Using Biometric Measurement to Help Develop Emotionally Compelling Games

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13.1 Introduction

To be entertaining and enjoyable, videogames need to evoke some heightened level of emotional experience during play (Keeker et al., 2004). With this heightened emotional experience comes the experience of being immersed in the game environment so that the player’s attention is fully on the game and he/she is not easily distracted from gaming. This immersion and enjoyment isn’t just a function of positive emotion. In fact, a common emotional experience in role-playing, action and many other types of games is the build up of tension and negative emotion during
player to think-aloud and report their experience as it happens is an example of
an experience interfering technique. Post-interaction questions and interviews can
be helpful for overall feedback but they lack the ability to give reliable and uncon-
taminated reactions to events and features that occurred minutes previously, and
which may have been followed by many more events and features. Video taping of
the gameplay and then the reviewing of the playback attempts to get around this
dilemma of having to choose between contaminating the play experience or depend-
ing on remote memory. With this approach the video of the gameplay is reviewed
with the player and the player retrospectively thinks-aloud. This technique can be
useful for understanding the player’s cognitive elaborations and preferences, but
less so for behavior and emotional responses.

A fundamental problem with these verbal measures is that emotional experi-
ences are not primarily language-based. Cognitive effort is required to put emotional
experience into words, and this effort can contaminate measurement. Many people
are not that adept at putting feelings into words, and also are often not that aware
of what impacted them to make them feel that way. If one is involved in developing
children’s games this difficulty is only exacerbated, as children have less developed
cognitive and language abilities, and are even less able to verbalize their feelings.

13.3.1 Physiological Measurement of Emotion

Certain physical changes usually accompany different feeling states. For example,
when we get excited, our heart rate and breathing increases, when we feel pleasure
we smile, or when we are annoyed we frown. These physical reactions can provide
information about how the player is reacting to the game. The biologic system offers
the advantage of a continuous readout of the player’s moment to moment emotional
experience. The moment-to-moment level of positive emotion, tension, effort, and
arousal is valuable information with which to evaluate the quality of the game ele-
ments in play. The advantage of physiological measurement is that it can provide a
biometric marker that accompanies changes in emotional state, and doesn’t require
cognitive effort or memory to produce.

13.3.2 Arousal Measures

Measures reflecting autonomic nervous system activity like heart rate and skin
conductance indicate levels of arousal or emotional intensity. These measures do
a limited job at best in indicating emotional valence. For example, Anttonen and
Surakka (2005) found that heart rate was only able to differentiate between posi-
tive and negative stimuli at 6 seconds post-stimulus onset, and not during the first
5 seconds. For a moderate to fast-paced interactive session this delay would be very
problematic for linking interactive events with emotional responses. For most user
experience questions, knowing the emotional valence of a player, whether he/she is
feeling in the negative or positive realm is important. Sometimes though, emotional valence may be obvious, or not important for the questions being asked, and level of arousal is enough information for evaluating a game experience. Then heart rate or skin conductance can be useful measures. One of the difficulties with heart rate is that it is affected by the metabolic demands of the situation, and not just the emotional aspects. Therefore, level of activity needs to be controlled across situations that are being compared for heart rate to be an accurate measure of arousal.

13.3.3 Measuring Emotional Valence with Facial Expressions

One physiologic system that has been found to display emotional valence and is a natural emotion marker is the face. Charles Darwin first wrote about the changes in human facial expression as reflecting the individual’s current emotional state and to be a means of communicating emotional information. Paul Ekman, a prominent emotion researcher at UC Berkley, and his colleagues have shown that certain configurations of facial muscle movements have been identified with the expression of specific emotions across disparate cultures. In order to measure changes in facial expressions that reflect emotional experience, Ekman and colleagues developed the Facial Action Coding System (FACS), which codes observable facial muscle movements (Ekman & Friesen, 1978). There also have been developed several computer programs that use digital video analysis to automatically code facial expressions into emotion categories (e.g., FaceReader by Noldus Information Technology). However, whether the observer of the face is human or computer, human faces are not consistently expressive enough to note ongoing emotional state. The few attempts reported in the literature that used these systems to record emotional reactions to various media found that there were too few facial expressions to score. These results reflect the findings in emotion research at large: Mild to moderate emotional stimuli are often not accompanied by visually observable changes in facial expressions.

