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Computer Science

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**Abstract**—Player decision modeling can provide useful guidance to understand player performance in games. This information is used to increase consideration of player characteristics from the user’s perspective and develop more user-centered video games. This paper presents an initial proposal of a factor such as sound that may be considered when developing games, to see if horror games are facing challenges related to sound aspects of the game. Through related work, experiments, interviews and observations this paper aims to answer how sound in horror-games changes our gameplay experience as well as what impact the absence of sound has on a horror-game. We also present the results of this field study and present some suggestions for future research.

**Keywords**—Artificial Intelligence, Player experience, State of emotion, Sound impact, Horror-game sound, Heart rate.

## Definitions

Artificial Intelligence (AI) - “AI is the creation of computer programs that emulate acting and thinking like a human, as well as acting and thinking rationally.” [12].

Player modeling - “The study of computational means for the modeling of a player’s experience or behavior which is based on theoretical frameworks about player experience and/or data derived from the interaction of the player with a game.” [1].

Head-Up Display (HUD) - The area which the player can see important information. Information contained on the HUD can for example be the players health, resources or ammunition count etc. [35].

Non-Player Character (NPC) - The characters in games that are not controlled by a player. They are controlled by the computer via predefined or responsive behavior.

Spawn area - An area where an entity is placed in the gameworld, in this study the entity is an enemy.

Heatmap - Is a graphical representation of data that uses a system of color-coding to represent different values.

Travelpath - The path a player is taking from one point to another point, through a game level, represented as a graphical line or in 3D vectors values.

Expected impact event - An event in the playthrough where change on participants pulse is expected and data is collected as well as what time it occurred.

Player experience - How a player experiences the different aspects of a game. For example, what feeling is created when a player is interacting with an enemy in-game, interact with a start menu, listening to background music or other sounds etc.

## 1. Introduction

Player modeling has become an extensive area of game research, where significant volume of studies has been conducted exploring the interplay between physiology and gameplay by storing several kinds of data from players [1][2]. The main focus of these studies has been to collect and analyze data on how a player interacts with the different aspects of a game, such as game world, menu, items, avatars, NPC (Non-Player Characters) etc. The different interaction logs are used later to model players in-game and provide an artificial intelligence (AI) that adapts to the way players interacts with different aspects of the game world [1]. As described by Yannakakis Georgios N. and Julian Togelius [1], player experience is an important issue in most game development processes and in order to create games that keeps the players curiosity level high, we must analyse the player interaction with every aspect of the game, even sound (in this context referred to as all categories of sound in a game e.g. sound effects and background music etc.).

However, the players experience with sound and which type of reactions it may cause is left unexplored. It is common that sound is associated with classical or contemporary musical pieces. The reality however is that sound is much more than just “music”, but a well-crafted element that complements visual and interactive experiences, often described as audiovisual metaphors [3]. An important part of both film [3][4] and digital games [5][6][7] are the process of sound design, where sound designers fine-tune the intended emotional experience through expert knowledge to the exact content on-screen. This process is harder in digital games, as sound must accommodate player interactivity and the digital environment that vary between different visual styles along the course of an entire game [5][8].

The field of music emotion recognition has often concentrated to find a way to elicit more fear intensity from the player using

various approaches [9][10]. Designing sound for survival horror games is unique compared to other genre since it has strong emotions (e.g. fear, anxiety and suspense) that needs to be crafted more thoughtful than other common game emotions [18]. This paper argues that while fine-tuning these emotions through sound, it can result in generating negative emotions. This kind of emotions can possibly lead to a less pleasant experience of the game. Creating too much tension or fear might change the way we interact with game objects. Worst case scenario, it might result in players not being able to finish the game.

The purpose of this paper is to investigate what impact sound has in horror-games and how it affect player experience of games within the survival horror genre. Through experiments in the form of play tests, data has been collected at three different occasions, before, during and after the test session. Each participant has answered a questionnaire as well as participated in an interview after the play tests. Questions on the questionnaire, some that was answered before and others after the test session.

Once data has been collected it was analyzed, processed and based on these results, we tried to answer these questions:

- How does sound change our experience of horror-games?
  - Does sound contribute to the loss of interest for continuing playing horror-games?
  - What is the impact of sound in horror-games?
  - How does the absence of sound impact the emotional response of horror-games?

This paper also sets out to increase the expertise of player experience with sound aspects of a game and provide a basic understanding for how sound can be used in future development of games. Also, that game developers will be able to take the results of this study into consideration when creating player models and designing sound content for new games.

The outline of the remainder of this paper is as follows. We start by reviewing existing research on sound in horror movies as well as horror-games. We then briefly introduce tools and experiment procedures used for collecting and processing data in this work. Thereafter, we discuss our results and conclusions. Finally, the paper includes some thoughts on future research.

## 2. Related research

Former research have looked into the importance of sound and music in games [5][11] as well as the importance of data collection for player modeling [1]. These studies analyze the interaction with different sound content from the players perspective. Player modeling works by maintaining a profile of each player that captures the skills, weaknesses, preferences, application of strategy and other characteristics of the player by using different attributes. These attributes can be queried by AI to determine how to best adapt its behavior to the particular player [1][2][12]. However, the academic study on how players experiences the different sounds in horror-games and if it can be added to player modeling is a fairly unexplored area of research.

Most research on game sound has divided sound into two categories, interactive sound and background music [5][13]. Interactive sounds are plugged to an action or interaction. For example, jumping, kicking, enemy roar at encounter etc. The main goal of interactive sound is to keep the player connected to the game. Also, to give feedback to the player that something is actually happening when a button is pressed or an enemy is encountered. While background music is about creating the right atmosphere for different scenes. These soundtracks are played more frequently through a play session, for example the soundtracks of game Need for Speed [14] or in the case of Dead Space [15], the introduction song. The different sound elements in games such as sound effects, ambient sound beds, dialog, music, and interface sound together contribute to the overall enjoyment of gameplay [16][5]. These elements combined can also generate strong emotions in players such as anxiety, depression, anger, fear etc. [11].

The importance of sound in horror-games such as Silent Hill [17], Dead Space [15] etc. are discussed in former research [5][18]. However, there are few researches that dives deeply into the way player experiences the sound when playing survival horror-games. Neither is it brought up if these sound elements change the behavior or playstyle of players. There is a lot to explore in this area of research and it has been attracting researchers that wants to explore the enjoyments and displeasures derived from sound elements [5].

## 3. Method

This study followed the field study methodology, specifically experiments. The type of field study that was used, divides the process into three stages described as follows [19]:

1. **Planning and Preparation:** The objective of the field study must be decided. Once the purpose of the study is clear, gathering information on assets: locations, timetables, equipment and other connections needed to perform out tests, can start. Depending on the acquired equipment, methods for logging and preserving data can change. Some examples for recording the study's findings are: notes taken under tests, video recordings, audio recordings or a combination of the above.
2. **Running and Data Collection:** This stage has several alternatives in execution depending on the type of experiment that is performed. Examples of alternative techniques are: interviews, questionnaires, surveys or workshops. The collection of data occurs several times during the same test (before, during and after), this is important for acquiring as much data as possible from the participant.
3. **Data Analysis and Reporting:** Analyse and summarise collected data with the intention of answering the objective given at the start of the planning and preparation stage.

