

Physical responses (arousal) to audio in games for Euphonious

Introduction

This study investigated the importance of audio in computer games. To do this an experiment was designed that compared groups of participants that played the same games with and without audio. Participants' physical responses to the games were recorded via a bioharness, that recorded participant's breathing wave, heart rate, respiration rate and skin temperature. Analysis of the heart rate and respiration rate of participants showed that those playing games with audio had a higher level of arousal (a combination of heart rate and respiration rate) and demonstrated the immersion capabilities of audio in games.

Participants

12 students from the University of Abertay participated in the study. All participants had experience in playing computer games but little or no experience in the games selected for the study.

Materials

Experimental trials were conducted in Abertay's HIVE facility which provides a six meter rear projection screen, 7.1 surround sound and adjustable lighting providing a great gaming experience. Participant's physical responses were recorded with a bioharness (<http://www.zephyr-technology.com/>). The bioharness records a range of physical attributes including heart rate, breathing rate and skin temperature.

Three games were selected as stimuli for participants to play: Osmos (<http://www.hemispheregames.com/osmos/>), FlatOut Total Carnage (<http://www.bugbear.fi/games.html>) and Amnesia: The Dark Decent (<http://www.amnesiagame.com/>). These games provided a range of genres (racing to survival horror) and play styles (driving to first person shooter).

The aim of Osmos (illustration 1) is to propel yourself (bright blue orb), a single-celled organism (mote), into other smaller motes (dark blue orbs) to absorb them. Colliding with a mote larger than yourself will result in being absorbed yourself, resulting in a game over. Changing course is done by expelling mass. Due to conservation of momentum, this results in the player's mote moving away from the expelled mass, but also in their mote shrinking.



Illustration 1: Osmos Screen shot

FlatOut is a racing game with an emphasis on demolition derby-style races, and features a sophisticated physics engine. Races take place in a range of locations from busy street to storm water drains (Illustration 2). Players race against 11 computer controller opponents in races consisting of multiple laps. An additional speed boost can be gained by going off jumps and crashing into other cars.



Illustration 2: FlatOut Ultimate Carnage Screenshot

Amnesia the dark decent features an unarmed protagonist exploring a dark and foreboding castle (Illustration 3), while avoiding monsters and other obstructions as well as solving puzzles. The player plays and sees through the eyes of Daniel, making their way through the different levels of Brennenburg Castle as the story progresses, starting off in the Rainy Hall and eventually making their way into the deepest depths of the castle in their search for Alexander, the owner of the castle.



Illustration 3: Amnesia The Dark Decent Screen shot

Procedure

The experiment trials began with participants signing a consent form, where they agreed to take part in the experiment, understood what the experiment would consist of and stated they had no problem with projected images, as required by Abertay's experiment guidelines. Following the signing of the consent form participants were instructed how to wear the bioharness and once the bioharness was on recording of physical attributes began.

Participants played each of the three games in order: Osmos, FlatOut and Amnesia. Before starting each game participants had to be in a resting state, this was monitored with the bioharness. If participants were not in a relaxed state when they began the game, it would be challenging to determine the effects of gaming on physical responses. Participants alternated between the audio and no-audio conditions, where one participant would play the three games with audio and the next participant would play the three games without audio. All participants were given the same levels/locations in all three games to play. For Osmos participants were given two levels where they were tasked to become the largest. For Flatout all participants were given the first race (4 laps) and the same car. Finally, for Amnesia all participants were tasked with navigating through the open level of the game.