There is, however, a much more precise and sensitive method to measure changes in facial expressions than visual observation. Electromyography (EMG) measures small changes in the electrical activity of muscles, which reflects minute muscle movements. Electromyographic techniques have been applied to certain facial muscles, and facial EMG has been shown to be capable of measuring facial muscle activity to weakly evocative emotional stimuli even when no changes in facial displays have been observed with the FACS system (Cacioppo et al., 1992). Even when subjects are instructed to inhibit their emotional expression facial EMG can still register the response. Facial EMG studies have found that tension of the corrugator muscle, which lowers the eyebrow and is involved in producing frowns, increases when negative mood increases, or when the media being experienced is rated as more negative (Larsen et al., 2003). Activity of the zygomatic muscle, which controls smiling, is associated with positive emotional stimuli and positive mood state. Level of enjoyment and positive emotion therefore will be reflected in increases in smiling (zygomatic EMG level) and decreases in frowning (corrugator EMG level).
During interactive tasks the corrugator muscle EMG also has been found to provide a sensitive index of the degree of exerted mental effort (Waterink & Van Boxtel, 1994), and to increase with the perception of goal obstacles (Pope & Smith, 1994). The corrugator EMG can also measure the more negative emotional responses of the computer user, reflecting their tension and frustration during usage (Hazlett, 2003). During video gameplay therefore increases in the corrugator EMG reflect level of tension, negative emotion, and effort. For the gameplay perhaps the best overall label for what the corrugator EMG reflects is tension.

13.4 Measuring the Player's Emotional Experience with Biometrics

13.4.1 Validation of Facial EMG as a Game Emotion Measure

In order to validate the usage of facial EMG for gaming, I conducted a study with boys playing a car-racing videogame. I will report the method in some detail as it illustrates various aspects of game testing methodology (for a fuller report on the results, see Hazlett, 2006). Thirteen boys played the car-racing videogame Juiced (THQ, 2005) on an Xbox platform while facial EMG data was collected. This game involves the player in choosing and customizing a race car, and then picking from various race courses and conditions to race a number of other cars. The races tested in this study were all circuits, and the player raced for several laps against 3-5 other cars that were controlled by the game's AI. Displayed on the screen was various information such as current place, speed, and time from other cars.

Before the actual testing, three experienced players of the game were observed while they played the game and were interviewed about what they found to be clearly identifiable positive and negative events in the game. Identified positive events were passing other cars, making other cars crash and advancing one's standing in the race, and winning a race. Identified negative events were being passed by another car, being hit by another car, mechanical trouble, and running off the course or "wiping out."

Each of the thirteen players was tested alone in a naturalistic living room setting with the EMG testing equipment and experimenter unobtrusively positioned behind a low partition. The player used the smaller "S" Xbox controller and watched the game on a 52-inch Pioneer TV monitor from a distance of 175 cm. Each boy first practiced for several games and then chose a level and course that they felt would be challenging but also that they had a chance of winning. Then each boy ran two races while facial EMG data were collected. The boys were asked not to talk during the races that data were being collected.

Through video review positive and negative events during play were identified. It was found that the zygomaticus EMG was significantly greater during positive events as compared to negative events. Also, the corrugator muscle EMG was found to be significantly greater during negative events as compared to positive. Figure 13.2
shows these results by events and muscles. One can see that the negative and positive events had a different pattern of emotions. The negative events results were particularly striking, but the positive event results, though not as large, were still significantly different. This study demonstrated that positive and negative emotion can be measured in real time during video gameplay. Now that we see that this method can measure the player’s emotional experience, how can it be applied to developing more compelling and entertaining games?

13.4.2 Developing a Game’s Emotional Profile

Different game genres will have particular emotional signatures based on the objectives of the game and the methods used by the designers to engage the player. We will look at several genres to illustrate the approach, and to show how the measurement of a game’s emotional profile might be helpful for game development.

One of the most common game designs is to provide the player a challenge to overcome, and then when successfully overcome the player moves to a higher level with new powers, abilities, etc. Then the player faces a new challenge and the cycle continues as he/she advances through the game. When the player is immersed in overcoming the challenge, their emotional tone is tenser, and then upon success their emotion shifts to the positive. The right amount of tension, not too easy and not too frustrating, is critical to get the greatest positive emotional spike. The balance between tension and positive is an important aspect of a game’s emotional profile, and the reason many games offer to the player choices in level of difficulty. Consider the driving game Juiced that we just looked at. Though not reported on in the validation study, the moment to moment emotional readout shows the player
having bursts of negative emotion and increased tension when something bad happens like being run off the road and bursts of positive emotion when the player passes another car or wins the race. For driving games, there is a fairly ever-present mildly elevated tension level associated with concentration on driving, and bursts of positive and negative emotion throughout the race related to game events.