## 3.1. How the method was used during the project

### 3.1.1. Planning and Preparation

The objective of this field study was to answer the research questions mentioned in the introduction of this paper. Finding the equipment needed, in this study's case, a pulse reader that was easy to use while playing games (with keyboard and mouse or a controller), headphones and an eye-tracking system which allows gathering of data on where participants were focusing their eyes during testing. The computer, mouse, keyboard and headphones that was used for testing were provided by the researchers. The games used during testing were the following: *Dead Space* [15] and *Left 4 Dead 2* [20]. Questionnaires were performed at two separate occasions for playing without sound and with sound. The first part of the questionnaire was answered before the participant started to play and the second part of the questionnaire was answered after the participant finished playing. Interviews were performed after each play session and in the interviews, we asked questions from events observed during the test. Therefore, questions and interview topics was designed with the intent and focus on gathering usable data.

### 3.1.2. Running and Data Collection

During this experiment we wanted to have as many participants as possible to collect data. The decision on which game the participant got to play depended on what prior experience they had with the available games and their sequels. Our goal was to have the participants play a game that they had the least or no experience with. The reason for this decision was to eliminate the fact of player already knowing where different sounds were played during the chosen scenes. The total number of tests for this experiment were 33, of which 18 were *Dead Space* [15] and 15 of *Left 4 Dead 2* [20]. During the data collection stage, each experiment session used the methods mentioned above and follow this process:

1. Start the session with a short interview and record heart-rate before participant begins playing the selected game.
2. Participant plays the game without any input from the observers while heart-rate and eye-movement is recorded. The observers will be taking their own notes, including time-markers when participant experience a expected impact event.
3. After the play session is complete and the participant had a moment to rest (between 5-10 minutes [21]), the heart-rate will be recorded. The participant will be subjected to another interview and asked to answer the second part of the questionnaire as well as participate in an interview.

### 3.1.3. Data Analysis and Reporting

Once all relevant data is collected and stored it will be analyzed to see if any conclusions can be made. The pulse data from each individual participant is in a diagram which display what pulse they had during each of the events expected to show an impact in the experiment. Once all play sessions are completed, every participant data will be calculated and the average for each expected impact event will be displayed in another diagram.

## 3.2. Method Discussion

The games *Dead Space* [15] and *Left 4 Dead 2* [20] were chosen because of the way sound is used to produce emotional responses from the players [22][1][13]. In the interviews with the *Dead Space* [15] developers they explain that if you watch a scary movie and remove the sound it is not scary anymore [22]. They also explain how they make "simple things" scary with the help of sound. For example, the player looks around a corner and hear a sound of a creature in the air shafts and see a container rolling across the floor.

Since data was collected using different methods such as, eye tracking, heart rate measurements, physical observation, questionnaires and interviews, we believe that our conclusions are strong because it has input from multiple viewpoints.

However, depending on the participant some methods used for data recording can be less useful. For example, if the participant already played the game and the specific section they are asked to test while the experiment was performed.

Collecting data from different devices during play sessions may include small errors, also referred to as faulty data. The reason for faulty data can be many. For example, heart rate can change dramatically if the tester has to perform another task during a test session. This fact must be considered when data is analysed and conclusion are made.

## 3.3. Threats and Validity

The devices, described in section Equipment (4.3.), was chosen based on the functionality they possess. However, there are potential risks connected with these devices when collecting data. For example, there are different kinds of devices that can measure heart rate. Some are accurate, and others less accurate when measuring pulse. Furthermore, there are also various kinds of stress and eye-tracking devices that have their own benefits and drawbacks. For example, some devices are accurate and provide detailed data, but they are also expensive. While other equipment are cheaper, they can be less accurate which makes the collected data inconsistent when tracking eye movement or stress.

## 4. Solution

In this section we explain why the equipment that was used in the project was chosen. We go through and describe the theoretical backgrounds used and reflect on them. There is also a short description for each of the games used in this experiment.

### 4.1. Theoretical Background and Reflections

In order to fully understand how to test the specific sound genre of games, we first needed to dive deeper into understanding game AI development, how player modeling is connected to it and understand how sound can change our state of emotion as well as our experience of a game. The studies listed in our reference list gave us a great amount of knowledge about where player modeling is today and what researchers hope to achieve in the near future [1][2][5][9][11][12][24]. However, since we focus on sound in horror-games, some of the former studies, that are related to game sound and player modeling, will be discussed briefly in this section.

### 4.1.1. Artificial Intelligence and Games

“Artificial Intelligence and Games” is advertised to people that are interested in game AI and how it is implemented. Although people with an interest to game AI can read this book, it is mainly advertised to three groups of people, university students, AI researchers and computer game programmers [1]. This book presents the game AI research field and acts as a textbook, guidebook and field guide to the three groups mentioned above. The book clearly explains and defines the subject matter, Player Modeling, and mention several angels where player modeling is playing an important role in the AI development process. Since this book discusses the area that is of interest, it is appropriate to dig a little deeper, in order to find the approach that matches our intentions for this project.

However, the goal of this study is not to create an artifact, which means that the book was only used as a starting point to familiarize us in the field of general game AI and more specific Player Modeling.

### 4.1.2. Playing with Sound: A Theory of Interacting with Sound and Music in Video Games

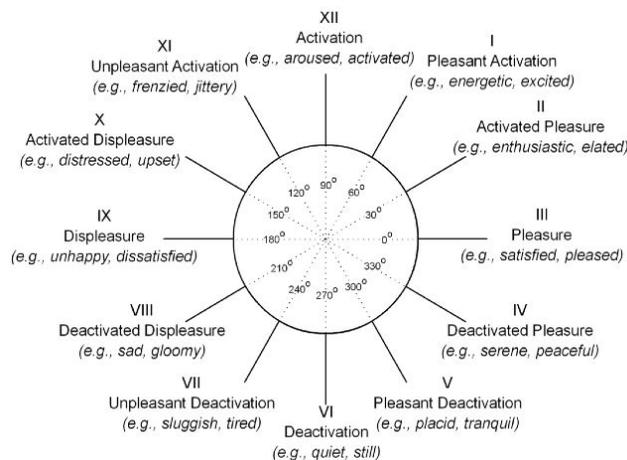
“Playing with Sound: A Theory of Interaction with Sound and Music in Video Games” discusses a variety of approaches for the study of game music such as user interactivity and how sound can complete a game scene. Among other things, the author K. Collins also brings up the different type of sound used in both movies and digital games, the role of these sounds and what the developers are hoping to achieve through them. Furthermore, K. Collins discuss the importance of sound in digital environments, exploring the interactivity between sound and the player. In the course of developing games, the book mentions several ways of conceptualizing and analyzing game music. It explicitly considers other critical issues including the distinction between gameplay and music, how notions of diegesis are complicated by video game interactivity etc. The content of this book has been meaningful and a good starting point for us to understand how to collect data. Suggestions on what to observe during a test session of sound. For example, body language, facial expression, temperature changes, mood swings etc. The different usage of sound (such as using sound to create more fear or using sound to create calmer environments etc.) in digital environments that are brought up in this book makes this reference relevant to our research.

