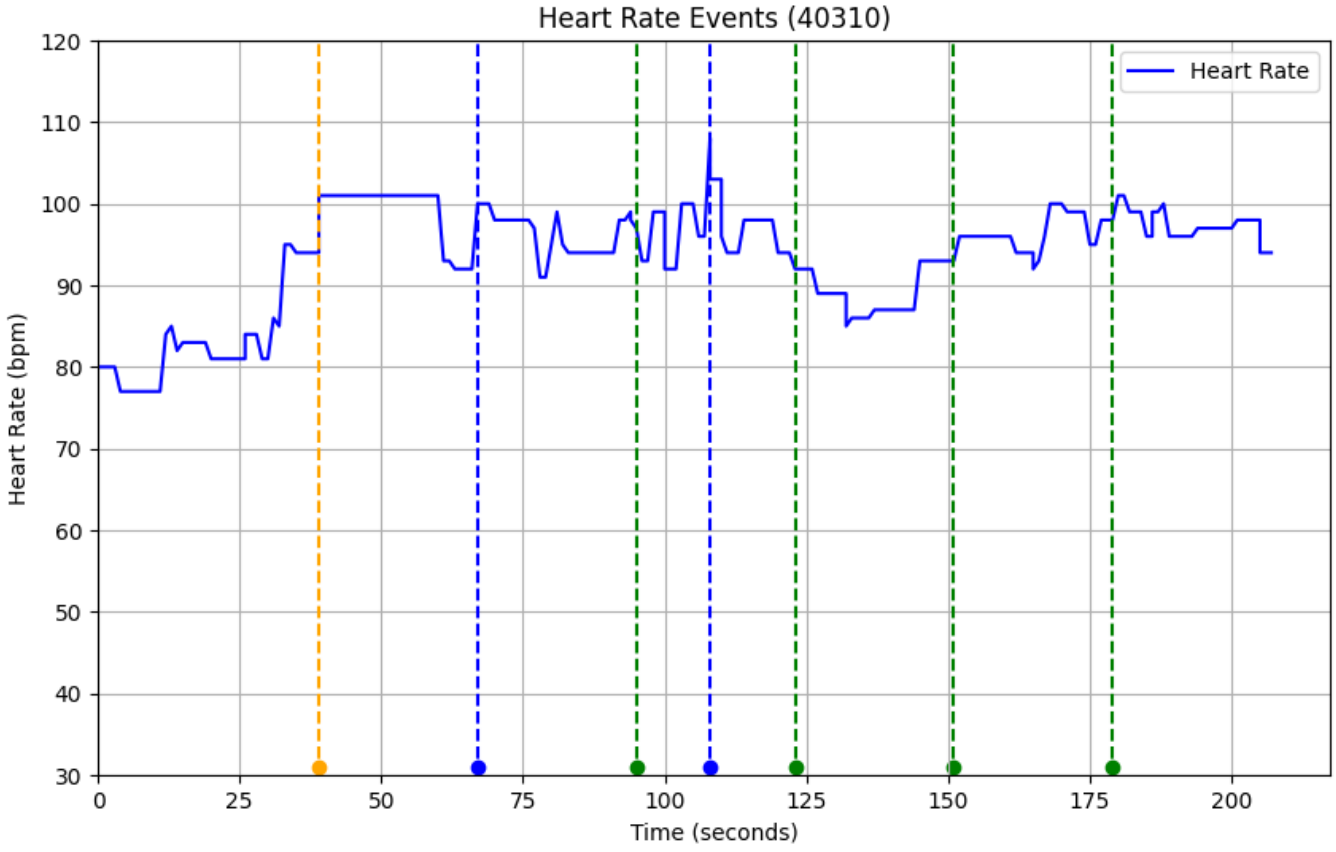
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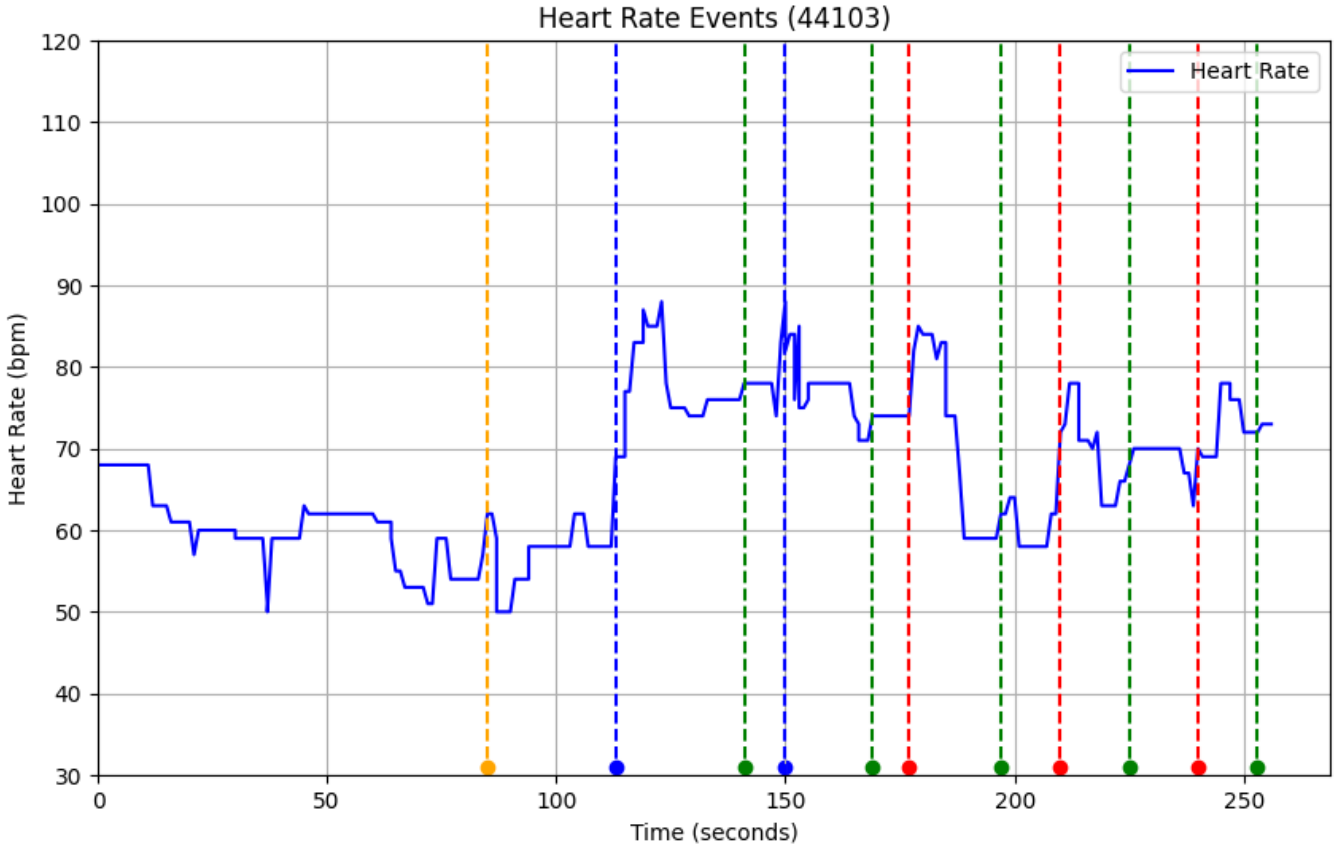
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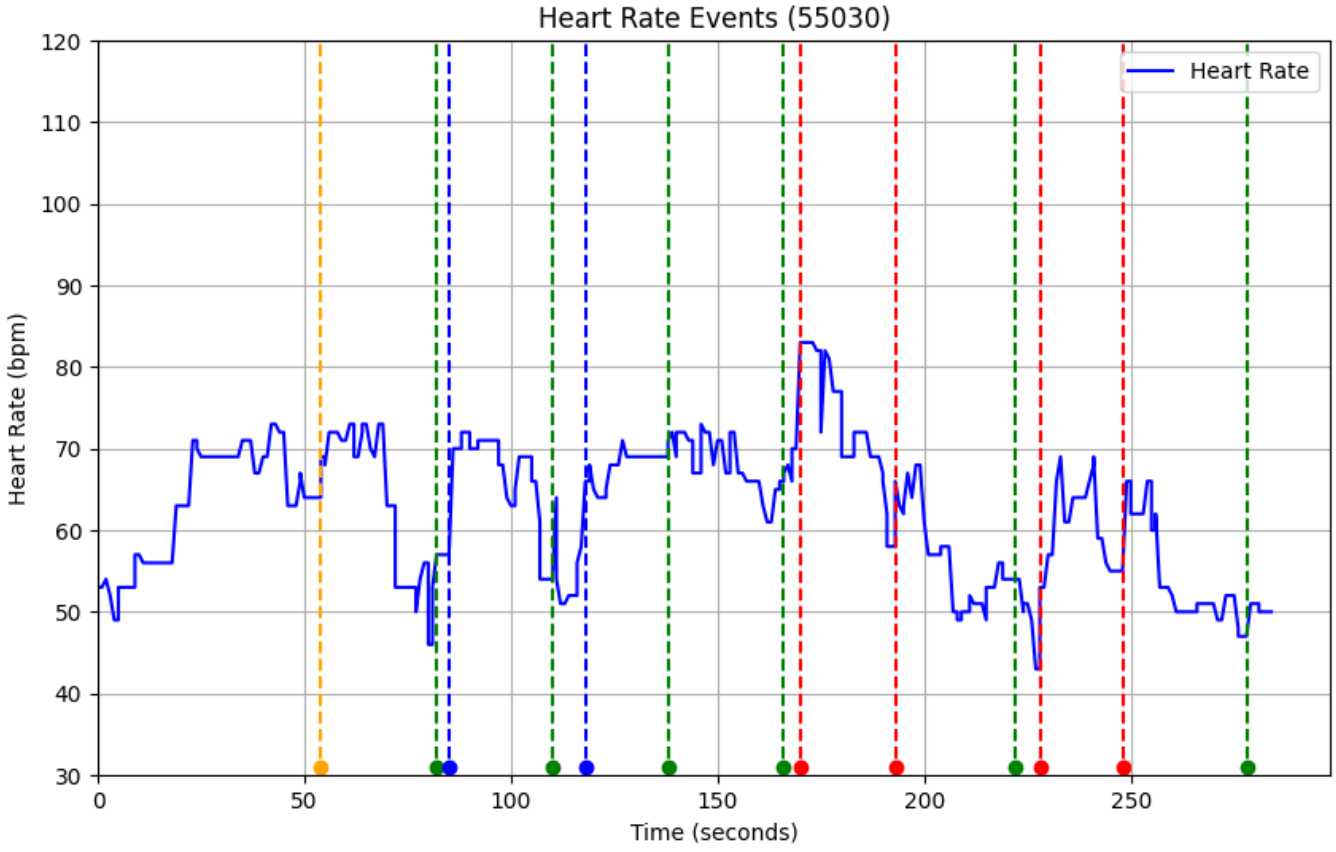
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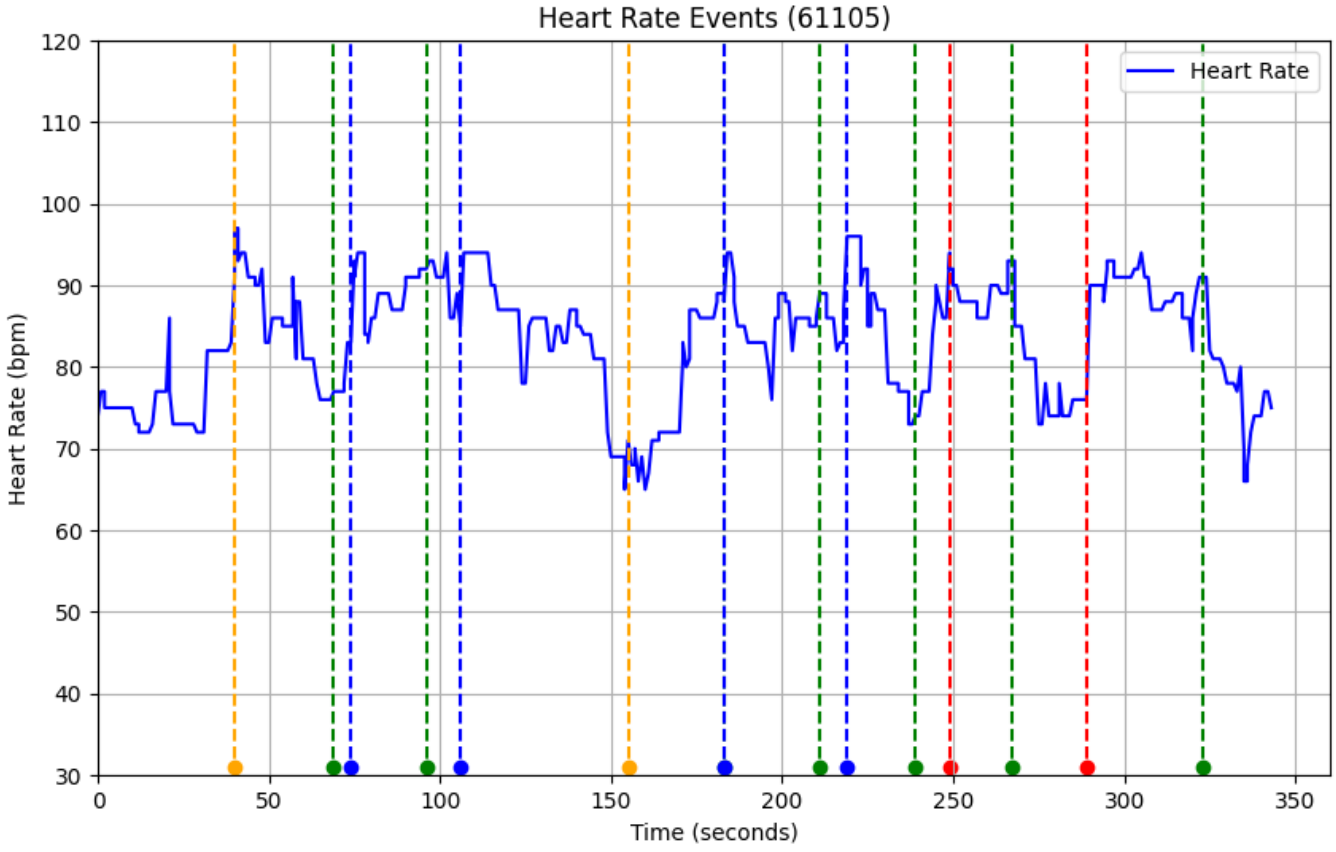
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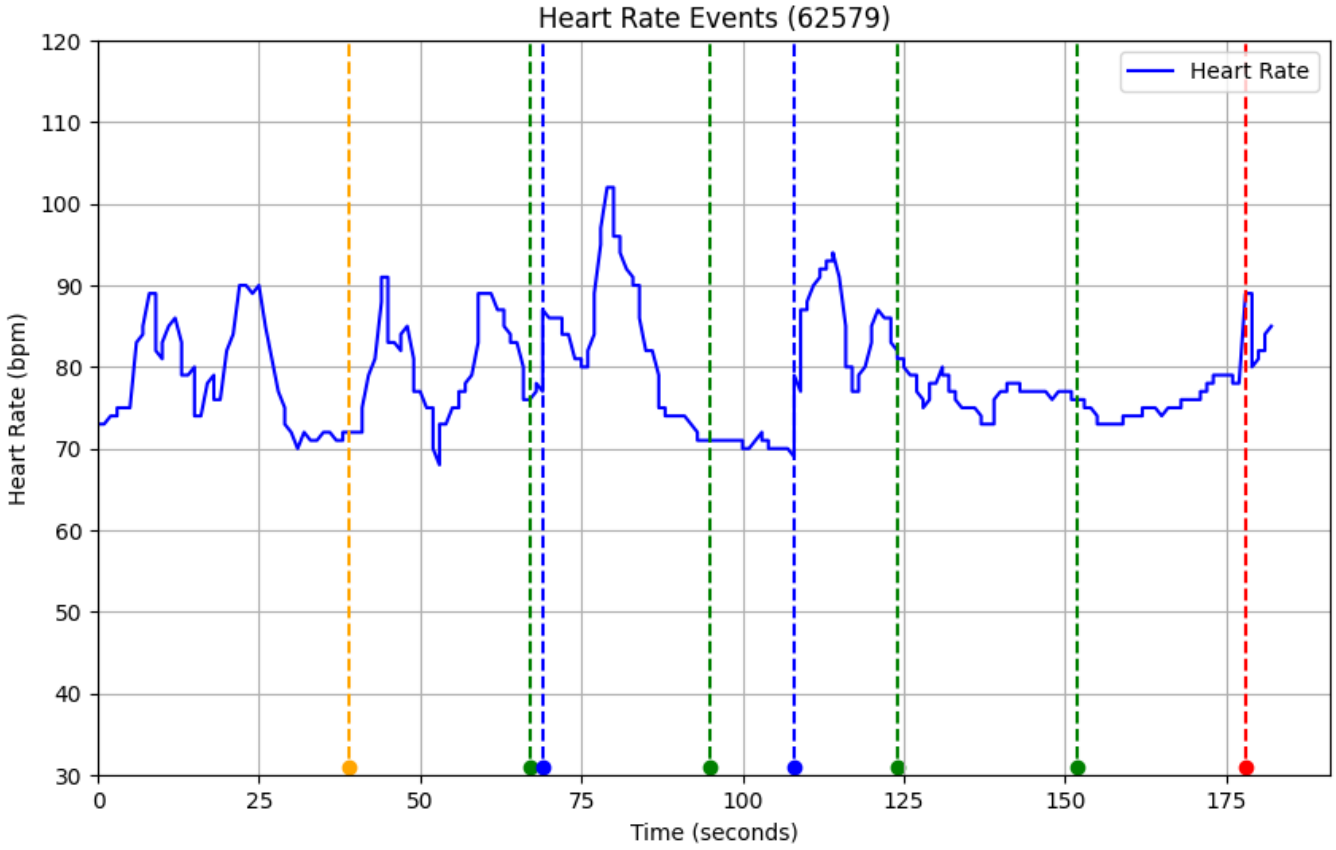
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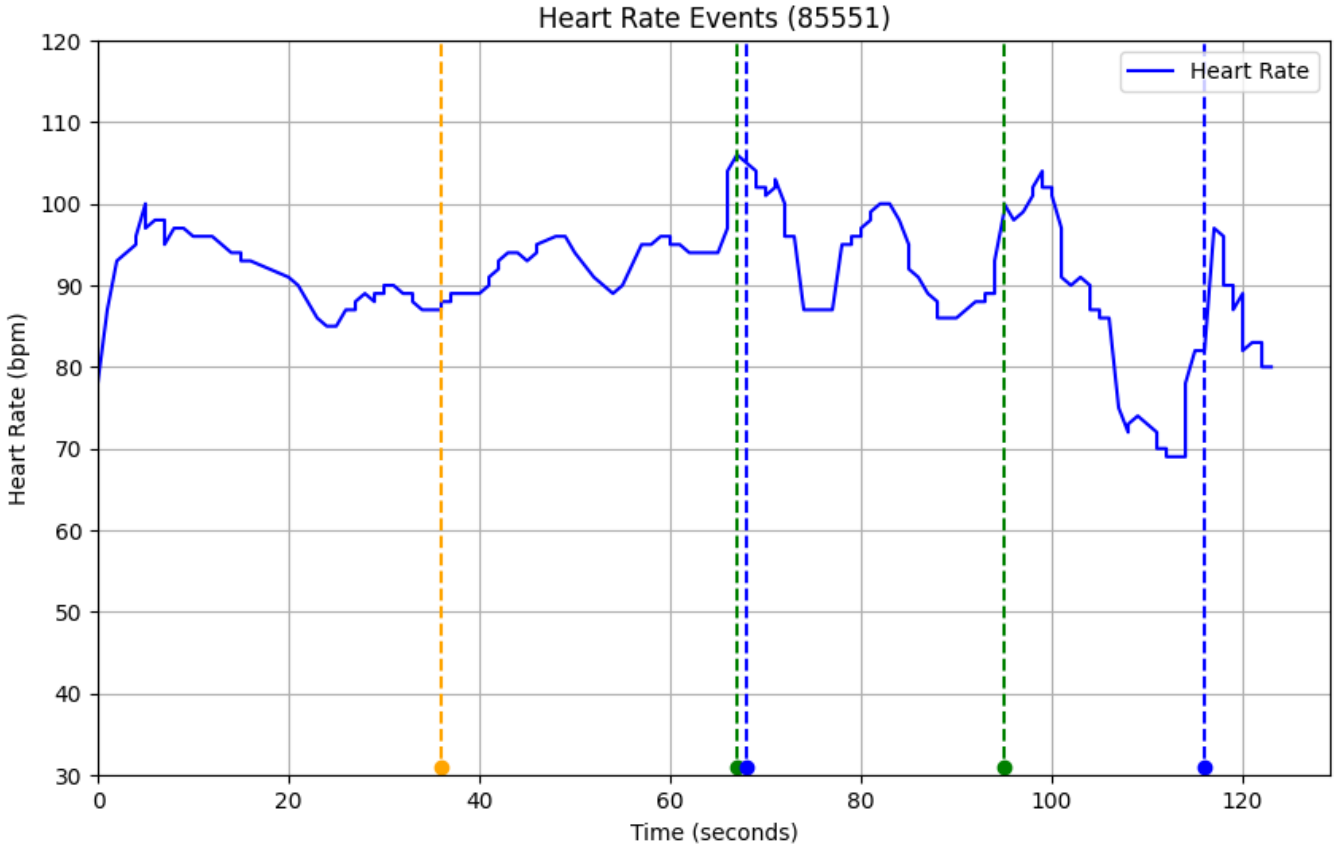
