Please Biofeed the Zombies: Enhancing the Gameplay and Display of a Horror Game Using Biofeedback

Andrew Dekker
Interaction Design, School of ITEE,
University of Queensland, Ipswich, Australia
s4012459@student.uq.edu.au

Erik Champion
Media Arts, COFA, UNSW, PO Box 259
Paddington, NSW 2021 Australia
e.champion@unsw.edu.au

ABSTRACT
This paper describes an investigation into how real-time but low-cost biometric information can be interpreted by computer games to enhance gameplay without fundamentally changing it. We adapted a cheap sensor, (the Lightstone mediation sensor device by Wild Divine), to record and transfer biometric information about the player (via sensors that clip over their fingers) into a commercial game engine, Half-Life 2.

During game play, the computer game was dynamically modified by the player's biometric information to increase the cinematically augmented "horror" affordances. These included dynamic changes in the game shaders, screen shake, and the creation of new spawning points for the game's non-playing characters (zombies), all these features were driven by the player's biometric data.

To evaluate the usefulness of this biofeedback device, we compared it against a control group of players who also had sensors clipped on their fingers, but for the second group the gameplay was not modified by the biometric information of the players. While the evaluation results indicate biometric data can improve the situated feeling of horror, there are many design issues that will need to be investigated by future research, and the judicious selection of theme and appropriate interaction is vital.

Author Keywords
Biofeedback, gameplay, horror, cinematics, shaders.

INTRODUCTION
While commercial computer games are crafted to cater for a large and often diverse audience [8], they are limited by the PC interface insofar as they can understand a player's deliberate and unintentional or automatic reactions to the gameplay. Due to this inability to fully understand the reactions of the player, the system is both limited in its experiential understanding (of the player and how the player will react to game events), and limiting in terms of how the player can react to the game.

We hypothesized that improved accessibility to biometric sensory devices (such as heartbeat monitors) would allow us to incorporate a participant's biometric information into a commercial computer game, allowing for more dynamic, unpredictable, but also more personalized and situated game experiences.

The primary benefit of incorporating this technique into computer games is that game developers can offer control over direction of game play and game events to the player. Rather than the flow and progression within the game being linear and scripted [13], a series of events can be strung together in a sequence that better appeals to the individual.

For example, Rouse [12] agrees that allowing the system to choose methods of conveying emotion dynamically rather then forcing players to take specific emotional journeys is a fundamental aspect of enhancing computer games. Rouse states that "the central problem is that games, through their interactive nature, give players the power to make their own choices, decisions which effect which emotions they may feel immediately or later in the game. Game developers need to set up game-worlds that present the possibility for various emotional responses in players, without ever guaranteeing that the player will feel a particular emotion at a particular time."

AFFECTIVE GAMING

> "This form of gameplay is commonly referred to as *affective gaming;* where the player's current emotional state is used to manipulate gameplay." [6]

While active and tangible interaction methods are a major focus in academia (through means of tracking and other non-conventional methods), Biocontrolled Unconventional Human Computer Interfaces (UHCI) – a large part of understanding the uniqueness of a user, is generally ignored according to Beckhaus et al [1]. The question arises, "can the uniqueness of a user be interpreted by the system' and 'in what ways can the environment be adapted to better suit the individual?"

Both Rouse [12] and Picard [9] believe computer games may take advantage of understanding the player through using biofeedback devices. Studies have shown that computer games affect the user in terms of both their mental and physical states [8, 9, 14].

Situated Play, Proceedings of DiGRA 2007 Conference

Although these states have been successfully measured in real-time, little research has been conducted to investigate how this information can be interpreted and used by a computer game dynamically. And the link between biometric analysis and player emotion is not always clear [2, 6]. Biometric data allows users' internal state to be effectively measured in lab-like conditions, but these need to be correlated with players in the real-world, which is difficult in the case of games that are not straightforward simulations of reality [10].