Results

Game 1

Analysis of participant responses focused on heart rate and respiration rate as variables demonstrating arousal. Participants were divided into two groups based on testing conditions: Audio and no-audio. Illustration 4 shows a comparison of the groups' heart rate over the duration of playing the first game. At the start of the game both groups had a heart rate around 75 beats per minute (bpm). The Audio group played the game for longer, but also demonstrate a consistently higher heart rate throughout and had greater maximum and minimum heart rate values (Audio group maximum 84bpm, minimum 68bpm, No-audio group maximum 78bpm and minimum 61bpm). Further analysis found this difference in heart rate to be significant (Mann-Whitney, $p < 0.001$). Illustration 5 shows a comparison of groups respiration rate during game play (Maximum and Minimum respiration rate of 25bpm and 7bpm for Audio group, respectively and 21bpm and 2bpm for No-Audio group, respectively). Analysis showed unlike heart rate a significant difference was not found (Mann-Whitney, $p = 0.182$).

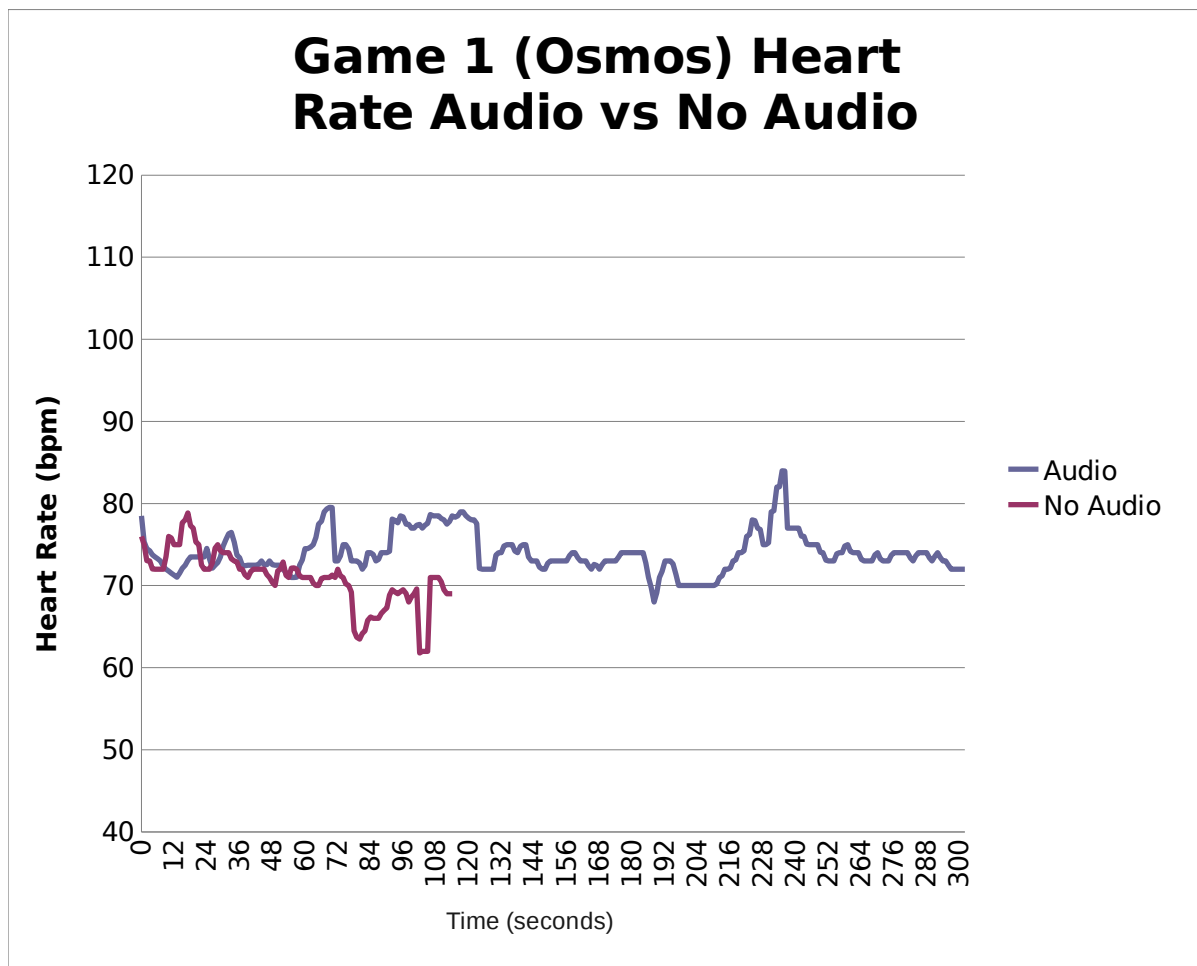