### 4.1.3. A Circumplex Model of Affect

This circumplex model describes the interplay between physiology and state of emotions. The study, done by Russell, describes the affect as a set of dimensions, such as excitement, displeasure, distress, depression and so on. These dimensions are interrelated, and they are represented by a spatial model. This model places the affective concepts in a circle following a predefined order (see Figure 1): Pleasure (0°), excitement (45°), arousal (90°), distress (135°), displeasure (180°), depression (225°), sleepiness (270°) and relaxation (315°) [24].

This model discusses the emotional state of humans and explains how they can change from one state to another. It is worth taking into account when testing the effect of sound in horror-games. Especially games that are not exactly the same on every playthrough, for example Left 4 Dead 2. Since the model brings up

the emotional state of a human [24], it is interesting to see if any emotional changes are tied to the sound of horror-games.



**Figure 1** [25]. The 12-Point Affect Circumplex Model (12-PAC). The vertical axis represents the degree of Activation-Deactivation, and the horizontal axis represents the degree of Pleasure-Displeasure. Reprinted with permission from Yik, Russell, and Steiger (2011)

### 4.1.4. Dead Space

In this interview (video [22] and text [26]) and the game informer article [23], the developers of *Dead Space* [15] talk about the games sound and how they designed and structured it. It is not about sound alone but rather the situation and context of which the sound originated, “Why the sound happened, the timing” - Don Veca, Audio Director of *Dead Space* [15] say in the interview [22]. The developers discuss the use of “Fear Emitters”, especially on the creatures in the game. The way a “Fear Emitter” works is that every object with a emitter has a sphere or area it can influence the sound, one example being volume [22]. Read the full interview in text-format [26]. With the way *Dead Space* [15] developers designed the sound, we can predict specific instances and points in the game and than use them for collecting the data of interest.

The interview was very helpful, in the way they described how the games sound systems different aspects of interactive and adaptive nature works. With this knowledge, directly from the developers, combined with experience of completing the game, we could decide which section of the game to use in the play sessions.

### 4.1.5. Left 4 Dead 2

The sound of *Left 4 Dead 2* [20] is organized in a way that is different from *Dead Space* [15]. Most of the times there are no background music but rather a surprisingly high frequency sound starts every time an infected creature appears at random. This factor leads to many players having issues enjoying the full potential of the game. A lot of players started to make requests on Valve [27] and the Steam website if it is possible to modify the sound or add another sound package to the game [28]. Shortly after, the developers realized that adding the same bullet sound to almost all weapons was not a good idea. Also, the sound package that is originally used in the game, contributed to the increasing complaints about the game overall. That is when they decided to add the functionality of letting players develop special mods (as in this case, modifying game content) for the game as well as adding personal sound packages [28]. They also released a silent mode for a selected level. This mode is without sound and the infected creatures are only attacking the NPC campaign characters. This

mod was an easy way to let the players explore the game world and improve their shooting skills with different guns. Since there are clearly connections between the sound of Left 4 Dead 2 and the players, we decided to use this game as a testing ground for our research and find out if it is possible to take this factor into consideration in future player modeling.

## 4.2. Play Session Design

This section has a short description for each game. Thereafter we explain what parts of the games was used during testing, why these parts were chosen and when a change in heart rate is expected to happen and gather data from.

### 4.2.1. Dead Space - Playtest settings

Dead Space is a third-person survival horror game, where the player takes control of an engineer named Isaac Clarke. The player is part of a repair crew tasked to make contact and help the mining spaceship Ishimura, which they recently lost contact with. But once arriving the repair crew are greeted by horrors they never thought possible [15].

With Dead Space being third-person and the HUD (Head-Up Display), while playing, being designed to not have health points, ammunition and other resources displayed at the upper or lower corners of the screen. Instead the health bar and other resources are shown on the player characters avatar, see Figure 2. We hope this HUD design will help determine if and when the player react with sounds. We can see this by looking at where the player is focusing their sight when encountering an enemy or other event. Some examples on events are:

- Is the player erratically shifting their focus between the enemy and health bar?
- Does the player stop and aim with their weapon a lot to see if it is loaded with enough ammunition to handle the next encounter?



**Figure 2 [29].** The vertical neon blue line on the avatars back indicate the players health. The neon blue circle on the right side is the stasis resource. A weapons ammunition count is displayed on every weapon but only while the player is aiming with it.

The section of the game that has been tested is the introduction scene (Chapter 1), when the player gets to control of the main character for the first time. The scene plays out as described below:

1. The repair ship, with player and crew, tries to contact the main ship (the Ishimura) and ask if they can dock, see Figure 3. With only a static answer from the radio they try to dock but almost crash in the process.



**Figure 3 [30].** Picture taken from the repair ship. The main character (Isaac Clarke) to the left and the two other important characters in the middle left Kendra Daniels and the middle right Zach Hammond.

2. After exploring the lights go out and the player gets separated from the repair crew.
3. Once the player is alone, they have no access to any weapons and only have the choice to flee.
4. After the player has entered a sort of safe area, they acquire their first weapon and can start exploring the corridors of the ship (Ishimura).
5. A few encounters with mutilated creatures and the player comes into contact again with what is left of their crew.

This is the end of the play session for Dead Space. The equipment is expected to gather data from all points listed above, but the points that most impact is expected from are point two and three. The reason for this expectation is that during those events, the player is constantly chased by monsters and can not really see them but only hear their roars and horrid scratches against the walls of the ship.

This scene was chosen because it is the first time the game shows-off its environment, atmosphere and sound design. The fact that it is also the first time our cast of characters in the game are exposed to the horror within the game, adds more emotion and fear overall. The scene was also chosen for its length, the play session is estimated to take 8-12 minutes depending on how careful the player is once their first weapon is acquired. Data collection was done with and without sound for comparison purpose.

### 4.2.2. Left 4 Dead 2 - Playtest settings

Left 4 Dead 2 is a first-person shooter game where the player takes control of one out of four survivors of the zombie apocalypse. The introduction of each level starts with the four survivors meeting each other. They decide, shortly after meeting, to find other survivors or a way to escape the apocalypse.