Secondly, research conducted in this area suggests that the relationship of biometric data to player emotion is subjective. It also relies on machinery presently not sophisticated or subtle enough to capture the full range of behavioral states [3].

The Demands of Players

Players currently interact within gaming environments through conventional means (digital devices such as a keyboard, mouse or joystick). These interaction devices are limited in that the system is unable to understand and act on the individual attributes and reactions of the particular user. As computer games advance in technological power and sophistication, understanding the individuality and the goals of the player are becoming more important in providing an engaging and tailored experience.

Another problem with current gaming environments is the player's virtual persona inside the game. While the player's avatar is becoming more detailed and capable of more refined and various animations, the avatar is not necessarily improving its dynamic potential to represents the player's personal feelings or current physiological state, habits, or character.

The importance of biometric feedback within computer games is not limited to incorporating direct reactions of the user. Biometric sensors have the additional ability to judge how the computer game narrative is affecting the player. Through this, the system can decide whether the emotional style and theme being presented is being effectively received or not by the individual.

There is currently no common name associated with the technique of using biometric devices for subtle or indirect interaction, although previous work has coined the term Biocontrolled Unconventional Computer Human Interfaces (Biocontrolled UCHI) [9]. Consequently, there are other possible names that may be given to this technique (unaware, passive interaction, inactive interaction, passive participation, inactive participation, biometric interaction, infective computing, emotionally adapted games or psychophysiology [11].

> "To exploit emotion effectively game designers need to understand the differences between purely cosmetic emotional implementations and deeper interactions between cognitive and affective behavior." [12]

DESIGN PROBLEM

Project Scope

The enhanced level is presented as a prototype and work in progress, rather than as a polished and complete implementation. Due to time limitations the level did not include background story and progression, and focused on the combat gameplay of the level. In-game assets were specifically created for the experimental design.

The Game Environment Chosen

Single player was chosen for the prototype over multiplayer because of this, and as it creates less variability and potential issues in evaluating user experience. Multiplayer or collaborative games may influence player reaction and biometric information through other users in the world, and as such is difficult to gauge whether the change in reaction is based on the enhancement of the game.

We decided that the horror and survival style of gameplay provided the most gameplay elements that could be enhanced through biometric information. It was anticipated that this style would also cause the most variation in the information that was collected.

Figure 1: Ravenholm

The chosen game for this prototype is the Source Engine, which is used within Half-Life 2 [15]. The Source SDK (the chosen game engine) includes various levels from the Half-Life 2 single player game. One of the included levels is Ravenholm, a horror and survival based level. Ravenholm combines a science fiction driven storyline and gameplay combined with a horror themed setting. The objective of this level is to navigate through a haunted village while avoiding or destroying waves of enemies. This level was chosen as the base for the prototype as it is polished and popular, and scares many players.

The prototype was designed to support the structure of the evaluation. Two game levels (named Level A and Level B) were developed for the evaluation. Level A used the above level; Level B was created as an extension to Level A, where added game events were triggered from biometric information.

Sensor Device

Figure 2: Biosensor

The chosen device for the prototype was the Wild Divine Lightstone device (Figure 2). The Lightstone device was chosen due to a low cost of under $200 (USD), unobtrusiveness (3 sensors that fit onto the fingertips of the user), and a SDK (Software Development Kit – The Lightstone device comes with code examples written in both C++ and Lingo (for Macromedia Director). It can measure the ECG HRV (Electrocardiogram Heart rate Variability) and the GSR (Galvanic Skin Response) of a player in real-time.

Thus the Lightstone device has the potential to measure anxiety and stress, relaxation and meditation, tension, sudden changes in mood, and breathing variability. While these measurements do not give enough information to make a complete Biometric Analysis [0], it does provide insight into the player's reaction to specific game events.