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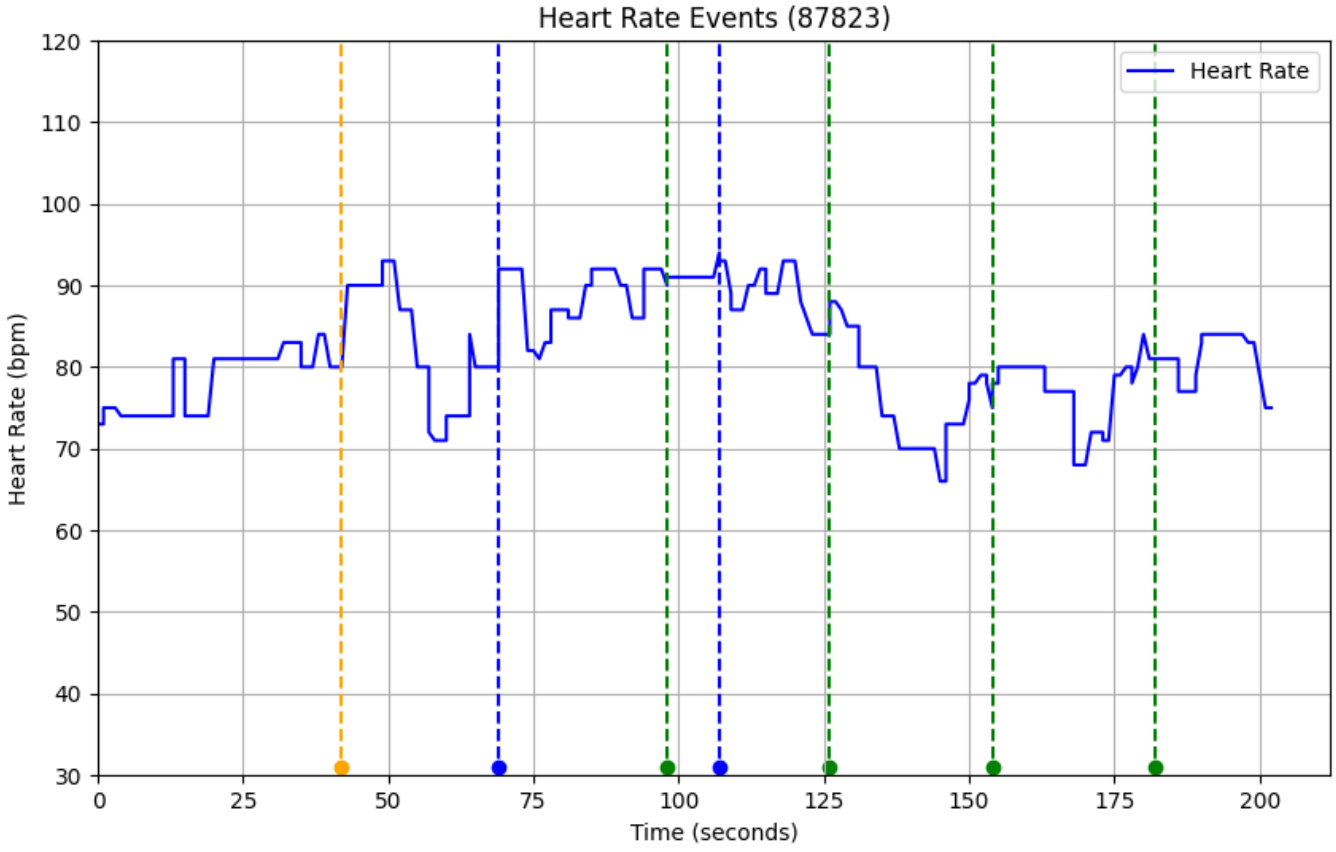
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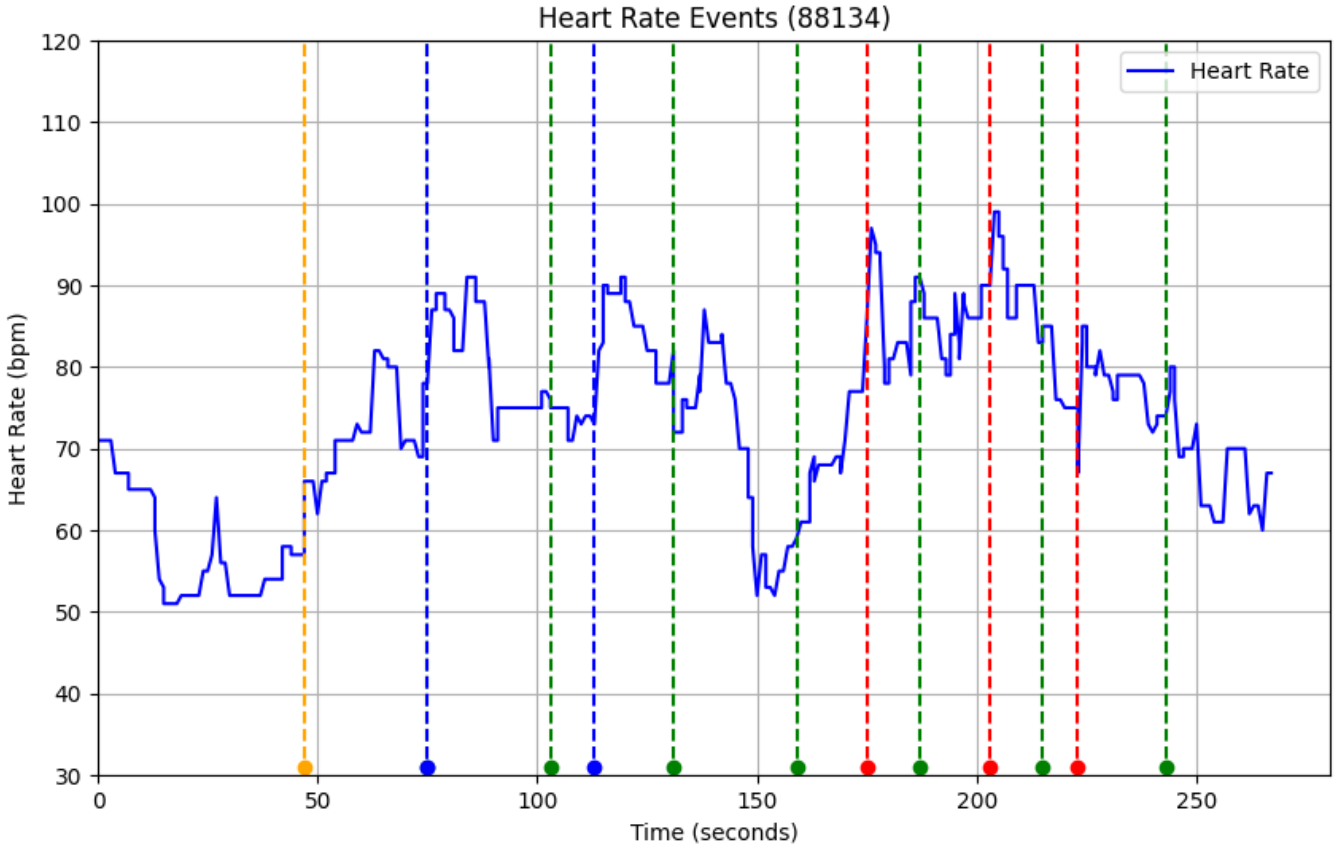
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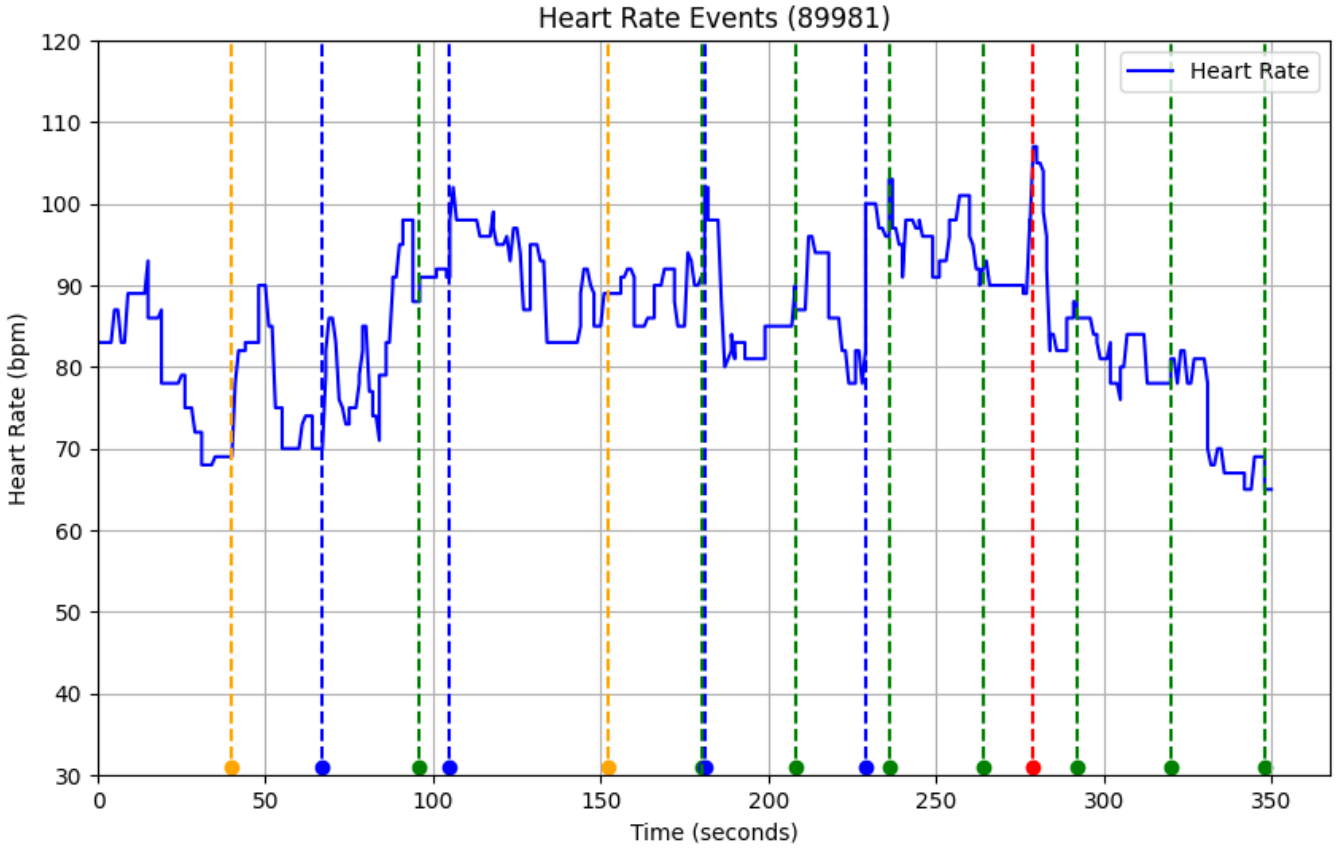
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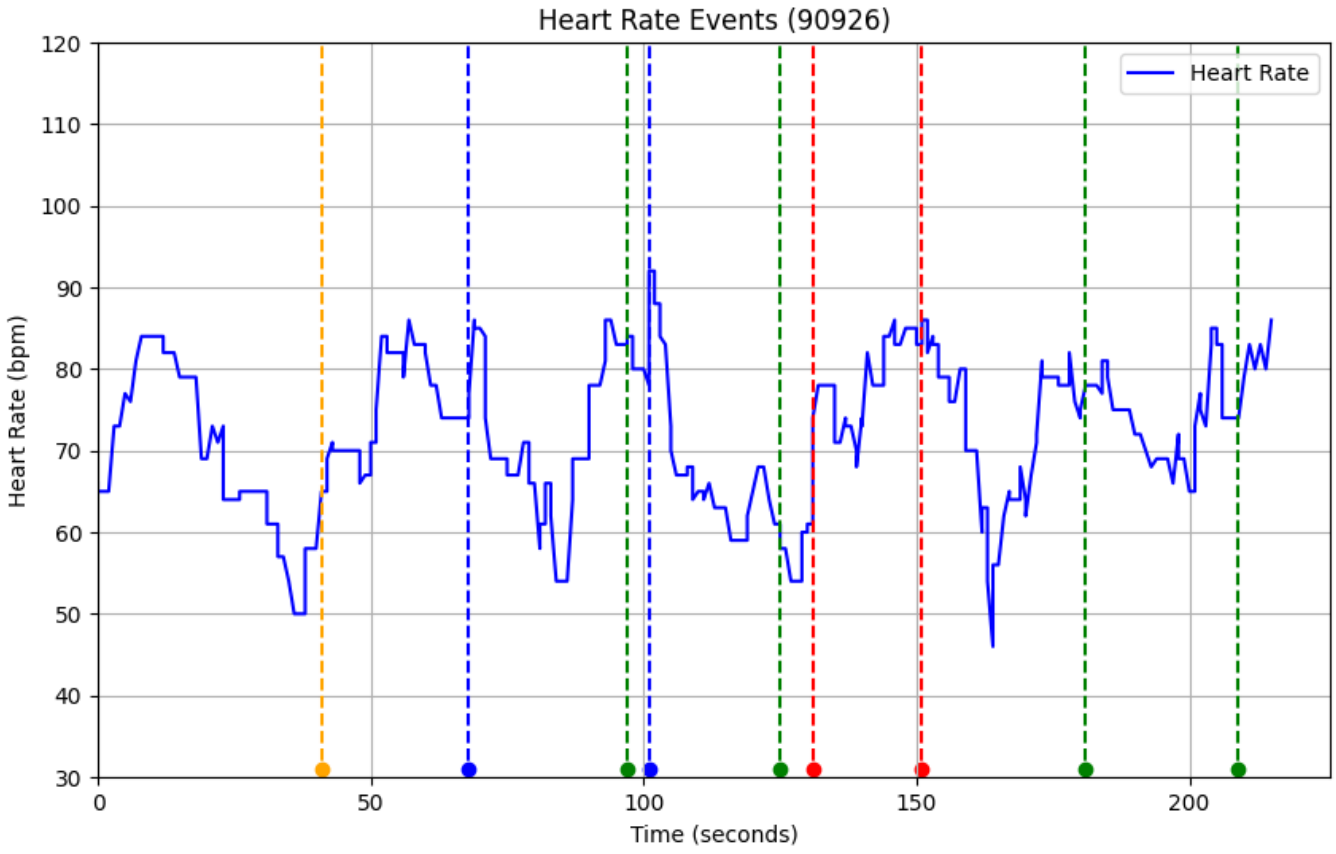
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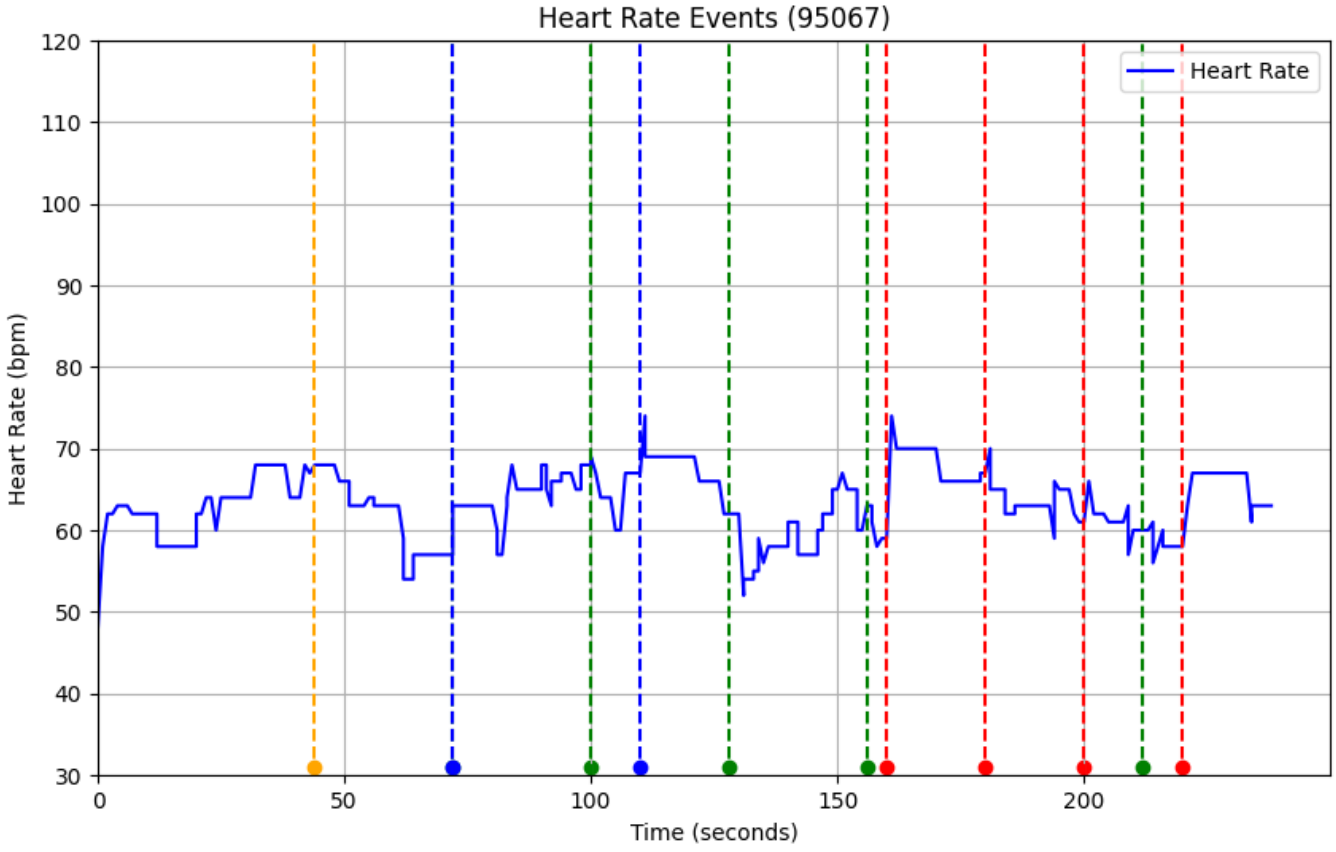