There are different modes to play the game. For example: survival, campaign, playing as infected or versus other players. These modes allow the player to play in different environments and have different goals to complete the game. For example, survival mode is all about surviving for as long as possible. There is no way to win in this mode but rather the play session ends once every survivor has been killed. The sound in this game mode does not stick out as much as in other modes. The reason for this is because the player is located in one area (e.g. a warehouse, building etc.) and constantly attacked by enemies, thus the only sound heard is enemies' roars and screams. Modes such as campaign have more linearity and players can complete levels by reaching the rescue point. There are also more sound effects which are used to create that horror feeling in the game. Some other aspects of the game are also connected to sound. For example, jumping or shooting on certain cars or shooting constantly can alert a horde of the infected creatures.

During playtests, our biggest focus was measuring the heart-rate during a specific level called "Blood Harvest". In this level, the survivors are supposed to go through an industrial area to finally arrive at a safehouse as their last spot to load up with weapons, resources, health kits and prepare for the final battle. The chapter of playtesting begins once you exit the safehouse. The scene plays out as described below.

1. The safehouse is a farmhouse near a cornfield, where the player can get guns, ammo health etc.
2. In the distance, they see a big villa and one of the survivors says it will be a great spot to get an overview of the place. They decide to go for it.
3. Going through the cornfield, they encounter lots of infected creatures together with some uncomfortable surprise sound elements.
4. Once through the cornfield, they find a radio in the house and can communicate with a rescue team. They are asked to hold their ground and wait for the rescue vehicle. See Figure 4 for visual details of the level.

This is the end of the play season because the last battle, while waiting for the helicopter, is not relevant for our study due to the lack of many sound interactions. Since the test scene plays out in a cornfield, which are tall enough to hide the infected creatures, there are more sound encounters to expect a good data collection for us to lean back on. The system collects data with and without sound for comparison purpose.



Figure 4. Left 4 Dead 2, picture taken in the final stage of "Blood Harvest".

## 4.3. Equipment

This section will go through the equipment that is being used in this experiment. The chosen products are presented further down.

### 4.3.1. Heart-Rate Monitor

To measure the Heart-Rate we used *Polar M400 HRM* together with the heart rate monitor. This sport watch can measure the pulse on participants and transmit the data to a webpage, where it can be exported to another medium of our choosing. The wristband has other functions like time, step counter etc. However, we are only going to use the Heart-Rate Monitor. The *Polar M400 HRM* was also chosen for its form. Since it is a sport watch, it is easier to wear and use during playtests while playing with a keyboard and mouse than for example electrocardiography.

### 4.3.2. Eye-Tracking

To be able to track the testers eye movement, we are going to use the eye-tracking device *Tobii Eye Tracker 4C*. This device track and record where the testers are focusing and gazing during specific parts of the play session.

### 4.3.3. Other Equipment

The headphones used in this experiment is the Sennheiser PC 363D that have a built-in soundcard [31]. As this experiment is based on sound, it is important that we are using headphones which can provide the highest settings of sound quality the game is providing. The mouse used in this experiment is the Razer DeathAdder Elite [36] and the keyboard used is Razer Ornata Chroma [37].

## 4.4. Experiment

To collect data, the testers are asked to play one of the two games available. The tester answers a questionnaire [Attachment 1] that is divided into two parts. The participant is asked if they have any prior experience with horror-games and specifically if they played any of the two available games. If the tester has experience with one of the games, they are going to test the other available game and if experience exist with both games the researchers picked one for the participant at random. The testers pulse is taken before the playthrough starts. At this point the experiment differs between both games. In the case of *Dead Space* [15] it is easier to repeat and compare data. This is in part to the scenes, chosen for this experiment, linearity and that enemies spawn at the same places every repeated playthrough. In *Left 4 Dead 2* the level layout is the same on repeated playthroughs, but the enemy placement differs. With this in mind the representation of the *Left 4 Dead 2* results will not use any expected impact events that *Dead Space* did.

The first playthrough is conducted without sound and the second with sound. Playing without sound first, prepares the tester of what is going to happen and in turn separate the impact of sound from the graphical impact. Data is collected for both playthroughs. In the case of *Dead Space* [15], when the events where expected impacts happen, the time is recorded so the pulse value can be acquired. However, in the case of *Left 4 Dead 2*, the time when enemies are encountered is recorded so those pulse values can be identified. Once both playthroughs are done, the participant will answer the second part of the questionnaire [Attachment 1]. While participants play, the researchers are answering their questionnaire with the

impact event questions [Attachment 2] for Dead Space and [Attachment 3] for Left 4 Dead 2.

After the data is stored, it is added to the rest of the results and plotted as a diagram so a comparison between the playthroughs (with sound and without sound) can be made. The comparison is made with the individual participants playthroughs and later added into another diagram which displays the average results.

During our play sessions, the system collected pulse data from the sport watch and we were able to compare it. When it comes to collecting data from the eye-tracking device, we were unable to extract any kind of data. Unfortunately, some potential risks became a reality and due to the device manufacturer not being clear on the usage of the device, we discovered during our first play test session that some functions worked differently then described in the user manual. Those functionalities required a premium licence in order to be able to extract any data from the device. Since this study was already at the testing phase, there was not enough time to acquire such a licence and use it for the intended purpose of this study.

## 5. Results

In this section, results from the experiments are presented from each game separately. First, four diagrams that displays two participants pulse without sound (see Figure 5 and 7, Table 2 and 4 for event values) and with sound (see Figure 6 and 8, Table 3 and 5 for event values). Second, for the Dead Space experiments, a diagram that displays the average pulse of all the participants in each of the listed events. The reason for this is because of the way Left 4 Dead 2 is structured, with enemy placements, being random and can appear depending on actions the player makes, expected impact events can not be anticipated. Lastly a summary of the interview and questionnaire that participants answered in their play sessions is presented.

### 5.1. Dead Space

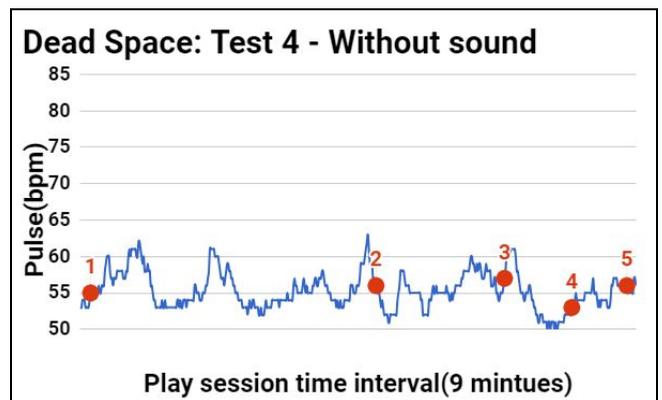
In most events a spike in the participants pulse is expected. However, in event 4 a decrease in the participants pulse is expected, this in part to the area being safe and the sound has become more relaxed from the previous event were the player was chased by creatures. A description for each of the events that are of interest can be seen in Table 1:

**Table 1:** Shows the description for every event of interest. The events have a number (Event) followed by a description of what is happening in the scene (Event description), and lastly a more detailed explanation of the area data should be noted (Event impact check).