The Biofeed Method Used

The Lightstone device collects heart rate variability and skin response information of the participant. Both of these values come in the form of an integer value. An analysis of these values over must be performed over time to understand a participant's reaction. Heartbeat was calculated from the heartrate variability of the participant. The analysis compared a sequence of heart readings, to analyze the number of heartbeats within the time.

The method used to analyze biometric information for the prototype compared the current reading with a control reading collected at the start of the evaluation. 2000 readings were taken during the initial stage of the evaluation, which were averaged to get the participants calibration average.

While Ravaja et al [11] state that this method is not ideal, other popular methods require analysis of both previous and future readings, which is not possible in real-time. While the authors provide a method of analysis that may be used to better interpret biometric information in real-time, they suggest the method requires further evaluation. "The present results suggest that it may be possible to user emotion-related phasic psychophysiological responses as criterion variables in game design in several ways, although the predictive validity of these responses to games remains to be established."

To compensate for possible problems associated with this method of analysis, readings were averaged at two-second intervals. This reduced the deleterious effects of any possibly incorrect readings, and provided an accurate representation of the participant at the particular time. The current average of the participant's biometrics was then compared against the calibration average, to create a multiplier. These three multipliers (heartrate variability, skin response and heartbeat) were used to dynamically change the game environment.

GAME ENHANCEMENTS

Classes were designed (individual objects inside the game but invisible to any player), to act as a socket between the sensor and the game level, to log the biometric data. They then changed the display depending on changes in the biometric data, and changed the environment depending on changes in the biometric data.

Gameplay enhancements

In the new enhanced level, via biometric data, the participant could change various elements of the level. The speed of movement of the avatar was based on the heartbeat multiplier combined with a base level of 200. The volume of the environment that the participant could hear was dynamically changed based on a base level volume of 1 multiplied by the square of the participant's skin response, which was multiplied by 0.8. A 'bullet time' effect was triggered if the participant's skin response was higher then three times their calibration average. This effect changes the density and gravity of the environment, to emulate the effect of the avatar being faster than other characters. As the participant's heartbeat increased past 3.8 of their average, the screen shook to suggest that the avatar was out of control.

However, there was also a stealth mode. If the participant could control their excitement, they gained an advantage. If the participant's galvanic skin response was between 0.5 and 0.7 of their average, the environment would become semi-transparent, to represent the ability to see through walls. The avatar became invisible to enemies within the level if the participant's heartbeat was under 0.5 and their skin response was under 0.5 of the calibration average.

Further, the damage of each weapon was dynamically changed through combining the heartbeat and skin response of the participant and multiplied by a base factor of 40.

There were shader effects based on excitement. A red filter was applied to the game if the participant's heartbeat was faster than 2 times the average. This was intended to suggest that the participant was getting more excited or anxious. If the participant's heartbeat and skin response were over 3 times their average, the screen would turn bright red, the field of view of the avatar would change to 130 degrees and the speed of the avatar would dramatically increase. Also, the screen faded to red if the heartbeat multiplier was over 3.5. This effect was designed to simulate the 'berserker' state commonly found in computer games.

There were also shader effects based on calmness. The screen faded to white if the participant's heartbeat multiplier was under 0.2 of the average. If the participant's heartbeat was under 0.8 of their calibrated average, the environment was displayed in black and white (Figure 3).

Figure 3: Game level enhancements

Artificial intelligence of the NPCs (Zombies)

There was also a controller for the game AI to frighten people who were too calm. It was designed to create a randomly chosen sound if the participant's skin response and heartrate was less than the calibrated average. The controller also increased and decreased the volume of background music dynamically and created a heartbeat sound to represent the participant's heartbeat. The controller also created a new enemy if the participant's heartrate was less than 0.8 of the calibration average, and created a boss enemy if the participant's heartrate was less than 0.4 of the calibration average.