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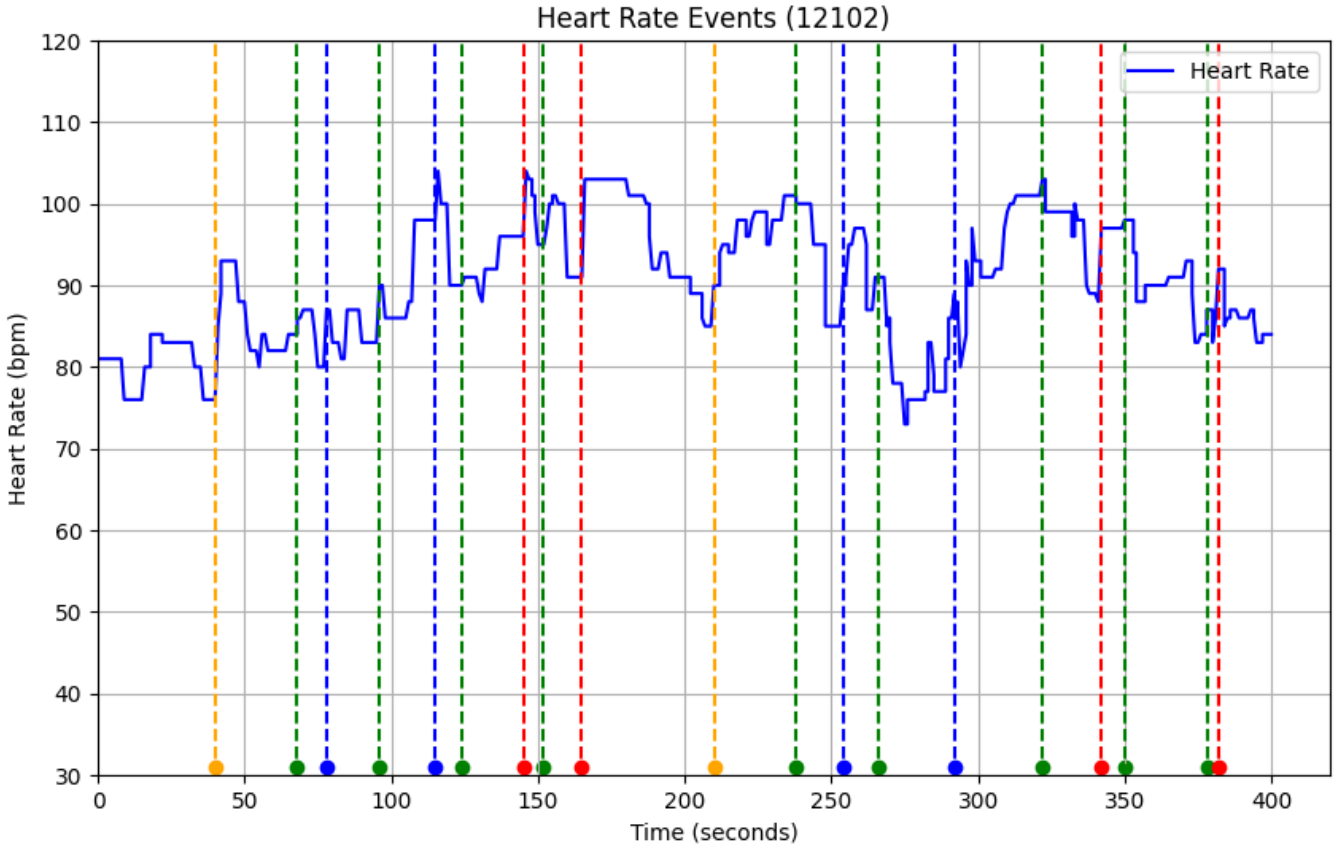
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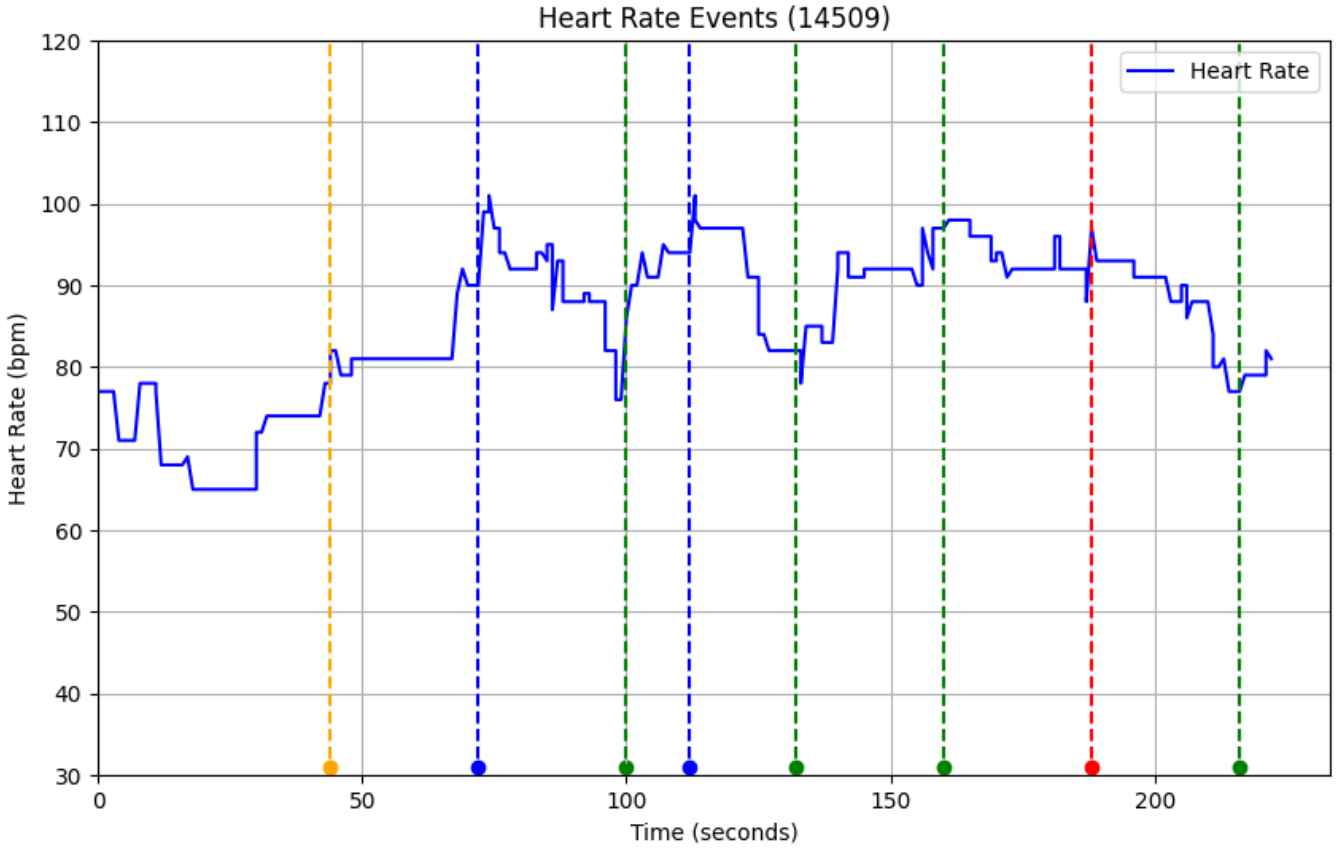
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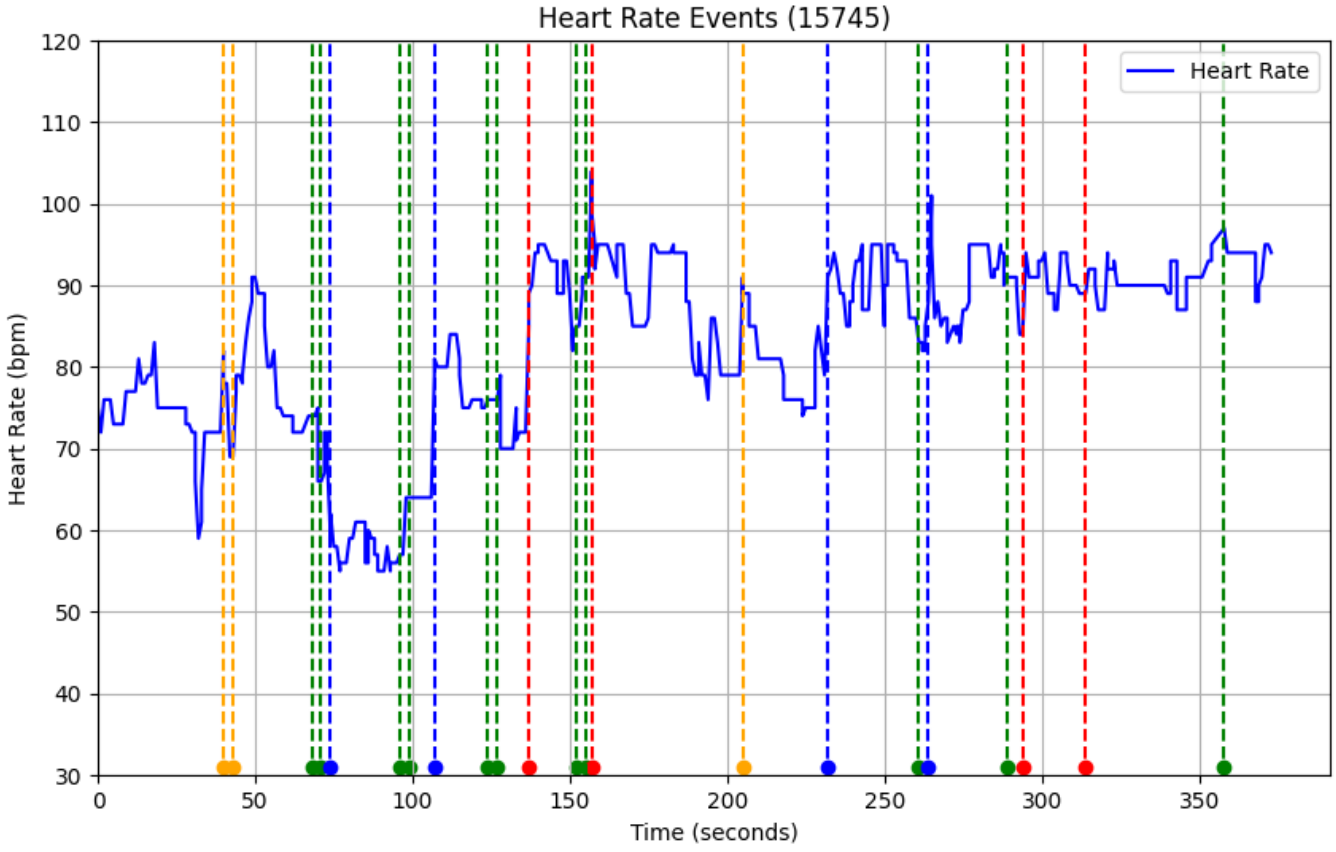
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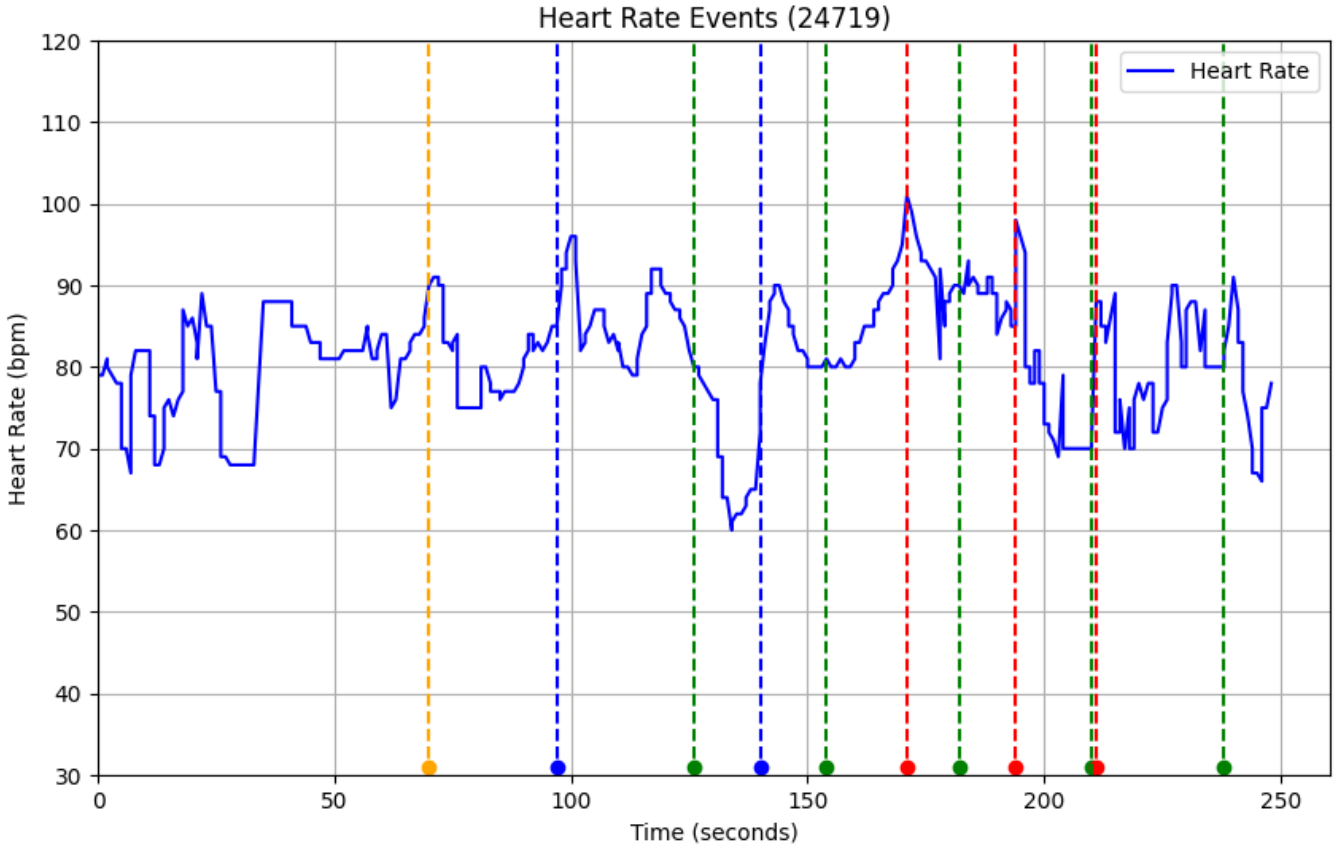
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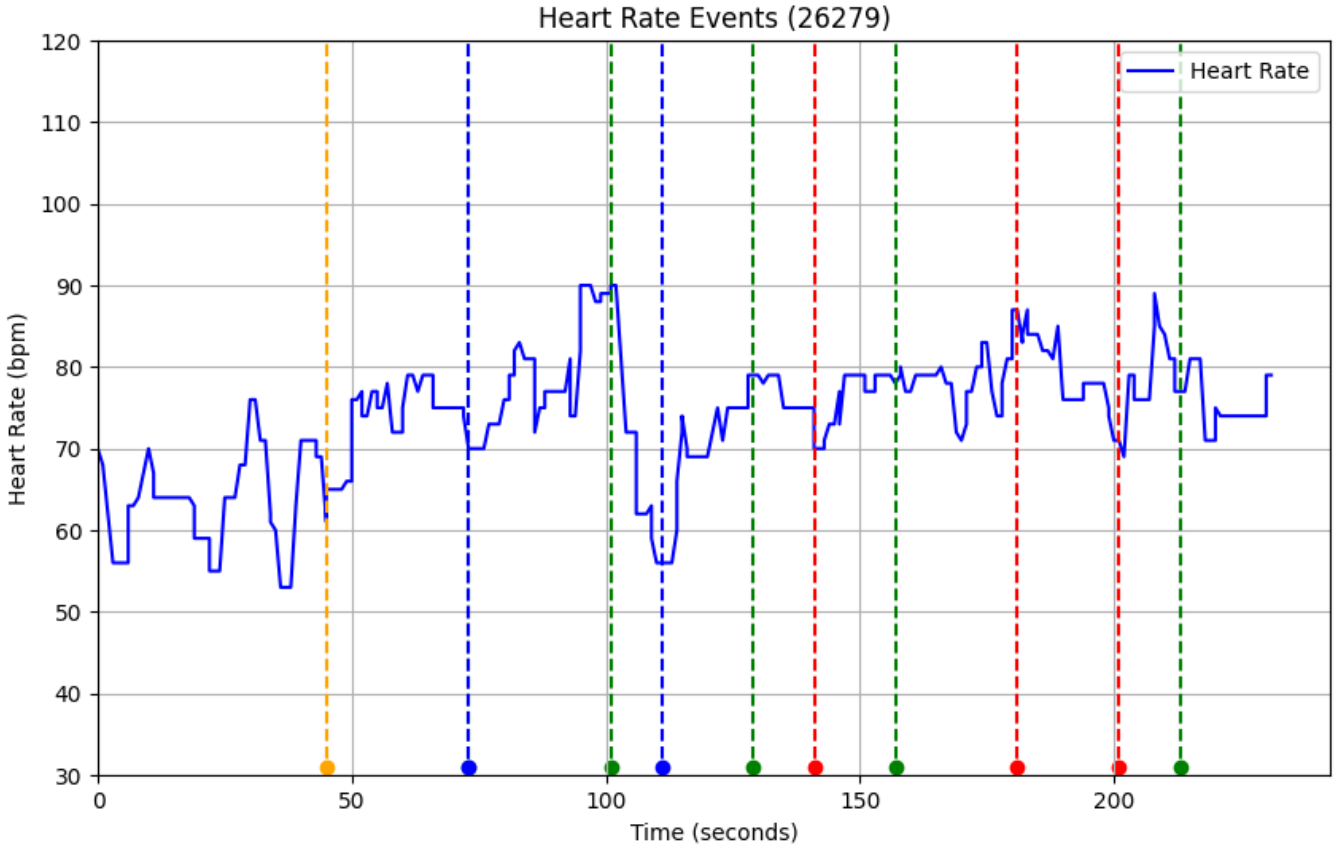