Event	Event description	Event impact check
1	The repair ship with player and crew tries to contact the main ship (the Ishimura) and asking if they can dock. With only a static answer from the radio they try to dock but almost crash in the process.	The static sound from the radio (Some strange noises can be heard if one listen).
2	After exploring the lights go out and the player gets separated from the repair crew.	Area before player gets separated from crew (go through door to smaller room).

3	Ones the player is alone they have no access to any weapons and only have the choice to flee.	Control room in the same area as Event 2 and the chase to the safe area.
4	After the player has entered a, sort of safe, area they acquire their first weapon and can start exploring the corridors of the ship (Ishimura).	Did equipping weapon calm the player down? Did they are still acting erratic or stressed?
5	A few encounters with mutilated creatures and the player comes into contact again with what is left of their crew.	A few encounters where creatures fake being dead and when player get close they awake.

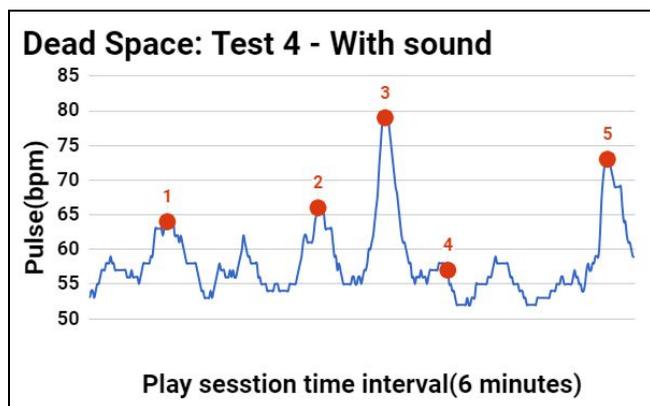
The data displayed in the two diagrams, Figure 5 and Figure 6, are taken during the same play session and from the same participant. Both playthroughs cannot be displayed in the same diagram because the same events do not occur at the same moment of time. This also explain why time values are high in the second diagram (Figure 6) with sound starting at 15:52 minutes, as they are recorded together in one session. The timeline is not shown in the diagram but instead the duration of the play session. The timestamp for each event can be seen in the table after each diagram. In both diagrams the blue line shows the participants pulse over the playthrough. The orange dots display expected impact events and the number next to the dots indicate which event it represents. The spikes between event 1 and 2 as well as 4 and 5 in Figure 6 and 8 indicate events that we did not focus on. The first spike (between event 1 and 2) is when a ship is crashing into another ship and some uncomfortable sound is played in the background. The second spike (between event 4 and 5) is the result of encountering an enemy attacking an NPC.



**Figure 5.** This figure shows a play session from Dead Space, test 4. In this diagram one can see that the expected events do not indicate any real impact and spikes in the pulse are related to the graphical impact the game have.

**Table 2:** Shows the value of each event, for test 4, displayed in Figure 5.

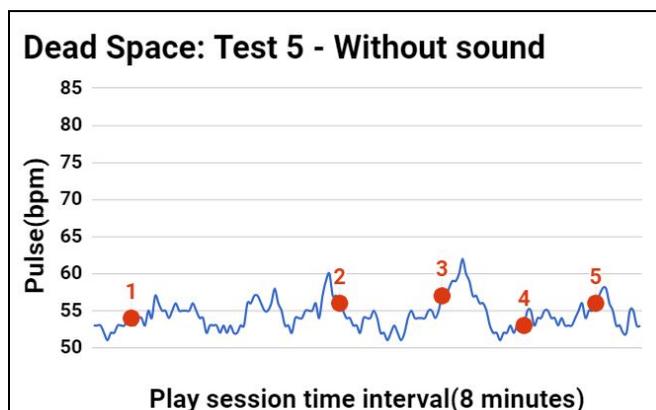
Event (number)	Without sound (bpm)	Time (minutes:seconds)
1	55	5:35
2	56	10:15
3	57	12:21
4	53	13:27
5	56	14:21



**Figure 6.** This figure shows a play session from Dead Space, test 4. Looking at the events in this diagram, where the game was played with sound, one can see that the pulse spikes at expected events. One exception is event 4 which reason was explained at the start of this section.

**Table 3:** Shows the value of each event, for test 4, displayed in Figure 6.

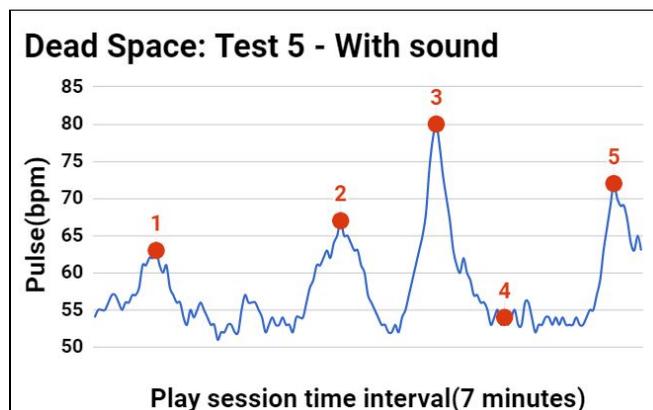
Event (number)	With sound (bpm)	Time (minutes:seconds)
1	64	15:52
2	66	17:33
3	79	18:18
4	57	19:00
5	73	20:47



**Figure 7.** This figure shows a play session from Dead Space, test 5 for comparison.

**Table 4.** Shows the value of each event, for test 5, displayed in Figure 7 for comparison.

Event (number)	Without sound (bpm)	Time (minutes:seconds)
1	54	0:54
2	56	3:45
3	57	5:28
4	53	6:37
5	56	7:49

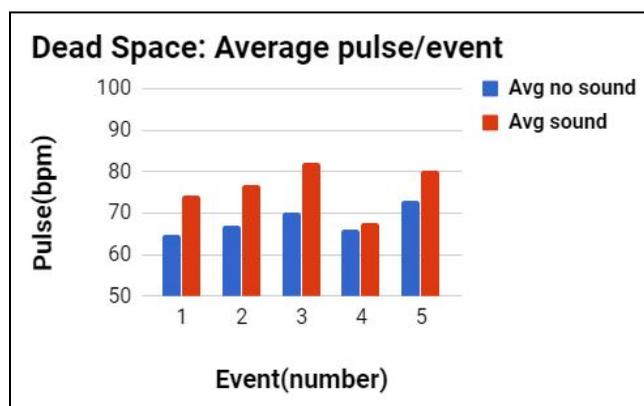


**Figure 8.** This figure shows a play session from Dead Space, test 5 for comparison.

**Table 5.** Shows the value of each event, for test 5, displayed in Figure 8 for comparison.

Event (number)	With sound (bpm)	Time (minutes:seconds)
1	63	0:58
2	67	3:02
3	80	4:15
4	54	5:06
5	72	6:42