Example of a User Scenario

1. The participant is calm during the initial stage of the game, (Figure 4).
2. The environment is black and white, and the speed of the avatar is slow and steady
3. As the participant investigates the environment, they notice strange sounds, screams and their own heartbeat.
4. Monsters within the environment begin to notice the presence of the player.
5. The environment is displayed in full color.
6. The participant navigates the level while avoiding or attacking the monsters.
7. As the participant's heartbeat increases, more monsters begin to attack, and the volume and speed of the game increases.
8. The screen begins to shake, and the environment is displayed in an overly bright red visualization.
9. As the participant begins to understand the computer game and relaxes, the ambient noises of screams and heartbeat begin again.

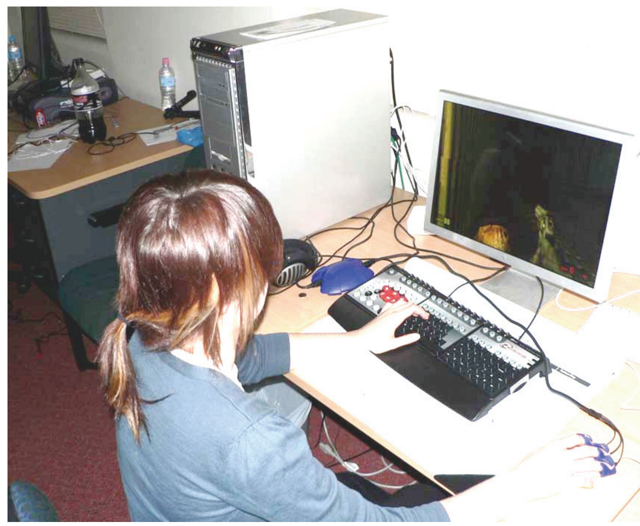

Figure 4: User Scenario

Design Issues

A separate keypad on the left of the keyboard was used as the primary interaction method, and keys not used within the evaluation gave onscreen feedback telling participants that the key was not in use. The mouse used in the evaluation (Figure 5) was a one-button mouse so as not to confuse participants, and to resolve interaction problems associated with the Lightstone device.

Figure 5: Revised mouse input

It was discovered during playtesting that the Lightstone device, which collected biometric information created problems with the user interaction. The Lightstone device is made of plastic, and surrounds the fingertips. While the Lightstone sensors can be worn on either hand, the sensors interfere with keyboard interaction more than mouse interaction. When wearing the device in the evaluation, mouse interaction was tolerable, but due to the solid state of the sensors, the participants could not receive (i.e., feel), physical feedback from the mouse. Multiple mouse buttons also created confusion while wearing the device. A one-buttoned mouse was used to lessen this confusion and lessen these interaction issues.

EVALUATION

A pilot study was conducted with 33 participants during the design stage of the project to understand which game genres, styles and themes are most preferred by the target user group. The design of the computer game was heavily influenced by the results of the survey to eliminate as much user preference of game genre, style and theme as possible. Informal evaluation sessions were also conducted during the development to understand any potential issues with the game play or flow [13] as well as issues that may arise in the evaluation.

Participants

For the evaluation fourteen participants were required to read the information sheet supplied and give consent to be evaluated and have their experiences video recorded. They had not been previously involved in the project and had not participated in a previous pilot study or the project development. Participants were not required to have previously played the chosen level and game, or first person shooters. They were required to have played computer games before, and preferably have an interest in adventure, fantasy or horror themed computer games or books.

Participants were chosen within the university community (students, staff, friends and other members), and were chosen randomly, without regard to gender, race, age, and gaming experience. Three of the fourteen participants were female; the age range was fifteen to fifty years.

All participants were asked questions regarding their previous experience and subjective preferences (Table 1). Five considered themselves gamers, four said they were causal gamers, five said they were not gamers (although all five of them had played first person shooter games before). Twelve had played first person shooters before (including all the “non-gamers”). Seven had played Half-Life 2 before (and two of the seven did not consider they were gamers). Seven liked horror games or horror films or horror books, five were neutral, and two participants did not like them at all.