A genre with a different emotional profile is the action role-playing game (RPG). We will examine play with Fable (Lionhead Studios), a successful and critically acclaimed game when it came out in 2004. This game consists of “the hero” developing skills and acquiring possessions such as weapons, and overcoming challenges that lead him through a portal to another place while he is hunting the “Jack of Blades.” Figure 13.3 shows the emotional readout from facial EMG of a fifteen-year-old boy playing Fable through three complete challenge cycles, just over 6 minutes, and leaves off with him in the fourth cycle. The positive zygomatic response is in blue, and the negative/tension of the corrugator is in orange. One can see the pattern of increasing tension during the challenge as he engages in combat, and then a positive spike when the challenge is overcome, and the hero moves onto the next place and the next challenge. This increasing EMG gradient is common in sustained tasks and is associated with increasing level of tension and effort (Malmo & Malmo, 2000).

\[\begin{array}{c}
\text{15 year old male} \\
388 \text{ Total seconds} \\
\text{Positive Mean: } 5.0, \text{ +1SD: 5.5\%} \\
\text{Tension Mean: } 7.0, \text{ +1SD: 17\%} \\
\text{Positive/Tension ratio: 0.32}
\end{array}\]

Fable Play.
Only the third challenge is missing the consistent tension build up where we would expect to find it. If we were going to analyze this data to help with game design, then as the developer we would be on the look out for patterns like this amongst players. Do most players lack the tension build up at that particular place in the game, or was this lack something idiosyncratic for this particular player? Using the immediate readout of EMG data to help with asking post-game questions is a particular usefulness for EMG, and will help the developer zero in on difficulties or emotional dead spots in the game that would have been overlooked with just traditional data collection.

One method of describing the emotional profile of a game is to count the number of seconds that the two emotional traces are at least one standard deviation above their mean. Since people vary on the absolute value of their EMG in microvolts, the standard deviation gives us a way to compare between players and games. In Figure 13.3, one standard deviation above the positive emotion mean is represented by the green line. This gives us a way of noting at a glance what places in the gameplay did heightened positive emotion occur. The same can be done for levels of tension. The percentage of time the EMG is elevated one standard deviation above the mean is related to the skewness of the data series, or how many and how lengthy are the spikes in the player’s emotional record. In this example of Fable the positive level is elevated for 5.5 percent of the series, and the tension level is elevated for 17 percent. The ratio of positive elevated moments to tension is 5.5/17, or 0.32. At this point in game research there is no database that we can compare this ratio to and find out if this is a favorable positive to tension ratio for an action RPG. Again, we are looking at one player in this graph, and it will be important to calculate this emotion ratio based a selection of players. Though there are no norms yet developed, this calculation does represent an opportunity to quantify the shifts in emotional experience that underlie enjoyment and immersion, and would give a quantitative score to help compare and evaluate games of the same genre.

The virtual board game or party game Mario Party (Nintendo) has a decidedly different emotional profile than Fable. Mario Party offers the player a series of short challenges called “mini-games” that are fun without too much work. Figure 13.4 shows a profile of a nine-year old boy playing Mario Party 6 on Gamecube for 6½ minutes. In comparing this emotional response profile to the Fable profile, we first of all see a much greater duration of elevated positive emotion. Positive emotion is elevated above one standard deviation 18.6 percent of the time, and tension is elevated 14 percent of the time, resulting in a positive/tension ration of 18.6/14, which yields the emotional profile number of 1.33. This number is quite above the emotional profile ratio of Fable and well in the positive range (1.00 would be the value when positive and negative elevations are balanced).