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Heart Rate (bpm)
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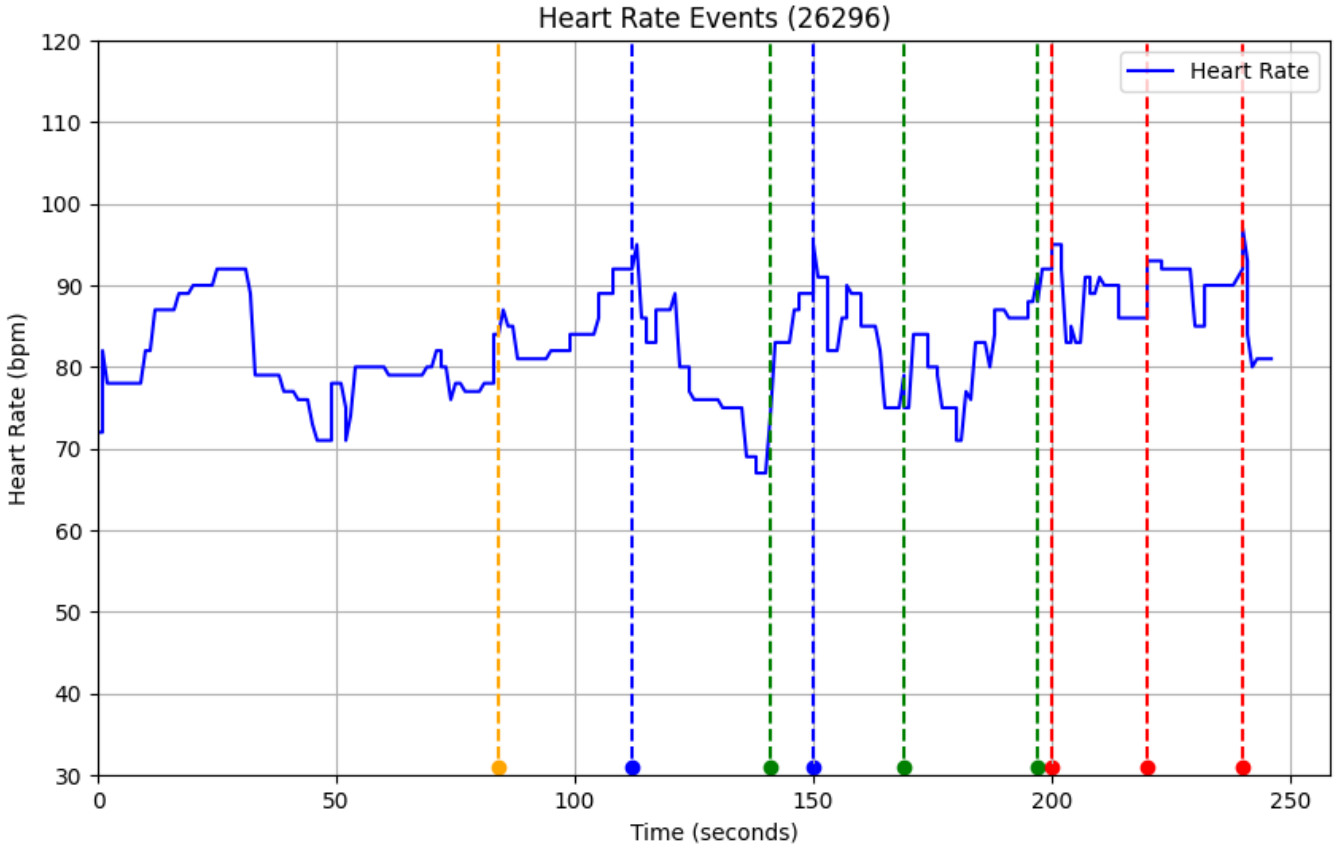
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Heart Rate (bpm)
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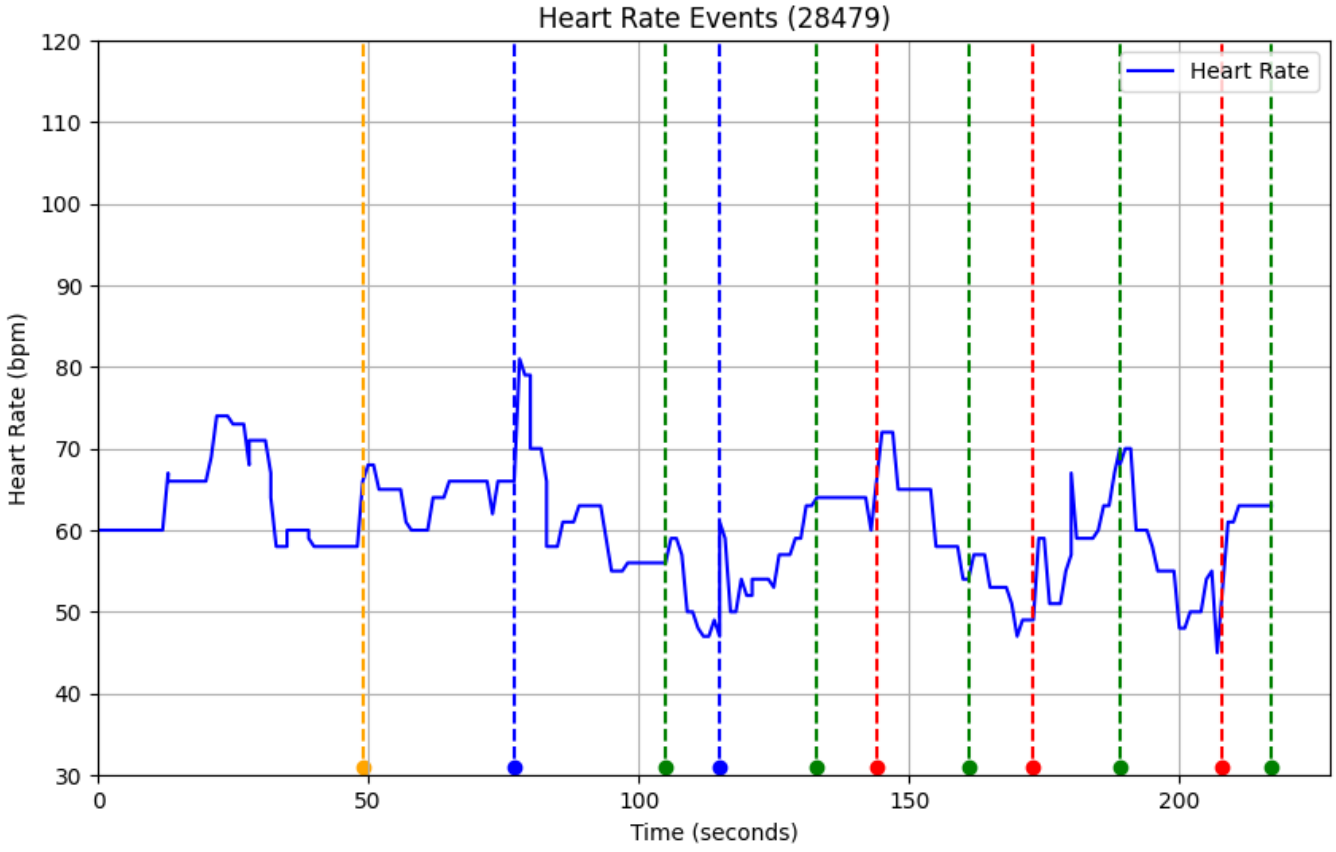
Heart Rate Events (28479)
Heart Rate
Heart Rate (bpm)
Time (seconds)
120
110
100
90
80
70
60
50
40
30
0
50
100
150
200