The questions were: Do you consider yourself a gamer? Do you enjoy, or have you played First Person Shooter games? Have you played Half-Life 2? Do you enjoy horror games, films or books? What do you enjoy about them?

Table 1: User Background.

User	Gamer?	Played FSP?	Played HL 2?	Liked horror games / films?
1	casual	yes	no	neutral
2	casual	yes	yes	neutral
3	no	yes	yes	yes
4	yes	yes	yes	yes
5	yes	yes	yes	yes
6	no	yes	no	neutral
7	no	yes	yes	no
8	casual	yes	no	yes
9	casual	yes	yes	yes
10	no	yes	no	yes
11	yes	no	no	no
12	no	yes	no	yes
13	yes	yes	yes	neutral
14	yes	no	no	neutral
Yes	5	12	7	7
Neutral	4	-	-	5
No	5	2	7	2
Total	14	14	14	14

The Method of Evaluation

A custom game menu interface was created to simplify the evaluation process. Each participant was required to play both the standard level (Level A) and the biometric enhanced level (Level B). To avoid a sequencing effect, six users were required to play Level A and then Level B, while the other users were required to play Level B and then Level A. When entering the game level, the participant would not be able to interact with the environment until the game had calibrated the participant's biometric information. A screen overlay was used for feedback to explain to the participant when to wait and when to begin interacting.

Then the participant played a level (either the standard or enhanced level), for 5 minutes. Then the participant played the alternate level (the level that was not previously played) for 5 minutes. After the playtesting, the participant undertook a short interview, answering questions about the game and discussing their experiences.

At the conclusion of playing both levels, users were required to be interviewed on their experiences they had during the course of the evaluation. The interview questions were targeted to start an informal discussion about the prototype and biometric enhancement and are mentioned below in the results section. After the interview, users were allowed to view their video footage, and discuss which game elements they found helped or hindered gameplay.

Evaluation Analysis

The evaluation (Figure 6) was analyzed through a series of observation and interview techniques. Biometric recordings of the participant's heartbeat, heartrate and skin response values were digitally recorded and one of the authors observed each participant playing each level (Level A and Level B).

Figure 6: Evaluating Participant and Game Display

Video recording of the participant's face (Figure 7) to gauge reaction to events and in-game recording were used. Each recording method was time stamped so that all recordings could be synchronized and played back simultaneously. Interviews with the participant (which were recorded), were also taken, discussing what the participant experienced during the game.

Figure 7: The Player Experience

It was anticipated that a video sequence of each user would be created (which showed all information). Compatibility issues between Fraps and the biometric process meant that recording to a video format was not possible. Instead, the analysis was performed through observing the recording of the user and the recording of the computer game were simultaneously analyzed on separate computers.

Issues Found During Evaluation

There were some gameplay issues. Participants did not try to adjust their breathing or heartrate to see how it affected the gameplay. It should also be noted that the brightness of the room (due to camera requirements) and other external factors affected the experiences of the participants.

Throughout the evaluation sessions and also during the analysis period, low-cost biometric sensors were a major usability issue, although the keyboard and mouse combination were effective for most users; and the interface allowed users to easily start and change the game levels. Future projects may be able to use commercial products, but one workaround solution for this experiment would have been to separate the actual sensors from the plastic clips, although this would probably have invalidated the warranty on the biofeedback device.

The learning of the environment was a major variable in the evaluation. Participants not familiar with the game genre (First Person Shooters) were more involved with learning how to play the game rather than the gameplay; and the game level (Ravenholm) led to some confusion during exploration due to its open nature. Some weapons in the game were confusing to participants unfamiliar with the game. Plus, when the participant was killed in the game, their concentration and engagement were hindered.

RESULTS

The below table (Table 2) is a summary of the answers to the first two questions and whether the participant was correct in identifying the enhanced level.