With all data analyzed the resulting diagram, Figure 9, display the average pulse for each event and, Table 6, show the average numbers while testing with and without sound:



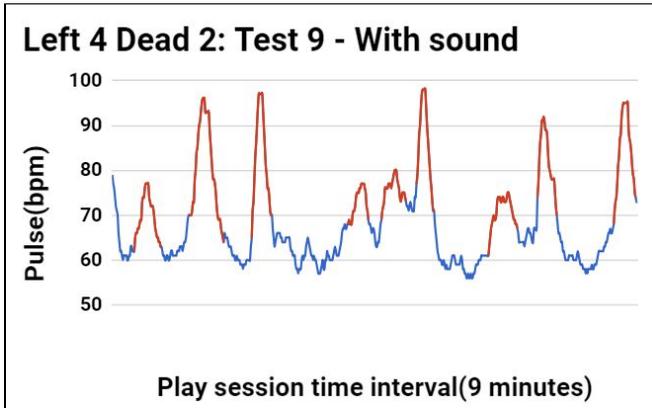
**Figure 9.** Display all participants average pulse for each event over 18 tests. The blue lines show pulse when the participants are testing without sound and red lines show testing with sound.

**Table 6:** Shows the average values from all tests that are displayed in Figure 9.

Event (number)	Average no sound (bpm)	Average sound (bpm)
1	64.75	74.25
2	67.00	76.75
3	70.00	82.25
4	66.00	67.50
5	73.00	80.25

## 5.2. Left 4 Dead 2

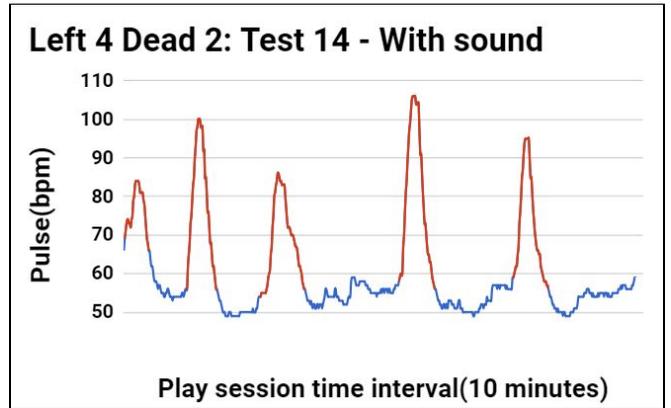
Play sessions of Left 4 Dead 2 are different from Dead Space because the enemy spawn time is random in Left 4 Dead 2. Keeping this in mind, we are looking for overall impact of sound throughout a play session and try to take notes of the time when an enemy or group of enemies are encountered. It is also worth mentioning that most of the players were more explorative and looked around the level during play sessions without sound. However, the same players were more task oriented during test session with sound. The focused shifted from exploring the map to the main mission. Further down we will go through some data diagrams (see Figure 10 and Figure 11) and statistics for the game Left 4 Dead 2.



**Figure 10.** This figure shows a play session from Left 4 Dead 2, test 9, looking at the pulse data, there are clear gaps between average pulse (blue line) and pulse at certain occasion when an enemy is encountered with sound (red line). The pulse starts high because the test session was recorded without starting a new recording from the test session without sound.



**Figure 11.** This figure shows the pulse of one participant, test 9. However, the pulse does not jump as much as with sound. Those small spikes are occasions where the player is surrounded by enemies which raise their pulse.



**Figure 12.** This figure shows a play session from Left 4 Dead 2, test 14 for comparison.



**Figure 13.** This figure shows a play session from Left 4 Dead 2, test 14 for comparison.

## 5.3. Questionnaire and Interview

In this section the results from questionnaires will be shown. The participant distribution between the games (see Table 7) as well as how many tested a game they had prior experience with (see Table 8). Firstly, two tables that show the number of tests were conducted in this experiment and how many of those tested a game they already had experience with. Secondly, results of the questionnaires general questions. Lastly, results on how much events impacted the tester as well as answers researchers had on the same events, so they can be compared.

**Table 7.** Shows the number of participants for both games used in this experiment.

Game	Number of testers
Dead Space	18
Left 4 Dead 2	15

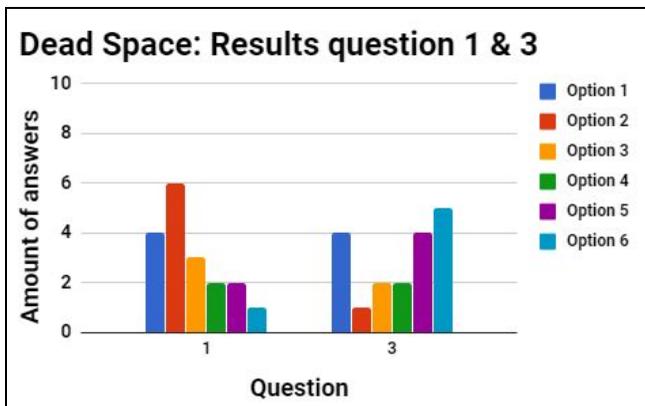
**Table 8.** Show the number of participants which had prior experience with either or both games in the experiment.

Game	Testers with prior experience
Dead Space	3
Left 4 Dead 2	4

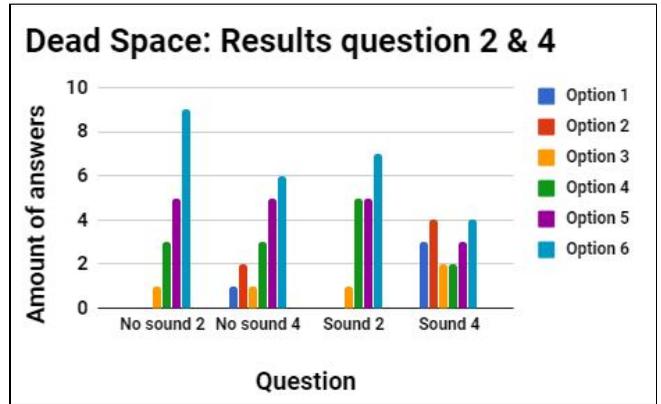
Each participant answered a questionnaire, some questions to be answered before the play session and other questions to be answered after. There are some exceptions, question 2 and 4, that will be answered twice during the whole play session. Question 2 will be asked before each playthrough (without sound and with sound) and question 4 after each playthrough. The reason for this is because we want to keep the general questions separate from questions related to expected impact events. It is important for us to know the emotional state (in this case, the mood of the participant) of a participant before and after the test session. In Table 9, all questions, to be answered before the play session are shown. After, two diagrams for each game, the first shows the results for question 1 and 3 (Dead Space - see Figure 14, Left 4 Dead 2 - see Figure 16) and the second shows the answers for question 2 and 4 (Dead Space - see Figure 15, Left 4 Dead 2 - see Figure 17):

**Table 9.** Shows questions in the questionnaire. All questions are answered with a number from 1 to 6, were 1 is the lowest scale and 6 the highest.