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

26296

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) [ ]

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- ( ) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- (●) Any other White background (Please specify) [american]
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
- ( ) Any other Mixed / Multiple ethnic background (Please specify) [ ]
- ( ) Indian
- ( ) Pakistani
- ( ) Bangladeshi
- ( ) Chinese
- ( ) Any other Asian background (Please specify) [ ]
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) [ ]
- ( ) Arab
- ( ) Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

Computer Science

Q7a. How frequently do you play video games?

- (●) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- ( ) Rarely
- ( ) Never

Q7b. If you do not play video games, how do you spend your leisure time?

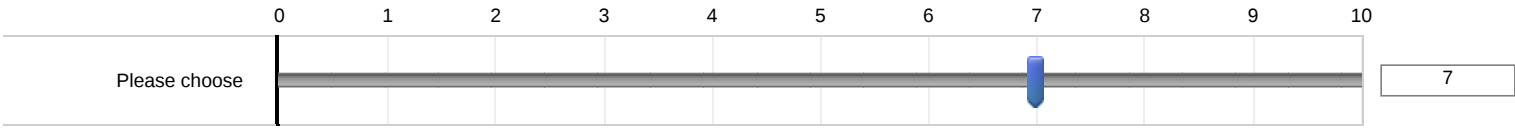
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ( ) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- (●) Rarely
- ( ) Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

The jump scares

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- (●) I felt relaxed
- ( ) I felt tense
- ( ) Prefer not to answer

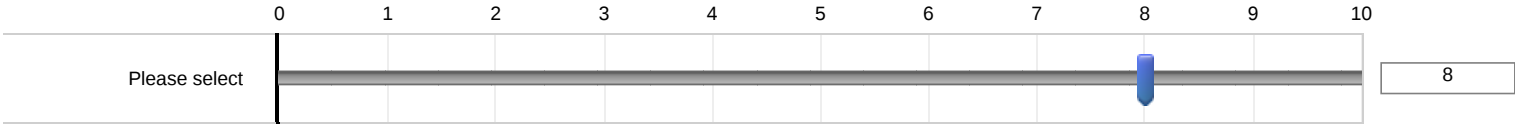
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I had a few jumps around the jump scares and i felt tense leading up to them

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

jump scares, lighting, sounds and the creepy animals

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

sweating and i felt my heart beating

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I think it worked well for scaring me. I didnt find the first scare scary

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

32696

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- (●) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- ( ) Any other White background (Please specify) _____
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
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- ( ) Indian
- ( ) Pakistani
- ( ) Bangladeshi
- ( ) Chinese
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- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) _____
- ( ) Arab
- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ◉ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

going out

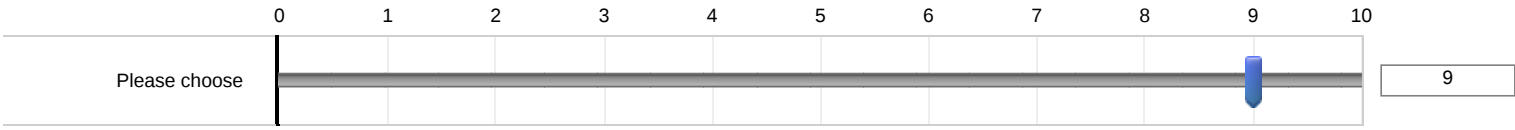
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

the lantern dimming was a bit scary

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

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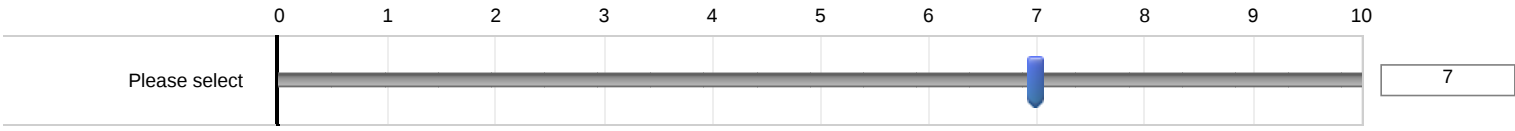
the monster made me tense

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

it was very scary to see the monster

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

heart rate

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

i felt involved in the story

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

15745

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- (●) 30-40
- ( ) 40+

Q2. Gender

- ○ Male
- ◉ Female
- ○ Non-binary / third gender
- ○ Prefer not to say
- ○ Other (Please specify) [ ]

Q3. Marital Status

- ◉ Single
- ○ Married
- ○ Divorced

Q4. Ethnicity

- ◉ English / Welsh / Scottish / Northern Irish / British
- ○ Irish
- ○ Gypsy or Irish Traveller
- ○ Any other White background (Please specify) [ ]
- ○ White and Black Caribbean
- ○ White and Black African
- ○ White and Asian
- ○ Any other Mixed / Multiple ethnic background (Please specify) [ ]
- ○ Indian
- ○ Pakistani
- ○ Bangladeshi
- ○ Chinese
- ○ Any other Asian background (Please specify) [ ]
- ○ African
- ○ Caribbean
- ○ Any other Black / African / Caribbean background (Please specify) [ ]
- ○ Arab
- ○ Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ◉ Yes
- ○ Maybe
- ○ No
- ○ Prefer not to answer

Q6. Subject of Study

I am not a student

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q7b. If you do not play video games, how do you spend your leisure time?