The questions that were asked during the interviews at the conclusion of playing the levels were:

Did you enjoy the first level you played, or the second level? And if so, why did you enjoy one level over the other? Did you realize which level was incorporation your biometric information? Did you like or dislike the visualisation effects that were present in the enhanced level, what did you like or not like about them? What other game elements did you find different between the two levels, did they aid or hinder the game experience? What other game elements do you think may be enhanced through incorporating biometric information? From your experiences in the prototype, do you feel that biometric information can assist in creating a more engaging experience?

Table 2: Identification of Enhanced Level.

User	Prefer enhanced version?	Noticed enhanced version?	Correct?
1	no	no	
2	yes	no	
3	yes	yes	yes
4	yes	yes	yes
5	no	no	
6	yes	yes	no
7	yes	no	
8	no	yes	yes
9	yes	yes	yes
10	no	yes	no
11	yes	yes	yes
12	no	no	
13	yes	yes	yes
14	yes	no	
Yes	9	8	6
No	5	6	2
Total	14	14	8

The above table shows that nine preferred the enhanced (biometric-driven) level. Eight said they noticed one level was driven by their biometric data, although two chose the wrong level. Four participants did not notice at all that one level was biometric-driven.

The below table (Table 3) is a summary of participant responses as to whether they noticed the visualizations, and, if they did notice them, if they liked them. It also records if they noticed other (non-visualization) game events (driven by their biometric data), and if they thought biometric data-driven games have potential.

Table 3: Response to Biometric-Driven Events.

User	Noticed viz?	Like them?	Noticed biometric events?	Potent-ial?
1	yes	no	yes	yes
2	yes	yes	yes	yes
3	yes	yes	yes	yes
4	yes	yes	yes	yes
5	no		no	unsure
6	yes	yes	yes	unsure
7	no		yes	yes
8	yes	no	yes	yes
9	yes	yes	yes	yes
10	yes	yes	yes	unsure
11	yes	no	yes	yes
12	no		yes	yes
13	yes	yes	yes	yes
14	no		Wrong*	yes
Yes	10	7	12*	11
Unsure	-	-	-	3
No	4	3	1	0
Total	14	10	13*	14

*Please note that user 14 thought they noticed biometric-driven events but they ascribed it to the standard level when it was actually part of the enhanced level so there were 12 correct "yes" answers not 13.

Players 1 and 8 did not like the visualization effects, but neither had played Half Life 2 before. Eleven of the fourteen thought biometric information could assist engaging game experiences. Two of them also suggest that it could measure retinas twitching, or be related to the type of weaponry carried.

Apart from users 6, 8, 10, 11 and 12, all participants had suggestions. User 1 suggested more ammunition and a larger area to explore. User 2 suggested health should be based on heartbeat. User 3 asked for more dynamic audio effects. User 4 suggested accentuated colors and more dynamic visualizations. User 5 preferred a less limited area. User 7 wanted more stress to create fewer enemies. User 9 suggested the interaction device (sensors) and out of synch audio could be improved. User 13 also said audio was out of synch and the external environment could improve. User 14 suggested better game balancing of the learning curve.

Observations Made During Evaluation

The calibration period (during which the participant could not move), gave an accurate base level; and the biometric sensors were reasonably effective in reading biometric information, although unbelievable readings were sometimes experienced. Participants' facial expressions were easily comparable to the biometric information; however individuals had wildly differing biometric data.

Audio effects had a considerable effect on participants' biometric information and reactions. They seemed to be more engaged in the enhanced version especially when sounds were played. The black and white visualisation made users calmer. The red filter visualisation did not effect biometric information significantly while the white screen visualisation confused participants (and two remarked on this in the survey). Participants reacted strongly when the screen shook; it was not a popular feature.

While the levels were created off the same base level to limit evaluation variables, participants took advantage of this, and used their past knowledge of the first level to their advantage in the second. This led to different user goals and experiences within the two game levels. The maps perhaps needed to be more cognitively confusing, or randomly set.