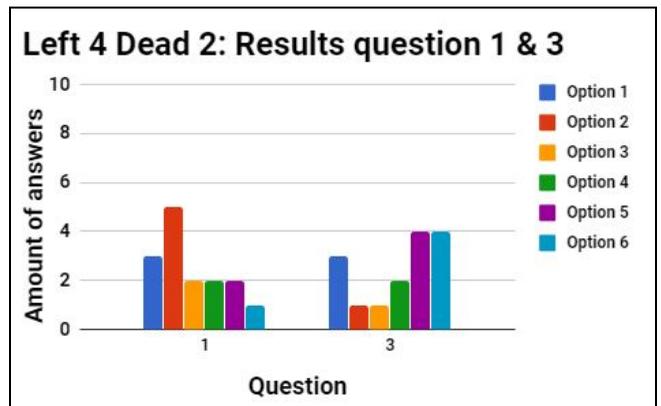
<p><b>Question 1:</b> Are you scared easily? 1 - Very easy 6 - Never</p>
<p><b>Question 2:</b> What mood are you in now (before playing)? 1 - Bad 6 - Good</p>
<p><b>Question 3:</b> Where would you say your prior experience with horror-games lay? 1 - Never play horror-games 6 - One of my favorite game genres</p>
<p><b>Question 4:</b> What mood are you in now (after playing)? 1 - Bad 6 - Good</p>



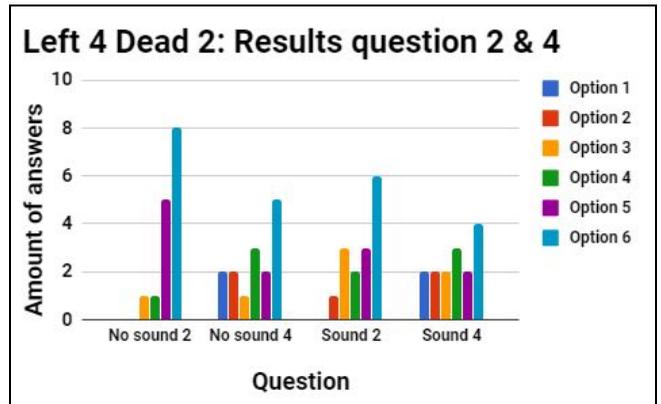
**Figure 14.** This diagram shows the results, for question 1 and 3, of the questionnaire from all 18 participants that tested Dead Space.



**Figure 15.** This diagram shows the results, for question 2 and 4, of the questionnaire from all 18 participants that tested Dead Space.



**Figure 16.** This diagram shows the results, for question 1 and 3, of the questionnaire from all 15 participants that tested Left 4 Dead 2.



**Figure 17.** This diagram shows the results, for question 2 and 4, of the questionnaire from all 15 participants that tested Left 4 Dead 2.

The second part of the questionnaire, to be answered after the play session, contains question about the expected impact of events (see section 5.1. for Dead Space). Both the researchers (see Table 11) and participants (see Table 10) answered those questions separately with no interaction with each other so comparisons could be made. The average values from both results (without sound and with sound) of the impact event level are shown in the same table. The level of impact is graded with a number between 1-5. Where 1, being the lowest score, translates into the tester did not react physically during the expected impact events and 5 being the highest score and translates into the tester reacted more physically (e.g. jumped or screamed from being surprised). This was explained to the participant before the test session.

**Table 10.** Shows all testers average impact levels for each expected impact event.

<b>Dead Space: Tester impact results</b>		
<b>Event (number)</b>	<b>Impact no sound (average answer)</b>	<b>Impact sound (average answer)</b>
1	1,0	1,3
2	1,0	2,1
3	1,2	3,6
4	1,0	1,8
5	1,5	3,5

**Table 11.** Shows the researchers interpretation of average impact levels for each expected impact event over all play sessions.

<b>Dead Space: Researcher impact results</b>		
<b>Event (number)</b>	<b>Impact no sound (average answer)</b>	<b>Impact sound (average answer)</b>
1	1,2	1,9
2	1,0	2,6
3	1,3	4,1
4	1,0	2,2
5	1,8	3,9

#### 5.4. Connecting to circumplex affect model

As described in section 4.1.3., this model was taken into consideration when looking at the answers of question 1 and 4 from the questionnaire. These two questions are more related to the humour or emotional state of the player, thus answers from these questions are important to see whether a change in emotion has taken place after each game session. This was more important during the playtest of Left 4 Dead 2 due to the fact of enemies spawn point is different for every gameplay. With the help of the Circumplex affect model, we tried to create an understanding of the behavior of the player when playing with and without sound. As the results in Figure 15 and 16 shows, there is a mood change in most cases. Most participants get disconnected from the game when there is no sound and get bored. However, playing with sound shows that there is still a mood change in most cases but rather scared and annoyed than bored. We also observed that participants acted differently when playing with sound. For example, most participants killed a certain enemy when playing without sound but avoided the same enemy when the sound was on. While looking at these two figures, they are similar but having Russell's model in mind, the results of the two questions on the left side of Figure 15 describes the gameplay without sound and a mood change towards boredom. While the results of the two questions on the right side describes gameplay with sound and shows a mood change towards being excited, scared, irritated and annoyed.

## 6. Discussion

The sound elements in a game are a crucial part of the experience that players get from a game. The different sounds within a game binds the player to the game. For example, people familiar with the game PacMan [32], every time they hear the PacMan [32] sound, they recognizes the sound and know where it is from [5]. As stated in previous work and what we also discovered during our test sessions, sound can create positive connections between games and players [5]. If sound can create positive connections this also means that it can create negative memories or connections. To build upon already existing work, on sound aspects of games, we discuss the possible impact of sound in horror-games based on the results of this study.

We usually think of curiosity as one of the main drivers of humans playing games. However, we believe that some background music or sound effects might limit players from fulfilling their curiosity. During our test sessions, we discovered that most players are less curious about different parts of the games when playing with sound. They rather focus on reaching a safe spot or complete the main objective of the game then exploring game world. There is also a slight mood change due to the background music and sound effects in the chosen games as shown in Figure 14 and 12. The heart rate is another factor that shows the effect of sound on players (see Figure 5, 6, 7, 8).