TV

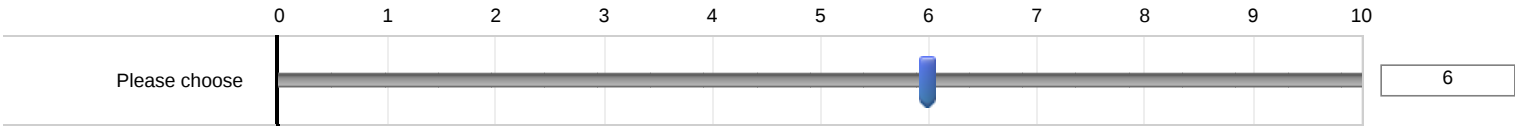
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

i am not sure

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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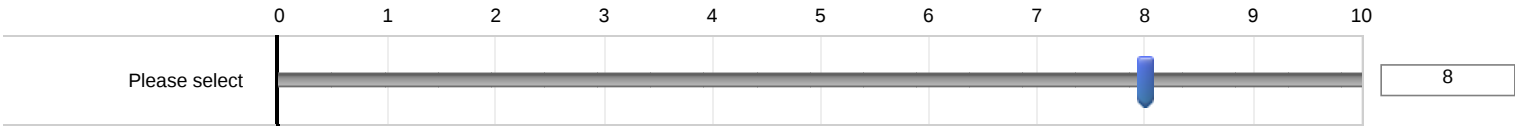
the jump scares got me

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

the forest was scary and dark. the lantern flickering was also scary

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

no

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

the wires were a bit distracting

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

12102

Q1. Age (years)

- (●) 18-20
- ( ) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
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- ( ) Divorced

Q4. Ethnicity

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- ( ) Indian
- ( ) Pakistani
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- ( ) Chinese
- ( ) Any other Asian background (Please specify) _____
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) _____
- ( ) Arab
- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

maths

Q7a. How frequently do you play video games?

- ○ Daily
- ◉ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

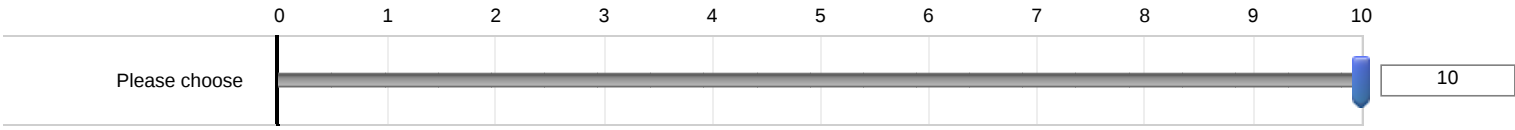
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ◉ Rarely
- ○ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

suspense

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ○ I felt tense
- ○ Prefer not to answer

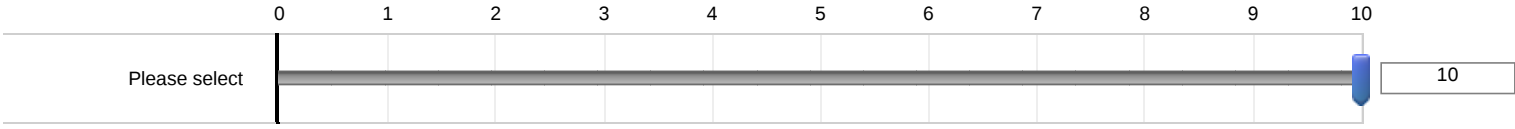
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

when the ghost appeared

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

the ghost appearing

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

heart rate and i felt scared

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

it was really cool

Location Data

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. I confirm that I am willing to take part in this research

- (•) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

61105

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- (•) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
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- ( ) Caribbean
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- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

no

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ◉ Once a week
- ○ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

i go out with my buddies

Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
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Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

the wires were distracting me because they were short

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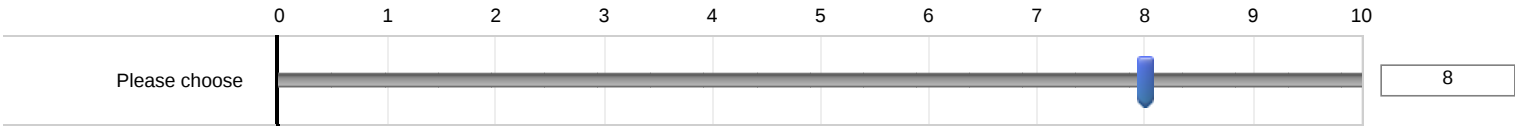

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- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

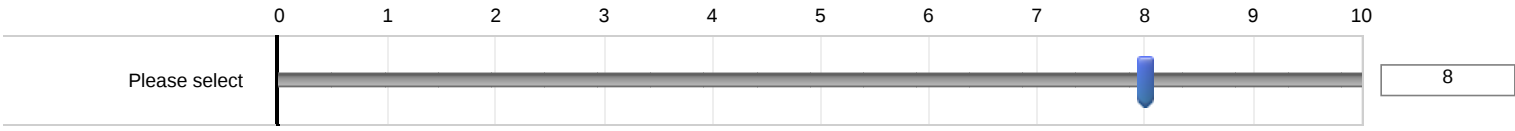
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

when the scary thing spawned

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

the thing that made me stop walking

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

i didn't

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

i was too involved in the game and didnt pay attention to myself

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

they enhanced it.

Location Data

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- [x] I agree to my physiological data to be published after anonymisation as part of this research.

. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

24719

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) [ ]

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- ( ) English / Welsh / Scottish / Northern Irish / British
- (●) Irish
- ( ) Gypsy or Irish Traveller
- ( ) Any other White background (Please specify) [ ]
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
- ( ) Any other Mixed / Multiple ethnic background (Please specify) [ ]
- ( ) Indian
- ( ) Pakistani
- ( ) Bangladeshi
- ( ) Chinese
- ( ) Any other Asian background (Please specify) [ ]
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) [ ]
- ( ) Arab
- ( ) Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

computer science

Q7a. How frequently do you play video games?

- (●) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- ( ) Rarely
- ( ) Never

Q7b. If you do not play video games, how do you spend your leisure time?

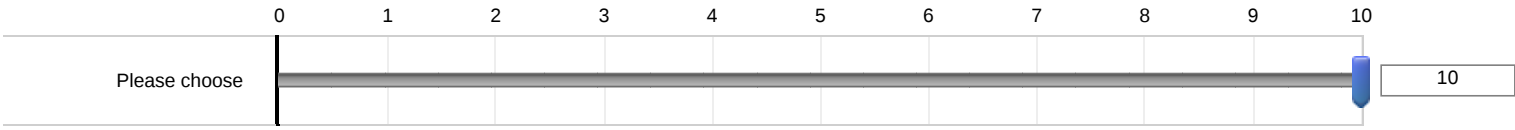
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ( ) Daily
- (●) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- ( ) Rarely
- ( ) Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

The monster reminded me of the spirits from phasmophobia, which is my favourite game

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- (●) I felt relaxed
- ( ) I felt tense
- ( ) Prefer not to answer

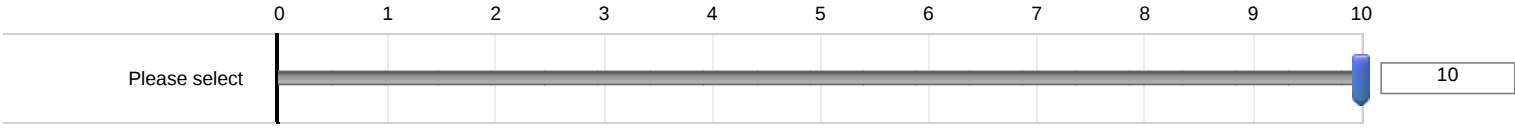
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I felt excited to see the spirit and it scared me the next time I saw it

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

the lighting, sounds, spirits, animals and trees

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I was sweating

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I thought it was really cool and I wish more games did that. Seeing my own heart rate helped it feel tense

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

85551

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) [ ]

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- ( ) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- (●) Any other White background (Please specify) [American]
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
- ( ) Any other Mixed / Multiple ethnic background (Please specify) [ ]
- ( ) Indian
- ( ) Pakistani
- ( ) Bangladeshi
- ( ) Chinese
- ( ) Any other Asian background (Please specify) [ ]
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) [ ]
- ( ) Arab
- ( ) Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

Business Studies

Q7a. How frequently do you play video games?

- (●) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- ( ) Rarely
- ( ) Never

Q7b. If you do not play video games, how do you spend your leisure time?

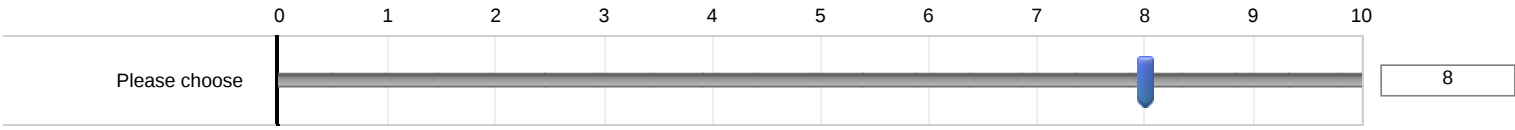
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ( ) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- ( ) Rarely
- (●) Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

The controls were easy, and it was tense to make sure I stopped walking when the thing appeared

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- (●) I felt relaxed
- ( ) I felt tense
- ( ) Prefer not to answer

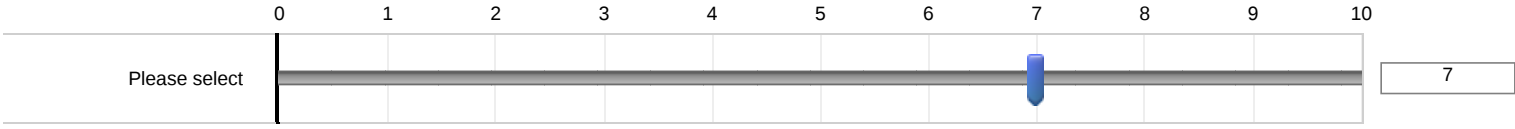
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I jumped when I saw the thing and walking past the deer was tense

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The thing spawning

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I felt tense

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I liked it, I have never played a game like that before

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

62579

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- (●) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) [ ]

Q3. Marital Status

- ( ) Single
- (●) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- ( ) Any other White background (Please specify) [ ]
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
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- ( ) Indian
- ( ) Pakistani
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- ( ) Chinese
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- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) [ ]
- ( ) Arab
- ( ) Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

I never went to university

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q7b. If you do not play video games, how do you spend your leisure time?