Mario Party is designed for multiple players, and that is one of its fun elements. But for this test we control the social interaction and have the player play solo. He is playing Mario, while the console is controlling the three other players. For the first mini-game the player first rolls the dice and then hops to the proper space based on the dice roll. That ends at around second 80, and then there begins a mini-game called “Take a Breather.” All 4 players hold their breath and go underwater, and
Mario stays under the longest and thus wins the game at 105 seconds. From the graph, you can see the dramatic increase in positive emotion that occurs when the game is won. The interesting thing that this data shows us though is that in contrast to playing Fable winning challenges isn’t the only way that the player experiences increases in positive emotion. We can see this pattern in the next thing that occurs for Mario. He begins a long dice roll and walk at around 160 seconds, which lasts for about 50 seconds to second 210. During the roll he becomes giant size and he gets doubles, but at the end of the roll he lands on a space that loses him several points. In looking at the graph one can see that the player experiences elevated positive emotion all through Mario’s turn until the end when he loses points and then the positive emotion goes down.

The next Mario Party mini-game illustrates heightened positive emotion during the mini-game. Beginning at second 250 the player engages in a mini-game called “Candle Light Flight.” For three times the players chase each other around in the dark, and there is very little feedback to the player on how he is doing. Only at the end of the three mini-games do the players find out who won. The three positive emotional spikes at seconds 260, 300, and 315 correspond exactly to the playing of the three games. The sharp increase in positive emotion occurs while the player is using his controller to
elude the other players. Figure 13.4 tells us that this is the fun element for the player. At the end of the three games the player actually finds out that his character Mario lost. After that loss the player goes on to engage in another series of dice rolls and moves, which as we can see, are very enjoyable. By looking at the positive emotion trace we can also see which of the mini-games the player enjoys the most. For example, this player finds the “Candle Light Flight” more enjoyable than “Take a Breather.”

So in summary, for a party game the player does experience pleasure when winning, but in contrast to the action RPG most of the pleasure occurs during the play no matter what the outcome is. The game designers recognize this, and have many fun elements, like giant sizing, genies, etc occurring during the play. The graph for Mario Party also illustrates how tension levels stay low and spikes are minimal, indicating that tension is not a predominant element in the emotional experience of the player for this genre. These two profiles were used to illustrate how different types of games will evoke different emotional experiences. The player of an action RPG can tolerate and enjoy a much lower tension to positive emotion ratio than the player of a fun causal game like Mario Party.

Recent trends indicate that the growth in the gaming industry may lie in areas other than the traditional fare of hardcore gamers. There has been a recent increase in popularity in causal games and causal game platforms, serious games, and games targeted for seniors and baby boomers. These new players appear to be seeking a different gaming experience that involves different emotional profiles. In order to understand and design for these emotional experiences the accurate assessment of the emotional experience of these new gamers is vital. Since these new players do not fit the typical hardcore gamer demographic developers now more than ever can’t expect that their gut reactions and interests will be similar to the intended player. Facial EMG can give feedback to the developer on what features of the game enhance emotional experience, and what mini-games, scenes, places, characters, challenges etc work best.

Warning

There are many infamous disasters in advertising and marketing that have occurred when executives thought that the intended consumer’s reaction to an ad or product would be similar to what the executive’s reaction was. Don’t make the same mistake in game development and assume you know what the potential player’s preferences and experiences will be. Testing the player’s experience and emotional responses are vital to successful game development.

13.5 Practicalities of Using Biometric Measures

Using physiological measures in game testing is a step up in the complexity of measurement. It takes some extra equipment and technical knowledge. However,
it takes training and expertise to conduct any type of user experience and usability study. Physiologic measurement is not as daunting as it may first appear, and there are equipment makers, consultants and written resources that one can turn to for help. This section will give a brief overview of what is involved in emotional measurement of games using facial EMG.

Physiologic testing of game players is conducted preferably in a living room setting, simulating a natural environment as much as possible. Two tiny micro-sensors are placed over the zygomaticus and then the corrugator muscle (see Tassinary et al., 1989 for more complete description). A common ground sensor can be attached anywhere on the body. Convenient ground attachments are a wrist bracelet or an ear lobe clip. The facial muscle sites are cleaned with alcohol and a conductive gel is used to make the connection between the skin and the sensor. Figure 13.5 shows a gamer at play with the EMG sensors attached. An experienced technician can hook up a player and be ready to test in less than five minutes. These sensors on the face may seem like they would interfere with the player’s experience. However, experience shows that people soon forget them as they get involved in the game, just like test subjects forget about the one-way mirror in a two-room testing situation. The wires from the sensors connect to a bioamplifier for each muscle that amplifies the signal, and these bioamplifiers connect to an analogue-to-digital (A/D) converter (Psylab, made by Contact Precision Instruments, is one of the