It is important to take into account that measuring the influence of sound in a game is hard. Even if sound plays a huge part in games, measuring the exact impact of sound can differ from person to person. For example, during test sessions, some participants were easily scared, and the reaction was clearly visible at the specified events. Others were more resistant or able to ignore the sound at certain moments. Nonetheless, the change in heart rate occurred in all testing occasions. Since is it hard to measuring what effect sound have [13], one can not really tell if participants that had slight changes in heart was because of the sound or maybe plain excitement while playing with sound. However, the big spikes in pulse changes were a clear sign of being scared or feeling uncomfortable. One could confirm this from observing the body language as well as facial expressions of the participants. This argument could be even stronger if the eye-tracking equipment worked as intended. Data from the eye tracking equipment would have been a great asset to compare with heart rate and other observations. Data such as how stressed a player is during parts of the game could have strengthen our observations and to ensure that they lead to the same conclusion (e.g. that both methods points that the player show stress at the same moment).

When sound was eliminated from the game, players got bored, lost interest and focus in the game, in other words, the connection to the representation of the player ingame was lost. As a result of this mood change, the player did not care about what was happening in the game. It is interesting that the same scene with sound made some of the players react strongly. Without sound, it was a completely different situation. For example, during test sessions of Left 4 Dead 2, we noticed that most players acted differently when playing with sound then playing without. Most players avoided an enemy called "Witch", due to the background music and sound effects being played when she is encountered. The enemy, mentioned above, always appears in dark areas of the game, crying loudly and the background music played around her is unpleasant. While playing with sound most players avoided killing

her and just passed by. But playing without sound, almost everyone shot her. Discovering this during play sessions, it was worth asking the participants why they acted the way they did. The participants got surprised at first when we asked them why they acted differently in the same situation but when they reflected on it one of them answered: “*she appears scarier when you can hear her and the background music also it is uncomfortable hearing her cry, so you just want to pass the area quickly*”.

It was discovered late in the testing phase that it would be a powerful addition to the data collection if travelpaths or heatmaps were recorded. With the help of travelpaths one can analyze and get a visual picture of different paths that players are taking to get to the finish-line in games like Left 4 Dead 2. Data collection of this kind would strengthen the observation of player exploring more without sound and less with sound.

It might also be worth noting that even if there are interactive sound in a game, mentioned in previous research [5][16][13], other background music can also become partially interactive even if it was not meant to be that way. As described in the observation above, a player automatically reacts on sound without even realizing it. The participants got surprised at first when we asked them why they acted differently in the same situation.

Such situations can be the reason for exploring the effect of sound in horror-games and maybe include the adjustment of sound in future player modeling. By collecting data of the way a player is going through an area of a game level, we might be able to adjust the background music. For example, if someone is running through a map, it might be a sign of a stressed or scared person and the background music will tone down and vice versa.

Participants that had former experience with the games might have known what was coming but they still reacted when hearing the sound. In some way they connected the sound to a less pleasant experience from when they played the game in an earlier occasion. Hearing the Dead Space introduction sound, the common reaction among players that knew the game was: “*Oh it’s annoying to listen to this music*”, “*this brings up some old and scary memories*” etc.

Furthermore, data from tests shows that there is an impact on player behavior. Our observations made it clearer that it is possible that some parts of the game world might be ignored by players as a result of poorly integrated background music or sound effects. The data analysis shows that sound in horror-games clearly affects players experience. Due to the fact that most participants heart rate increased or that their playstyle changed when sound was involved, is a clear sign that sound affected the player experience to some extent. We also noticed during our research that measuring the impact of sound in a game is a complicated subject. This might be one of the reasons that there are few studies exploring this area. However, former research [1][14][5][7][11] in this area has been of great help to understand how player modeling works. Also, to understand how different state of emotions can be achieved through sound in digital environments as well as future artificial intelligence.

While other researchers focused on the positive side of Russell’s two-dimensional model of affect [25], we focused on the negative side. How sound in games are affecting people’s negative emotions and if it can be added to player modeling. To adapt the sound of a game via AI, the same way that enemies are adapting to the playstyle of a player in games today.

## 7. Conclusion and suggestion for future research

We have come to the conclusion that sound has not only a big impact on our experience of a game but also affects the way we play it. During our test sessions, we discovered that some areas of a level in a game are unexplored, possibly due to the fact of game sound not being perfectly balanced (e.g. too much stressful sound, the testers run through the area and not exploring). To back this theory, we measured heart rate with and without sound and stated some spontaneous questions about it. It was also observed during test sessions that most testers that had prior experience of games had the sound connected to a negative activity.

To our knowledge, former researchers has focused on sound interaction and how to keep the player constantly connected. There are also studies with focus on how to make the games more intense and scarier. However, in this paper we have specifically focused on the sounds that are supposed to enhance our experience of a game. To possibly find out if these sounds also contribute to negative experience.

Exploring the negative impact of sound can be tricky and this area is new to research but important. Exploring this gap will expand the knowledge of building balanced games. We hope that our findings and observations will be an important contribution to player modeling and sound development of future games. Also, that our study will serve as a good starting point for further exploration in this area.

Furthermore, to be sure that sound is the reason why some objects of a game are ignored, one must do more test with larger number of participants. It is also recommended to record travelpaths to see a possible pattern and compare the results from different testers.

In terms of future research, we particularly suggest using more advanced versions of data collecting devices as well as more different kinds of data gathering methods with new devices. Examples on devices we suggest are, a GSR (Galvanic Skin Response) [33] sensor combined with an Arduino [34]. With this equipment one can measure the participants sweat. Sweat is the normal function of the human body to keep it within a specific temperature. However, in both foot and hand regions sweat can be triggered by, negative or positive, emotional stimulation [33]. Another equipment that is highly recommended is the use of an EEG (Electroencephalogram), a device that can measure brain waves. With the help of this device, it might be possible to confirm the different emotions of a player. The last technology we suggest for future research is eye-tracking, we could not get the eye-tracking equipment working in our experiments as explained earlier in this paper. We think, being able to track participants eye movement during specific events can yield data that later can be used in areas for AI and player modeling purposes.

## 8. Acknowledgements

A special thanks to our supervisor, Jose Maria Font Fernandez, for all the guidance and supervision he has given us. We also like to take the opportunity to thank all the participants for their important contribution with data collection and personal thoughts as well as feedback. Finally, we would like to thank the revision group for various input, improvements and feedback they given us.

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## Attachments

[Attachment 1]

[https://drive.google.com/open?id=1UkYLZihUVNtcHesTHzsB-nY00XwgtbA\\_RSbKcW\\_PBE](https://drive.google.com/open?id=1UkYLZihUVNtcHesTHzsB-nY00XwgtbA_RSbKcW_PBE)

[Attachment 2]

<https://drive.google.com/open?id=1cWds1T577rHV-PnVg9eCOUjAEFkC8ixnrVD9xomWpl>

[Attachment 3]

<https://drive.google.com/open?id=1cqBUq2606e3QXBvo3zwDQsIo0MHcfhRQHv8zZA0Ce9I>