Reading books and watching TV

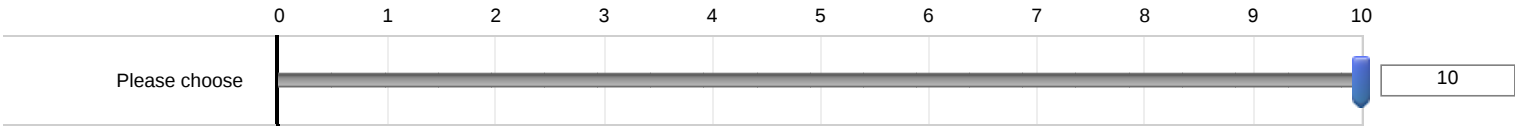
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

It was scary

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

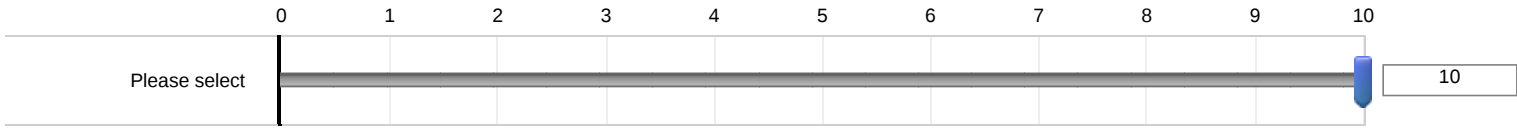
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I felt tense all the time

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

everything

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- (●) Strongly agree
- ( ) Somewhat agree
- ( ) Neither agree nor disagree
- ( ) Somewhat disagree
- ( ) Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

no

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

It was fun

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

37228

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- (●) 30-40
- ( ) 40+

Q2. Gender

- ○ Male
- ◉ Female
- ○ Non-binary / third gender
- ○ Prefer not to say
- ○ Other (Please specify) _____

Q3. Marital Status

- ○ Single
- ◉ Married
- ○ Divorced

Q4. Ethnicity

- ◉ English / Welsh / Scottish / Northern Irish / British
- ○ Irish
- ○ Gypsy or Irish Traveller
- ○ Any other White background (Please specify) _____
- ○ White and Black Caribbean
- ○ White and Black African
- ○ White and Asian
- ○ Any other Mixed / Multiple ethnic background (Please specify) _____
- ○ Indian
- ○ Pakistani
- ○ Bangladeshi
- ○ Chinese
- ○ Any other Asian background (Please specify) _____
- ○ African
- ○ Caribbean
- ○ Any other Black / African / Caribbean background (Please specify) _____
- ○ Arab
- ○ Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ○ Yes
- ○ Maybe
- ◉ No
- ○ Prefer not to answer

Q6. Subject of Study

Nurse

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q7b. If you do not play video games, how do you spend your leisure time?

Drinking

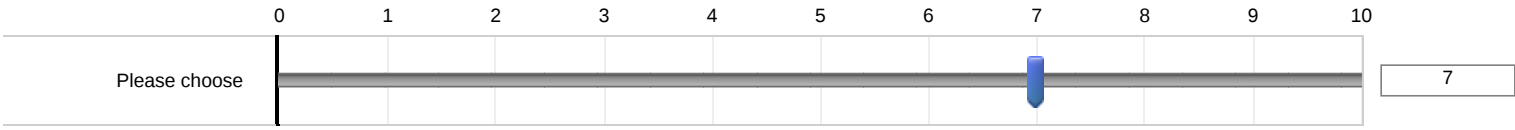
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

The wires were distracting me a little

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

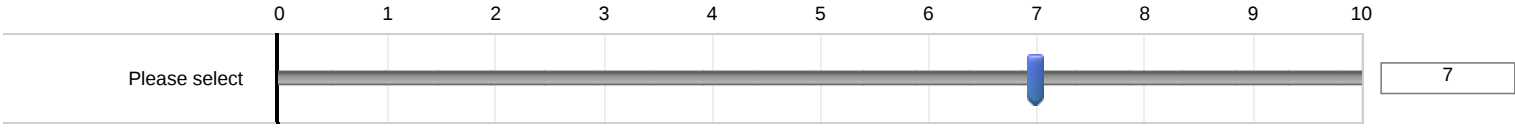
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I felt a bit scared after leaving the house

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The monster

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

No

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I felt my heart beating

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I am not sure

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

26279

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) [ ]

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- ( ) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- (●) Any other White background (Please specify) [american]
- ( ) White and Black Caribbean
- ( ) White and Black African
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- ( ) Indian
- ( ) Pakistani
- ( ) Bangladeshi
- ( ) Chinese
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- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) [ ]
- ( ) Arab
- ( ) Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

Maths

Q7a. How frequently do you play video games?

- ○ Daily
- ◉ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

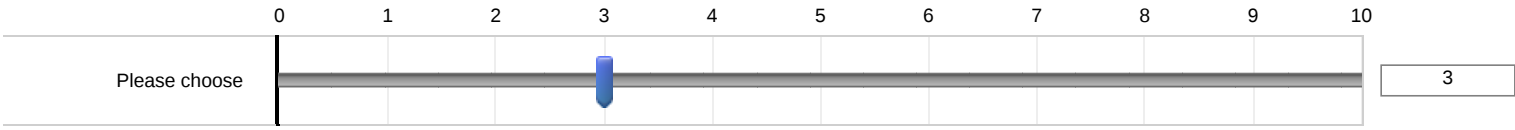
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ◉ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ○ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

no

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

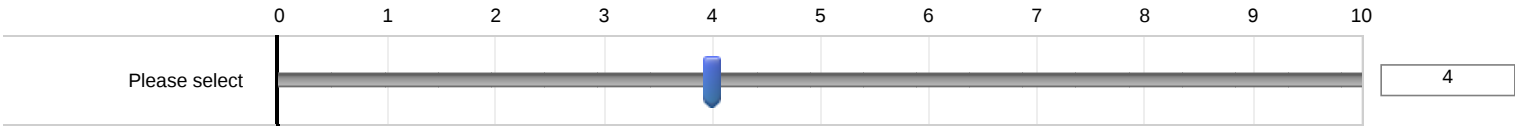
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I didn't

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

Maybe the jump scares

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

The scares were funny

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

It felt the same as other horror games

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

14509

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- ( ) Any other White background (Please specify) _____
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
- ( ) Any other Mixed / Multiple ethnic background (Please specify) _____
- ( ) Indian
- ( ) Pakistani
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- ( ) Any other Asian background (Please specify) _____
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) _____
- ( ) Arab
- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

computer science

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ◉ Once a week
- ○ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

I am always studying

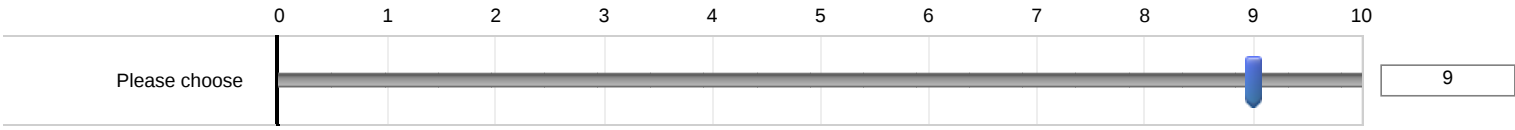
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ◉ Rarely
- ○ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

No

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

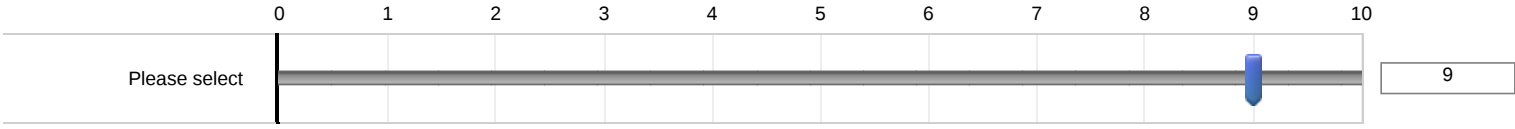
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

The monster spawning

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The monster spawning and the spooky forest with the dark lighting

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

I didn't

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

My heart rate increased

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

It was so unique to see the heart rate and I felt like the lantern was matching how I felt

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

95067

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
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Q4. Ethnicity

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Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

Computer Science

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ◉ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

Study

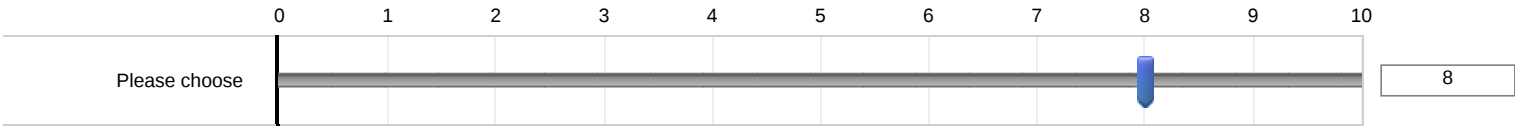
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

I don't know

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

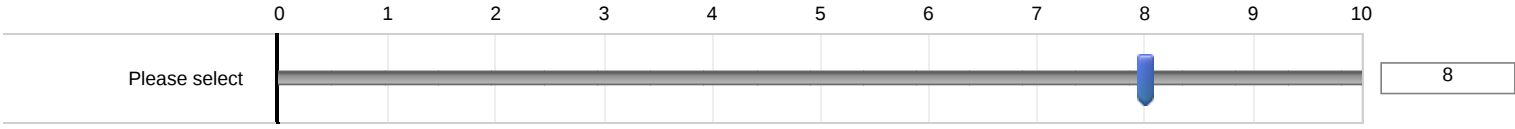
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

The jump scares scared me a few times at the end

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The jump scares and forest

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

No

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

No

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I don't know

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

40310

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- ○ Male
- ◉ Female
- ○ Non-binary / third gender
- ○ Prefer not to say
- ○ Other (Please specify) _____

Q3. Marital Status

- ◉ Single
- ○ Married
- ○ Divorced

Q4. Ethnicity

- ◉ English / Welsh / Scottish / Northern Irish / British
- ○ Irish
- ○ Gypsy or Irish Traveller
- ○ Any other White background (Please specify) _____
- ○ White and Black Caribbean
- ○ White and Black African
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- ○ Any other Mixed / Multiple ethnic background (Please specify) _____
- ○ Indian
- ○ Pakistani
- ○ Bangladeshi
- ○ Chinese
- ○ Any other Asian background (Please specify) _____
- ○ African
- ○ Caribbean
- ○ Any other Black / African / Caribbean background (Please specify) _____
- ○ Arab
- ○ Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ○ Yes
- ○ Maybe
- ◉ No
- ○ Prefer not to answer

Q6. Subject of Study

Astrology

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q7b. If you do not play video games, how do you spend your leisure time?

I like to talk with my friends

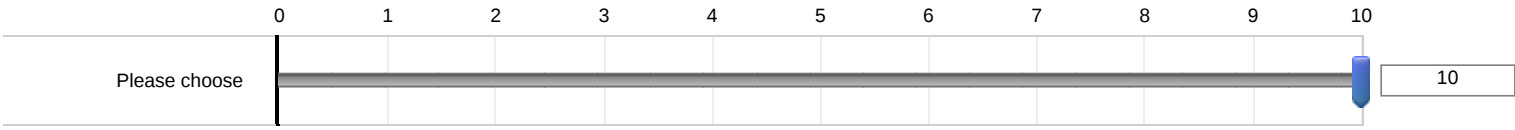
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

No

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
- ○ I felt tense
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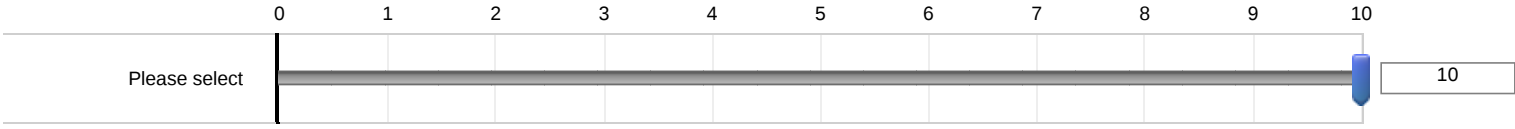
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

The jump scares

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The jump scares, the mood lighting and the tree falling

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

n/a

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

Heart rate and sweating

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I felt like the game jump scared me when I least expected it

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

28479

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- ( ) 30-40
- (●) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) [ ]

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
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- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) [ ]
- ( ) Arab
- ( ) Any other ethnic group (Please specify) [ ]

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- (●) Maybe
- ( ) No
- ( ) Prefer not to answer

Q6. Subject of Study

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q7b. If you do not play video games, how do you spend your leisure time?

I sit in the garden

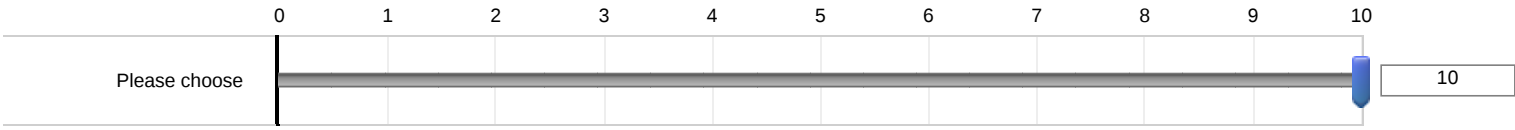
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

I was unsure how the use the mouse properly

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
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- ○ Prefer not to answer

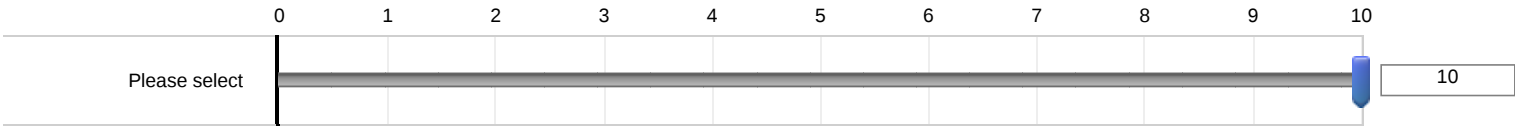
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I felt scared sometimes

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The monster scared the shit out of me

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



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Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

My heart was racing

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I think it must have made it very scary

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

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55030

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

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- ( ) Bangladeshi
- ( ) Chinese
- ( ) Any other Asian background (Please specify) _____
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) _____
- ( ) Arab
- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

Not a student

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ◉ Once a week
- ○ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

I am always working

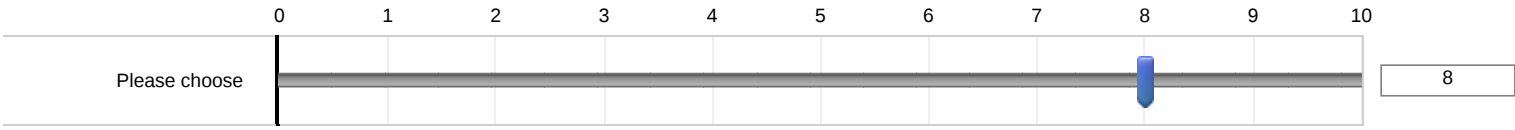
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ◉ Rarely
- ○ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

No

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- ○ I felt relaxed
- ◉ I felt tense
- ○ Prefer not to answer

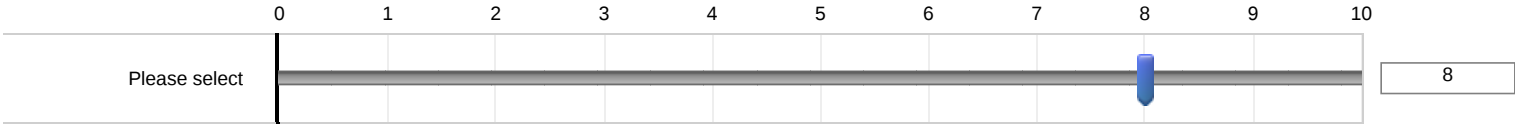
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

The scares

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

The scares

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

No

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I felt a bit sweaty

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I thought it was cool and could be used in some other games

Location Data

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- [x] I agree to take part in the above study

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. **Please initial box**

- [x] I agree to have my physiological read for the study
- [x] I agree to my physiological data to be published after anonymisation as part of this research.

. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

87823

Q1. Age (years)

- (●) 18-20
- ( ) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- ○ Male
- ◉ Female
- ○ Non-binary / third gender
- ○ Prefer not to say
- ○ Other (Please specify) _____

Q3. Marital Status

- ◉ Single
- ○ Married
- ○ Divorced

Q4. Ethnicity

- ◉ English / Welsh / Scottish / Northern Irish / British
- ○ Irish
- ○ Gypsy or Irish Traveller
- ○ Any other White background (Please specify) _____
- ○ White and Black Caribbean
- ○ White and Black African
- ○ White and Asian
- ○ Any other Mixed / Multiple ethnic background (Please specify) _____
- ○ Indian
- ○ Pakistani
- ○ Bangladeshi
- ○ Chinese
- ○ Any other Asian background (Please specify) _____
- ○ African
- ○ Caribbean
- ○ Any other Black / African / Caribbean background (Please specify) _____
- ○ Arab
- ○ Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ○ Yes
- ○ Maybe
- ◉ No
- ○ Prefer not to answer

Q6. Subject of Study

Veterinary science

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ◉ Rarely
- ○ Never

Q7b. If you do not play video games, how do you spend your leisure time?

reading books

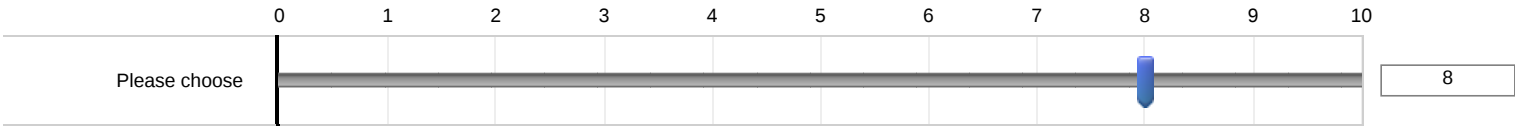
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

I thought the forest was scary

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

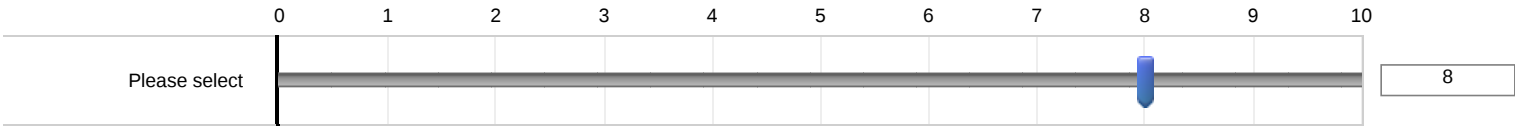
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

the jumps cares scared me a few times

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

lighting, jump scares, fire

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I felt scared

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

The monster always came when I felt at ease and scared me again

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

90926

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- ( ) Any other White background (Please specify) _____
- ( ) White and Black Caribbean
- ( ) White and Black African
- ( ) White and Asian
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- ( ) Indian
- ( ) Pakistani
- ( ) Bangladeshi
- ( ) Chinese
- ( ) Any other Asian background (Please specify) _____
- ( ) African
- ( ) Caribbean
- ( ) Any other Black / African / Caribbean background (Please specify) _____
- ( ) Arab
- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- (●) No
- ( ) Prefer not to answer

Q6. Subject of Study

computer science

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ◉ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ○ Never

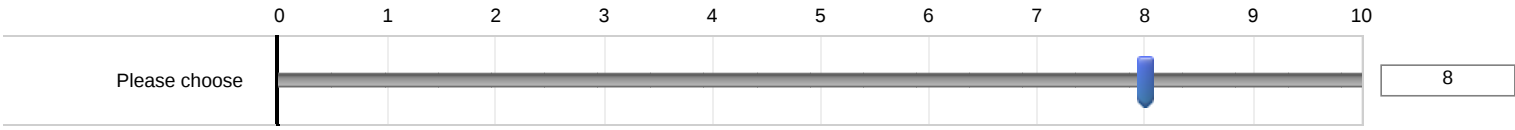
Q7b. If you do not play video games, how do you spend your leisure time?

Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ◉ Once a week
- ○ Rarely
- ○ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

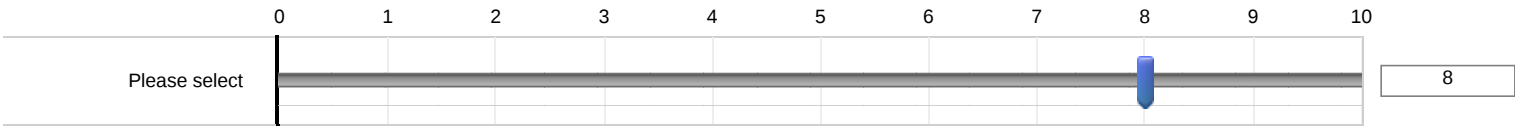
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

The jump scares and the cutscene

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

It was scary that you couldn't look behind you, especially when I heard a sound telling me that something is behind me. The jump scares were also scary

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I felt a bit nervous

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

The wires were a bit distracting and I would prefer more complex controls

Location Data

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. **Please initial box**

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

44103

Q1. Age (years)

- ( ) 18-20
- ( ) 21-25
- ( ) 26-30
- ( ) 30-40
- (●) 40+

Q2. Gender

- ○ Male
- ◉ Female
- ○ Non-binary / third gender
- ○ Prefer not to say
- ○ Other (Please specify) _____

Q3. Marital Status

- ○ Single
- ◉ Married
- ○ Divorced

Q4. Ethnicity

- ◉ English / Welsh / Scottish / Northern Irish / British
- ○ Irish
- ○ Gypsy or Irish Traveller
- ○ Any other White background (Please specify) _____
- ○ White and Black Caribbean
- ○ White and Black African
- ○ White and Asian
- ○ Any other Mixed / Multiple ethnic background (Please specify) _____
- ○ Indian
- ○ Pakistani
- ○ Bangladeshi
- ○ Chinese
- ○ Any other Asian background (Please specify) _____
- ○ African
- ○ Caribbean
- ○ Any other Black / African / Caribbean background (Please specify) _____
- ○ Arab
- ○ Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ○ Yes
- ○ Maybe
- ◉ No
- ○ Prefer not to answer

Q6. Subject of Study

n/a

Q7a. How frequently do you play video games?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q7b. If you do not play video games, how do you spend your leisure time?

reading magazines and watching TV

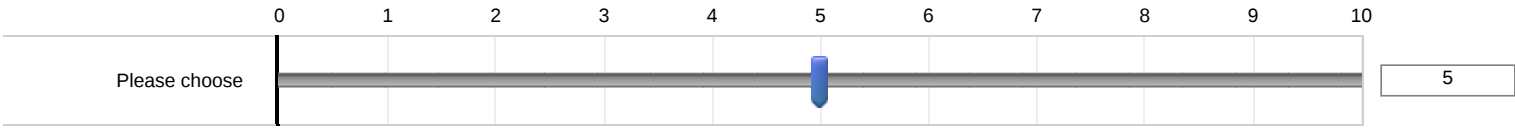
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ○ Daily
- ○ 4-6 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Rarely
- ◉ Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

The heart rate monitor was a bit uncomforting

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



Q11. Before the virtual experience, how would you rate your baseline tension level? (please choose one)

- ◉ I felt relaxed
- ○ I felt tense
- ○ Prefer not to answer

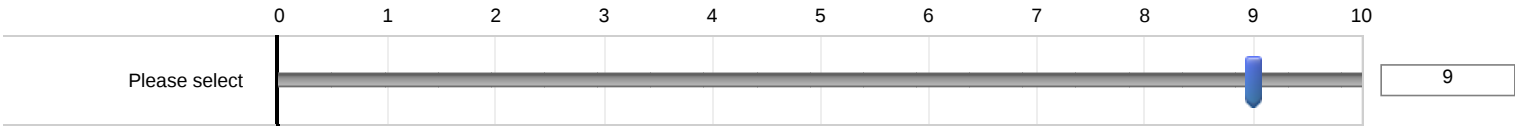
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I felt very scared by the monster

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

Lighting, monster, sounds

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

no

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

I jumped

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I am unsure

Location Data

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. I confirm that I am willing to take part in this research

- (●) Yes
- ( ) No

. Please enter your anonymised ID given at the end of the study

88134

Q1. Age (years)

- ( ) 18-20
- (●) 21-25
- ( ) 26-30
- ( ) 30-40
- ( ) 40+

Q2. Gender

- (●) Male
- ( ) Female
- ( ) Non-binary / third gender
- ( ) Prefer not to say
- ( ) Other (Please specify) _____

Q3. Marital Status

- (●) Single
- ( ) Married
- ( ) Divorced

Q4. Ethnicity

- (●) English / Welsh / Scottish / Northern Irish / British
- ( ) Irish
- ( ) Gypsy or Irish Traveller
- ( ) Any other White background (Please specify) _____
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- ( ) Any other Black / African / Caribbean background (Please specify) _____
- ( ) Arab
- ( ) Any other ethnic group (Please specify) _____

Q5. Do you consider yourself to have a disability?

- ( ) Yes
- ( ) Maybe
- ( ) No
- (●) Prefer not to answer

Q6. Subject of Study

Computer science

Q7a. How frequently do you play video games?

- (●) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- ( ) Once a week
- ( ) Rarely
- ( ) Never

Q7b. If you do not play video games, how do you spend your leisure time?

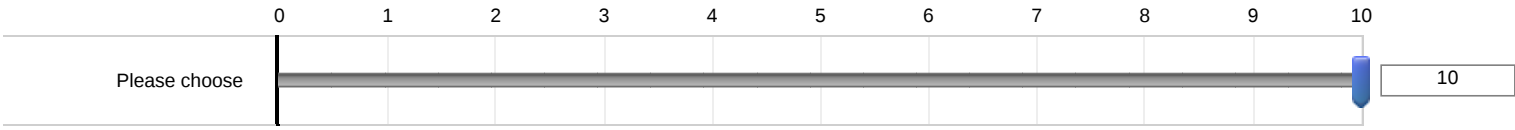
Q8. If you play video games, how frequently do you play video games in the horror genre?

- ( ) Daily
- ( ) 4-6 times a week
- ( ) 2-3 times a week
- (●) Once a week
- ( ) Rarely
- ( ) Never

Q9. Did you find any specific environmental adaptations particularly helpful or distracting in regulating your tension? Please elaborate.

I felt panicked when reading my heart rate on the screen

Q10. To what extent did you feel immersed in the virtual environment, considering the dynamic changes based on your tension levels? (Choose between 1 and 10, with 10 being very immersed)



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- (●) I felt relaxed
- ( ) I felt tense
- ( ) Prefer not to answer

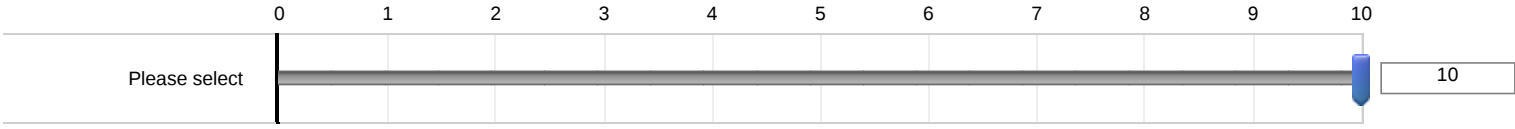
Q12. During the virtual experience, at what points did you notice changes in your tension levels? Can you describe those moments and your emotional response?

I felt tense during the monster attacks

Q13. Were there any aspects of the virtual environment that you found particularly effective in inducing tension? Conversely, were there elements that alleviated tension? For example, you might think that the lighting felt scary.}

monster, lighting and the animals. i thought the deer would attack me

Q14. On a scale of 1 to 10, how would you rate the overall impact of the interactive virtual environment on your tension levels? (10 being the highest)



Q15. Did you feel any discomfort or negative effects related to changes in the virtual environment? If yes, please describe.

Q16. Some particpants do not read the questions and will select a random answer. If you are paying attention, choose "Strongly Disagree"

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ◉ Strongly disagree

Q17. Were there any specific physiological reactions (e.g., increased heart rate, sweating) that you noticed during the virtual experience?

i felt tense

Q18. Do you think the adaptations in the virtual environment enhanced or detracted from the overall enjoyment of the experience? Please explain.

I think the scares at the end were most scary

Location Data

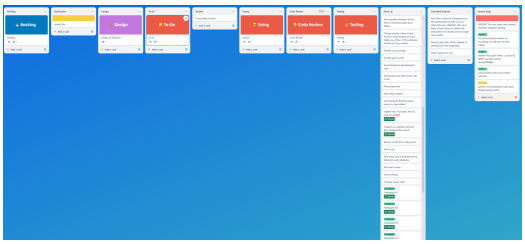


Figure 20: Final state of the Kanban board