![Figure 13.5](image)

**Figure 13.5**

Player with EMG Sensors, focused on gameplay.
better systems). In order to filter out noise, the EMG signal is typically filtered to only allow 30 Hz to 500 Hz to pass. Also, researchers often use a 60-Hz notch filter to block out AC line interference. The raw EMG signal is in the form of a bipolar sine wave, and needs to be rectified so the absolute values reflect the magnitude of the muscle contraction. Figure 13.6 shows both the raw bipolar signal, and the rectified version of the same raw signal. The signal can then be averaged and smoothed through a hardware device called an integrator, or it can be sent to the computer for software processing and averaging. Figure 13.6 shows the steps in this processing from raw EMG signal to the final smoothed signal that can then be related to game events. The sampling rate of the EMG signal is usually on the order of 1,000 Hz, so large data files are produced rather quickly (see Cacioppo et al., 1999 for overview.

**Figure 13.6**

**EMG raw signal**

- Microvolts
- Second

**EMG rectified**

- Microvolts
- Second

**EMG rectified and smoothed**

- Microvolts
- Second

**EMG Signal Processing.**
of EMG methods). Averaging to 100 msec or even 1 second values produces a workable time series that can then be synchronized with the video of the gameplay.

**Tip**

At 1,000 data points collected for each second, testing for a few minutes quickly produces large data files, and not only is disc space a concern but time to process starts to rise. One can minimize the processing time with writing some reusable code to rectify and aggregate the data that can be plugged in quickly. Sometimes a better alternative is to have the data crunched with a hardware device called an integrator and then sent to the computer. Sensitivity does seem to be affected by this approach though and some researchers, including myself, prefer to manage the larger data files for the sake of precision.

This EMG methodology is likely more of a quantitative approach than most are use to taking, but with a little preliminary work one can set up a system that you can use over and over again with little extra work. For example, an Excel spreadsheet can be made with the formulas for mean, standard deviation etc already in cells, and after the initial data capture and averaging, the positive data series and the tension data series can be dropped in two data columns of the Excel worksheet. The summary values of interest are then instantly calculated and available for use.

During the actual gameplay the EMG signals can be of use as well, without any extensive data analysis. The tester can observe the gameplay and also have an eye on the EMG readout that is flowing across the screen. When there is a particular positive or tension spike on the screen the tester can note what the gameplay was, and then after the play session ask the player what might have been occurring for him/her at that moment. The EMG readout then can be quite valuable in directing the tester’s attention to significant reactions and events in the gameplay that would have gone unnoticed otherwise.

**Warning**

In any type of player experience testing the presence of others is a powerful influence. Other people are strong emotional elicitors, and social interaction will overwhelm reactions to the game. The tester should always strictly control this aspect of the testing situation, or risk invalidating the data and learning little about the game.

Players are usually tested alone, as the presence of other people influences smiling and the report of positive emotion. Basically, sharing experiences with others
increases one's enjoyment. Of course, if one is interested in testing the multiplayer experience, then the involvement of other players would be important. But as in any method of testing, the social variable can have a potent effect on the player's experience and should be strictly controlled from test to test. To get a good sample it would be wise to test at least 6-8 players at a minimum, and more if one has the time and resources. This requirement is similar for any type of testing that a developer would want to conduct, and not just EMG methods.

Note

Biometric methods in general require fewer subjects than verbal methods to be valid, as the error variance is usually less. However, the more players one can test the more confident one can be in their results. The balance between collecting enough data and costs in time and money is always an issue.

13.6 Applications for Biometric Methods

There are many interesting game development applications for biometric methods. We have already taken an in-depth look at some of the possibilities with the Fable and Mario Party examples, so here we will expand some on the possibilities. The emotional profiling of games gives a useful evaluation of a game's impact on a player, how compelling they find the game, and how the game measures up to other games in its genre. If there are weaknesses in the game, the moment-to-moment emotional profile can help pinpoint where those weaknesses lie. Individual elements of a game can be tested separately or compared to other variations so one can choose the variation that has the strongest emotional impact. This can be any element such as static visual scenes, music, characters, story, etc. The elements don't have to be finished versions, but it needs to be kept in mind that the more barebones something is, the less of an impact it will have. That is why one would want to compare things that have the same level of finish to them. The causal games that are becoming evermore present on phones and handhelds often depend on short simple experiences of fun for their addictive quality. Facial EMG is well-suited to measure the intensity of positive emotional bursts associated with this fun, and to allow comparisons amongst games and mini-games.