Illustration 4: Heart rate comparison of groups with and without audio

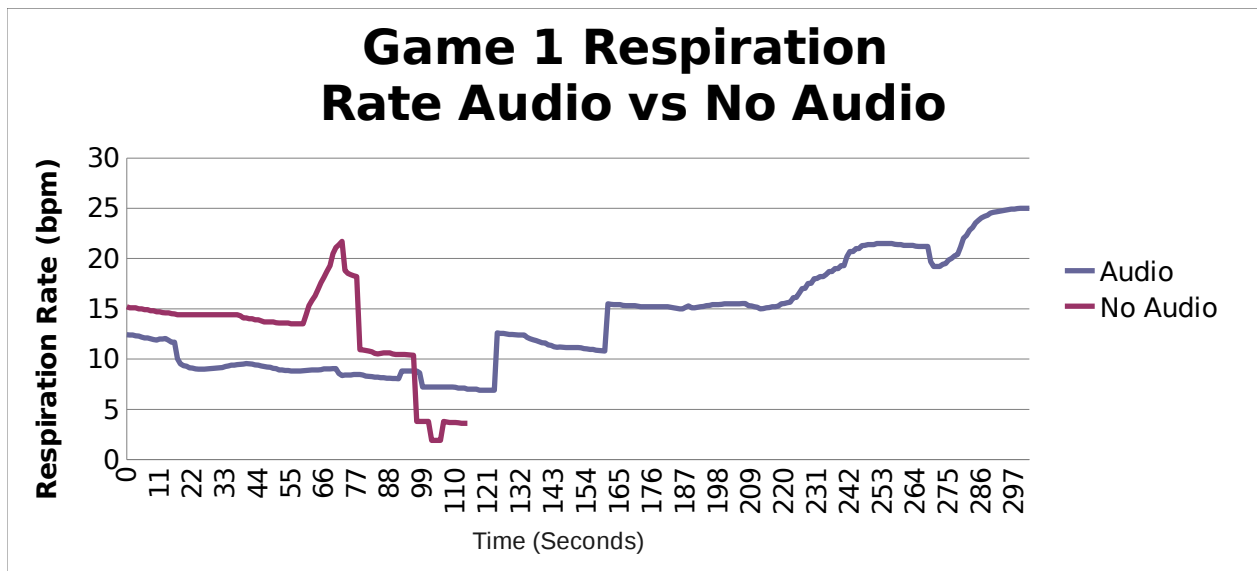


Illustration 5: Comparison of respiration rate of Audio and No Audio groups

Game 2

Illustration 6 shows a comparison of Audio and No-audio groups' heart rate while playing game 2 (FlatOut). The graph shows a clear difference between the groups with the Audio group having a much higher heart rate throughout the game compared to the No-audio group (Audio group maximum 91bpm, minimum 57bpm and No-audio group maximum 77bpm, minimum 64bpm). Further statistical analysis showed this to be a significant difference (Mann-Whitney, $p < 0.001$). Illustration 7 shows a comparison of the two groups' respiration rate throughout the game. During game play both group show fluctuation in respiration rates with the Audio group having a slightly higher maximum and minimum respiration rate (Audio group maximum 24bpm, minimum 14bpm, and No-audio group maximum 22bpm, minimum 12bpm). Statistical analysis found the difference between groups to be significant (Mann-Whitney, $p < 0.001$).