CONCLUSION

The evaluation analysis gave insight into possible ways that biometric analysis may affect and enhance current computer games. The results indicate that while a biometric analysis that uses EKG, GSR, EMG and EEG has the ability to effectively understand an individual's emotional state, a device that measures EKG and GSR can determine to some extent a user's reaction to an event.

Biometric Accuracy

The biometric information recorded by the prototype correlated well with the answers given in the evaluation interviews. However, events that were triggered by biometric analysis but could not be related to the gameplay were considered confusing and lowered the participants' engagement. For example, the majority of participants felt that the white-filtered visualisation was confusing and detracted from the experience.

An unexpected finding during the evaluation was the difference of the variation of biometric information between male and female participants. While male participants had a wide variation of biometric responses to game events, female biometric responses remained reasonably constant. Investigation of this finding has been reported on elsewhere [5], and is outside the scope of the paper. However, we note in passing that habitual exposure may have to be factored into future evaluations of biometric computer games.

Design Issues

The biometric Lightstone device [16] can competently read an individual's information for prototype development; however the usability of the device was a major concern to many participants. They felt that the biometric sensors attached to the fingertips were a distraction and detracted from the game experience. While the Lightstone device was worn for both the standard and enhanced game levels, the user interaction with the biometric device may influence the game experience dramatically. Technologies such as MEMS [7] allow biometric sensors to be incorporated directly into game peripherals, which may eliminate these interaction design issues and may provide more accurate readings.

Effect of Genre

It was anticipated that the biometric information would aid participants in increasing their engagement and customizing gameplay to suit individual tastes, but this seems strongly dependent on their enjoyment of the genre. It was noticed that participants who enjoyed the horror genre were more engaged within the game, and the biometric feedback was more effective in guiding their experience.

While this proved to be successful for the majority of users who related to the theme, those who did not enjoy the horror genre, (although experienced gamers may prefer to call this level an action game with zombies), found that the non-enhanced level was more engaging. This is an evaluation variable that was not anticipated, in that participants who do not like the horror genre (possibly because of its relationship with anxiety levels) may subconsciously become less engaged and aware of the environment. This leads us to suggest that the prototype does have the ability to increase engagement for target users, but may in fact make other users less engaged in the environment.

Participants who were not as familiar with the game genre (first person shooters) were less likely to become engaged within the environment. This 'learning' variable was taken into account during the design of the evaluation and the level, however it was not anticipated that this 'learning' would directly influence the biometric analysis. It can be seen that in biometric enhanced computer games that this issue of 'learning' for new game players must be taken into account.

Visual and Audio Effects

Surprisingly, the most effective depictions of biometric information within the prototype were the audio cues present within the enhanced level. The majority of participants felt that the audio effects had a large impact on engagement, and that while at times it was confusing (as the audio cues were not linked with the gameplay); it heightened the participants' experiences. In particular, the sound of the avatar's heart beating made participants significantly more anxious, and the heartbeat created a connection between the participant and the avatar.

The visualization effects within the game received mixed results. Engaged participants said the visualizations aided in the engagement, while those not engaged felt it distracted.

While the visualizations were not related to the gameplay within the environment, engaged participants made connections between the gameplay and effects. This lack of connection for non-engaged participants may have been a factor in some participants preferring the standard game level.

FUTURE WORK AND RECOMMENDATIONS

We would like to implement different biometric and interface technologies that are preferably not intrusive, do not hinder usability, and are thematic and appropriate. For example, since the sensor we used is for meditation games, we could easily adopt this for games where calmness allows the players to develop super powers such as invisibility and the ability to fly or walk through walls (although if they get excited they might get stuck inside one).