Note

If you are testing reactions to a series of visual or auditory features like scenes, music, characters, etc., it would be important to vary the presentation order between players so that there are not order effects in the testing results.
Another example of application of biometric methods to games comes from the Serious Games area, and involves the assessment of post-traumatic stress disorder (PTSD) treatment approaches using game technology. Treatment of PTSD is aided by creating controlled re-immersion experiences for patients, and researchers are now using videogame technology to create such therapeutic environments (for more information, see DeMaria, 2006). Intensity of the experience needs to be in a therapeutic range: high enough to activate the emotional memories, but not too intense so they overwhelm the player and he/she can't emotionally process. Biometric methods can help researchers determine the state of the player and keep it in optimum range.

When successful treatment has been achieved the trauma environment will not cause such a high level of arousal to occur for the player. Gaming with biometric measurement therefore is also a superior method for assessing treatment success and the achievement of game goal objectives. An example of successful PTSD treatment with virtual reality immersion is shown in Figure 13.7. This data is from a female patient I assessed who had been held up at gunpoint and subsequently developed PTSD. She was assessed at the beginning and the conclusion of PTSD treatment. The typical assessment paradigm for PTSD is to immerse the patient in three different environments: relaxed or neutral, general stress, and traumatic. The neutral and general stress environments are used as control conditions to make sure the biometric changes measured from before and after treatment only occurred in the trauma condition, and therefore are caused by changes in reactivity to the trauma cues. Heart rate was measured during a 5-minute exposure to each of these

![Graph showing heart rate response to different scenarios](image)

**Figure 13.7**

Pre- and Post-Treatment Response to Virtual Reality Immersion of Trauma Victim.
three virtual environments, and the means are shown in Figure 13.7. As can be seen, the trauma changes were much larger and more significant than the other two environments. (Note: the assessment and treatment in this case only used virtual reality immersion with video of appropriate environments for each of the three environments. The addition of actively involved gaming in assessment and treatment for this type of patient would be an advancement, and is on the drawing board.)

This example of PTSD treatment illustrates that when the goal of a game is beyond just entertainment, player experience assessment can provide another function besides feedback to help game design. Biometric player assessment can inform about the success of each player in achieving game goals. This is of course important for the player, but also a log of cumulative player success can then provide performance and ROI data about the game itself. Information such as percentage of players that achieved game goals, amount of time and effort required to achieve goals, and so on can be used for interested parties such as stakeholders and for marketing and sales purposes. This information becomes important with serious games because unlike entertainment games, the purchaser of the serious game may likely not be the intended player, and personal play experience is not a source of information for the purchaser.

13.7 Summary

In this chapter, I have tried to give the reader a brief introduction to the nature of emotion, and how the player’s emotional engagement and reaction is the fundamental driving force of the gaming experience. Game development is enhanced by feedback about the emotional experience of the player, and this information can be used to arrive at an emotional profile of the game. The challenge is in measuring the emotional experience of the player without interfering with the natural gaming experience. The player’s verbal report is not so informative about their moment to moment emotional experience so physiological measures have been turned to. The best physiologic measure for tracking emotional valence is facial EMG. These methods were described and shown to have validity for measuring emotion during gaming. Even though the EMG methodology is more quantitative than most approaches, there are ways to collect and analyze the data that minimize the work.

One of the main goals of biometric assessment in game development is to provide information on the emotional profile of the game, and how the different elements of the game enhance or detract from the game’s approach to engaging the player. In this chapter, biometric assessment of an action RPG and a party game demonstrated how different game genres have different emotional profiles and methods for emotionally engaging the player. In addition to entertainment games, biometric assessment can be useful with serious games. We saw how serious games have a somewhat different assessment need than entertainment games, and how biometric assessment might be useful in providing feedback on the less objective
outcomes desired for some of these games. Applying game and virtual reality technology to help with the treatment and assessment of PTSD gave us an example of how gaming with biometric measurement can achieve the game’s objectives of providing the player with controlled immersion and active learning. The biometric assessment also becomes useful for quantifying the effectiveness of the game.

13.8 References


13.9 Additional Resources