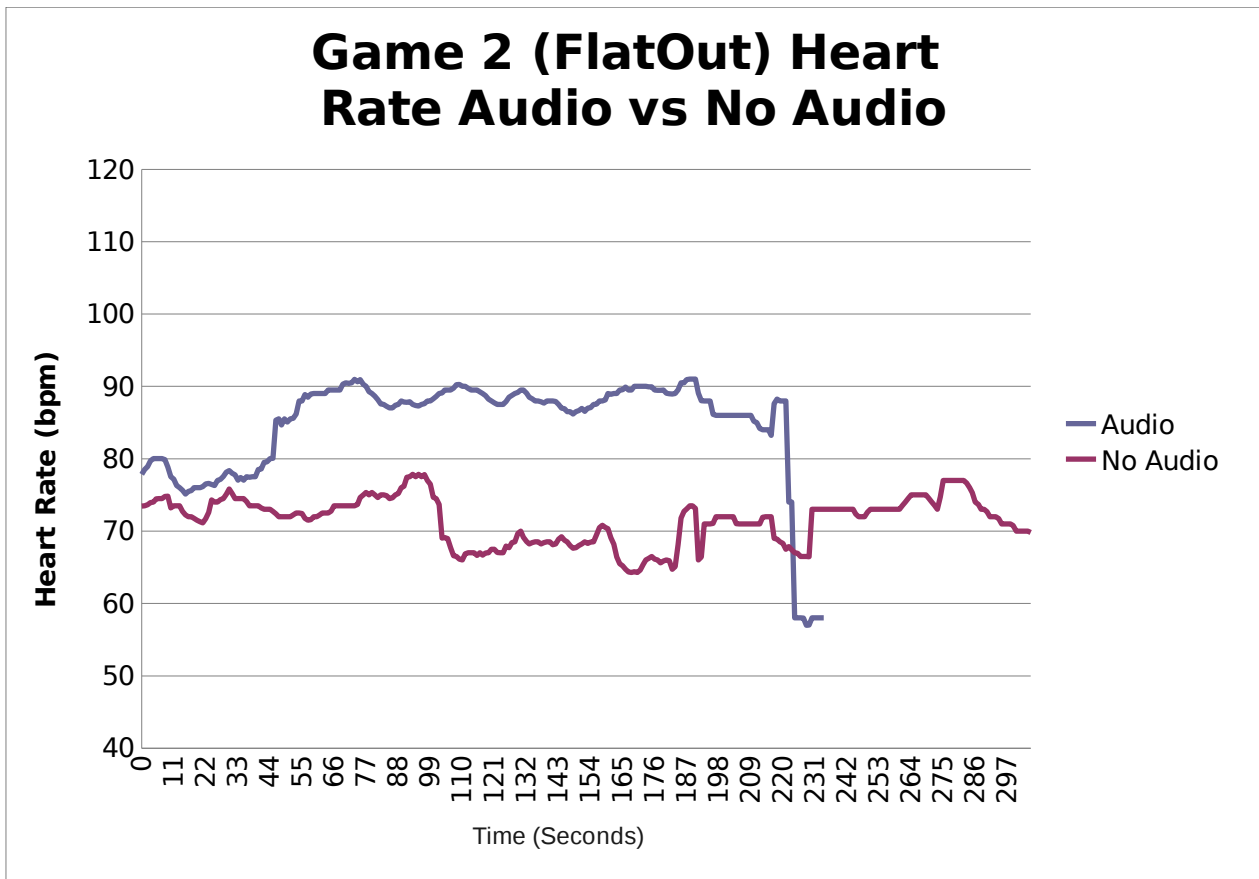


Illustration 6: Comparison of heart rates

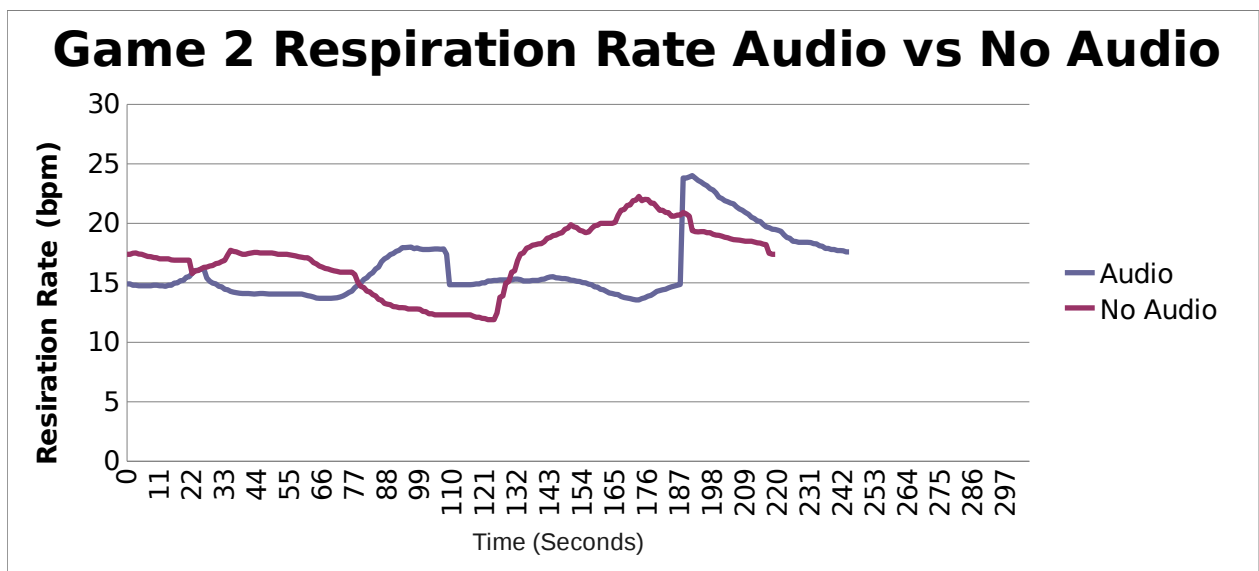


Illustration 7: Comparison of Audio/No-Audio groups' respiration rate for game 2

Game 3

Illustration 8 shows a comparison of heart rates for the Audio and No-audio groups while playing game 3 (Amnesia the dark descent). The graph shows that the Audio group had a consistently higher heart rate throughout the game-play session. The Audio and No-Audio groups obtained maximum heart rates of 90bpm and 77bpm respectively and minimum heart rate of heart rates of

74bpm and 52bpm, respectively. Further statistical analysis found the differences in heart rate to be significant (Mann-Whitney, $p < 0.001$). Illustration 9 shows a comparison of respiration rates throughout game-play for the Audio and No-audio groups. The graph shows overall the Audio group had a greater respiration rate (maximum rate of 27bpm and minimum rate of 10bpm) compared to the No-audio group (maximum 16bpm and minimum 6bpm). Statistical analysis found that the differences in respiration rate were significant (Mann-Whitney, $p < 0.001$).