We are also interested in the multiplayer possibilities, where the game player 1 is given information of biofeedback of player 2 and uses this knowledge in an attempt to trigger the phobias of player 2. It would also be interesting for an imposter style game where player 1 tries to uncover other players masquerading as NPCs, but their avatars animations and behaviors are feed by their biometric data, so they must control their excitement in order not to give themselves away. If the device was accurate enough, it could even be used as a basic form of lie detector. Zombie poker, anyone?

ACKNOWLEDGEMENTS

We would like to thank the participants in the evaluations, the School of ITEE at the University of Queensland, and the makers of Wild Divine for allowing us access to the SDK.

REFERENCES

1. Beckhaus S. and Kruijff, E., "Unconventional Human Computer Interfaces," in *Proceedings of the conference on SIGGRAPH 2004 course notes*, (Los Angeles California, 2003), ACM Press.

2. Bersak, D., McDarby, G., Augenblick, A., McDarby P., McDonnell, D., McDonald, B., and Karkun, R. “Intelligent Biofeedback using an Immersive Competitive Environment,” Media Lab Europe online article available at http://medialabeurope.org/mindgames/publications/publicationsAtlanta2001rev3.pdf

3. Conati, C., "Probabilistic assessment of user's emotion in educational games," *Applied Artificial Intelligence,* vol. 16, pp. 555-575, 2002.

4. Davies, S. G., "Touching big brother; How biometric technology will fuse flesh and machine," *Information Technology & People,* 7, (1994), pp. 38-47.

5. Gilleade, K. and Allanson, J. 2003. “A Toolkit for Exploring Affective Interface Adaptation in Videogames,” *Proceedings of HCI International* (Crete, 22-27 June, 2003). Available at http://info.comp.lancs.ac.uk/publications/Publication_Documents/2003-Gilleade-Videogames.pdf

6. Gilleade, K. and Allanson, J. 2005. “Affective Videogames and Modes of Affective Gaming: Assist Me, Challenge Me, Emote Me.” *Proceedings of DiGRA 2005 Conference: Changing Views – Worlds in Play* (Vancouver Canada, 10-16 June 2005). Available at http://www.comp.lancs.ac.uk/computing/users/gilleade/pubs/Gilleade_2005_Affective_Gaming.pdf

7. Memsnet, *"Memsnet,"* MEMS and Nanotechnology Clearinghouse, 2006.

8. Picard R.W. and Vyzas, E. “Toward Machine Emotional Intelligence: Analysis of Affective Physiological State,” *IEEE Transactions on Pattern Analysis and Machine Intelligence,* 2001.

9. Picard, R. W. "Does HAL Cry Digital Tears? Emotion and Computers," in D. G. Stork, D.G. (ed.). *Hal's legacy: 2001's Computer as Dream and Reality,* The MIT Press, Cambridge, MA, 2001, pp. 297-303.

10. Picard, R. W., "Affective computing for HCI," presented at *HCI99*, (Munich, Germany, 1999).

11. Ravaja N., Saari T., Laarni J., Kallinen K., and Salminen, M., "The psychophysiology of video gaming: Phasic emotional responses to game events, in *Proceedings of DiGRA gaming conference,* (Vancouver, Canada, 16.-20 June 2005), 2005.

12. Rouse R., "Games on the verge of a nervous breakdown: Emotional content in computer games," *Computer Graphics,* (2001), 35, pp. 6-10.

13. Sweetser P., and Wyeth P., "GameFlow: A model for evaluating player enjoyment in games," *Computer Entertainment,* 3, pp 3-3, 2005.

14. Sykes, J., and Brown, S., “Affective gaming: measuring emotion through the gamepad,” in *Conference on Human Factors in Computing Systems, CHI '03 extended abstracts on Human factors in computing systems,* (Ft. Lauderdale, Florida, US, 2003), pp.732 - 733.

15. V. Software, "Half-Life 2 Source," Vivendi Universal, 2004.

16. Wild Divine Project, "Journey to Wild Devine," *Wild Divine Project,* 2004. Available at http://www.wilddivine.com/