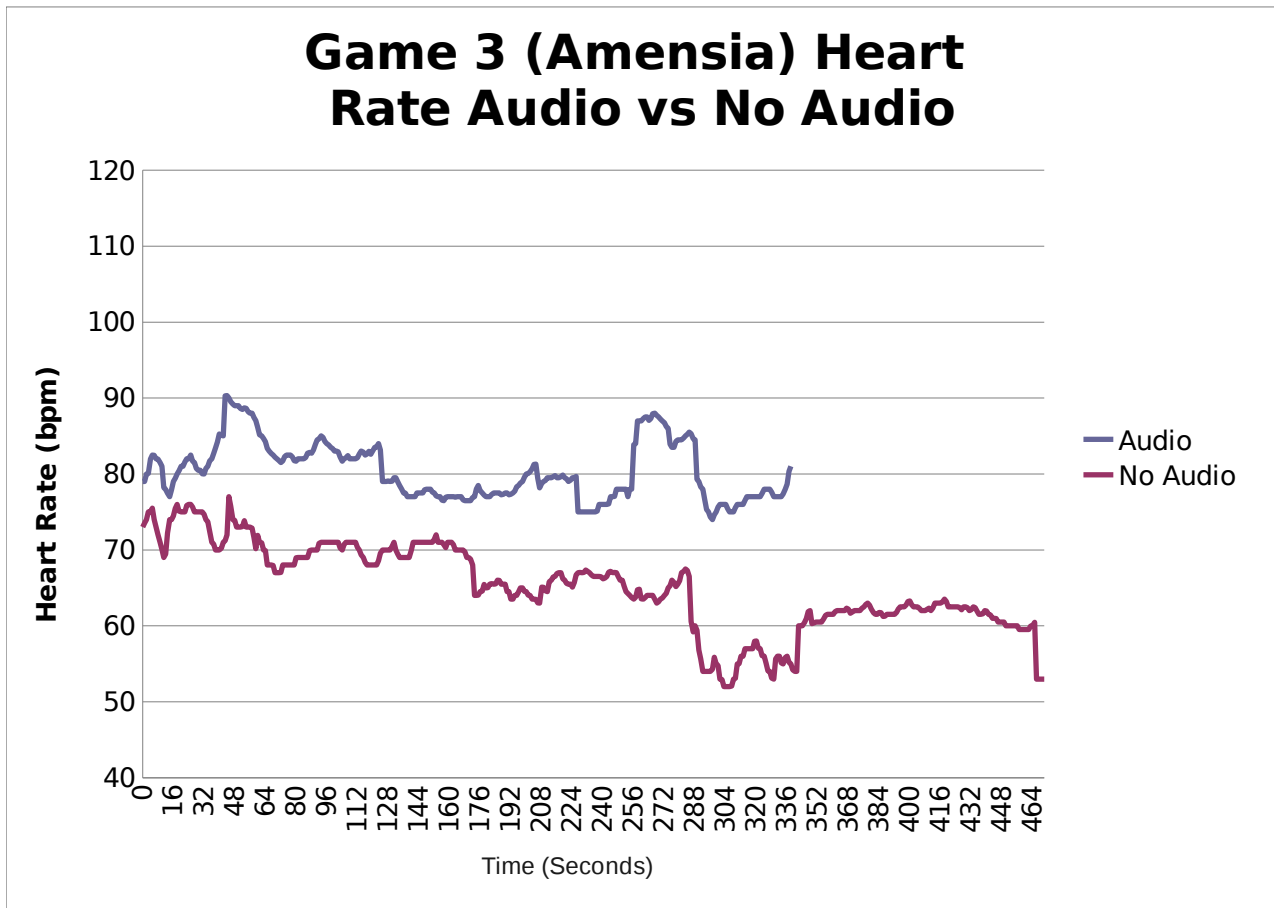


Illustration 8: Comparison of Audio and No-audio groups' heart rate for game 3

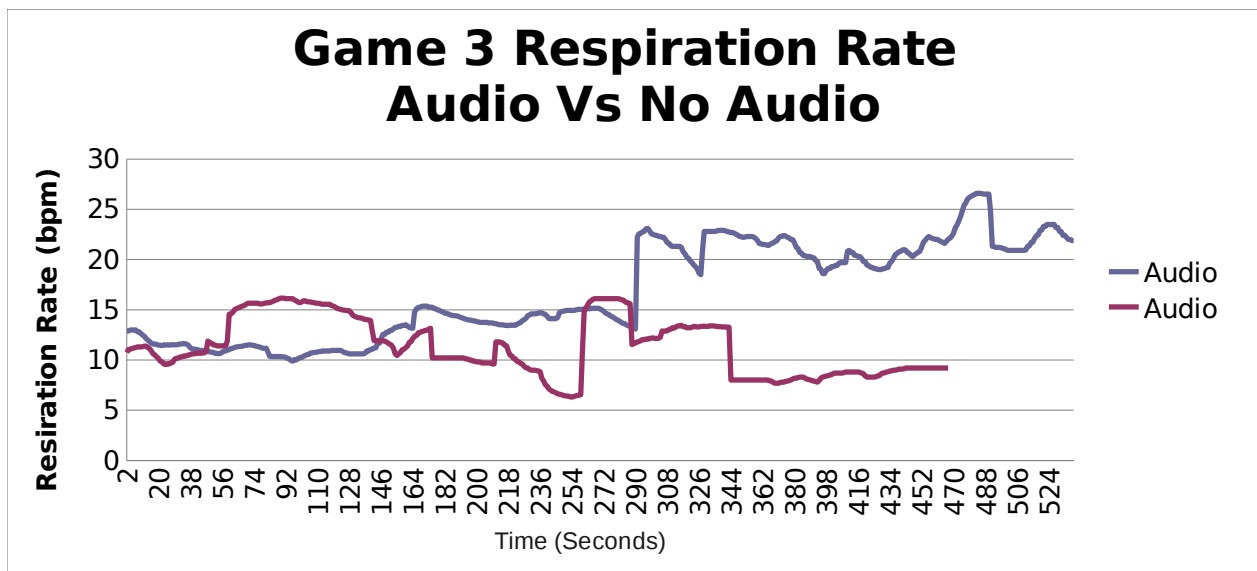


Illustration 9: Comparison of Audio and No-audio Groups' respiration rate for game 3

Summary

Firstly, a summary of results: During game 1 the Audio group had a significantly higher heart rate and a slightly higher respiration rate compared to the No-Audio group. During game 2 the Audio group had a significantly high heart rate and respiration rate than the No-audio group. Finally, during game 3 the Audio group had significantly higher heart rate and respiration rate compared to the No-audio group. These findings suggest that the presence of audio in games can increase in player arousal, as shown by an increase in physical responses (heart rate and respiration rate).

Focusing on the games individually, starting with game 1 (Osmos) the results show this game produced a low heart rate (68bpm) and lowest respiration rate (7bpm) for the Audio group. While these values are low both were still higher than that produced by the No-audio group. These values are low mostly likely because Osmos is a low stress game. The levels participants were tasked with completing were not challenging and the audio is relaxing, therefore participants did not express any frustration.

During Game 2 (FlatOut) the Audio group produced the highest heart rate (91bpm) and a slightly higher respiration rate compared to the No-audio group. The rationale for these high values is that FlatOut is an exhilarating racing game, more so with audio (engine noise, crash sound effects and background rock music). Furthermore, participant performance in the game may effect responses, for example if a player is winning they may respond with excitement (increasing both heart and respiration rate), or if a player is losing they may become frustrated also increasing heart and respiration rate.

Game 3 (Amnesia) best demonstrates the affect of audio in games. The audio group obtained significantly higher heart and respiration rates compared to the No-audio group during game play. This is more impressive given that the section of game all participants played through very little happens. There are no bad guys, no fighting, just exploration and the results suggest that audio can increase immersion in games.

Reviewing group responses to all games it shows the Audio group produced a high maximum heart rate and respiration rate for all games (heart rate Game 1: 84bpm, game 2: 91bpm and game 3: 90bpm; respiration rate game 1: 25bpm, game 2: 24 and game 3: 27bpm). The No-audio group

produced consistent maximum heart rate values over the three games (game 1: 78bpm, game 2: 77bpm and game 3: 77bpm). The difference in heart rates between the groups shows the effect audio in games has on players.

To further investigate the effect of audio in games another study could be conducted, that utilises the same methodology as the above study, but instead of using commercial games as stimuli could build a bespoke game environment for testing. The advantage of a bespoke testing environment is the ability to control almost everything. Such an environment could be used to investigate aspects such as quality or realism of audio and the responses of players.