Chapter 3

Video Games ~~and~~ Human Experience

Playing video games as a kind of experiential entertainment ~~would help people to have new internal experiences~~. The virtual world of video games let adults to play ~~as~~ new rolls and ~~enjoy filling their heads with new thoughts~~ experience ~~and~~ emotions. Games ~~are~~ provide opportunities for the development and design of environments ~~therefore~~ where the player can interactively experience various emotions and mental conditions. This interactive experience is in contrast to cinema and other ~~major types of entertainment is what makes them exceptional~~ more passive forms of entertainment.

In computer games, gameplay is usually considered of key importance [86, 61]. One can define gameplay as the pattern defined through the game rules [98, 71], the connection between the player and the game [57] or challenges [85] ~~of the game~~ presented by the game. Gameplay is not a singular entity, ~~it~~ and can consist of many different elements. ~~In fact it is the result of a large number of contributing elements.~~ Gameplay is essentially a synergy that emerges from the inclusion of certain factors [85]. In absence of a broadly accepted definition for gameplay, our focus here is targeted on one ~~frequently mentioned~~ core element ~~of it which is~~: *challenge*. The sense of challenge in video games is ~~what keeps many people playing them~~ a significant contributor to continued play. However, ~~this challenge~~ the ~~element of the~~ gameplay element should be carefully adjusted for the targeted audience. The process of adjusting the challenge level of the game is usually referred to as game balancing. To balance the challenge level or difficulty scale of the game, designers must change many ~~interacting~~ inter-related parameters to create a ~~gameplay~~ experience ~~somewhere~~ between too easy ~~to be~~ and boring and too hard ~~to be~~ and frustrating [53]. In this chapter, a history of related works investigating the relation between a game's difficulty level and various emotional states is provided.

the

List factors.

3.1 Gameplay and The Concept of Flow

Mihaly Csikszentmihalyi, in the mid 70s, in an attempt to explain happiness, introduced the concept of *flow*. His work as a professor of psychology has become fundamental to the field of positive psychology that ~~essentially~~ includes happiness, creativity, subjective well-being and fun [24]. The ~~feeling of complete~~ complete and energized focus while engaged in an activity is ~~what~~ usually referred to as flow, this feeling also has an ~~ambient~~ associated sense of enjoyment and fulfillment [24]. During the flow experience ~~our~~ high level of focus maximizes ~~our~~ performance and we ~~essentially~~ lose track of time and worries~~, rather we feel a pleasurable feeling from the activity~~. Flow is also referred to as the optimal experience or being in *the zone*. ~~This feeling is shared by every human being, and most probably has happened to one when he or she forgets to eat or sleep being so~~

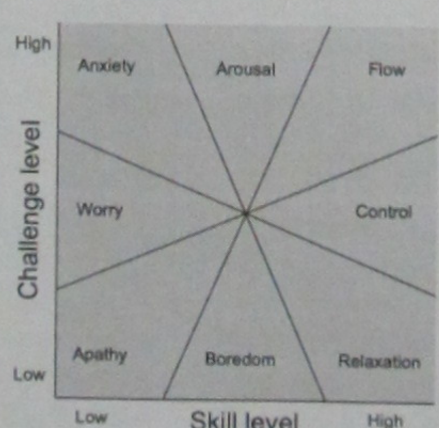
~~engaged in an activity.~~

Csikszentmihalyi in his work, identified eight major components of flow [24]:

- A challenging activity requiring skill;
- A merging of action and awareness;
- Clear goals;
- Direct, immediate feedback;
- Concentration on the task at hand;
- A sense of control;
- A loss of self-consciousness; and
- An altered sense of time.

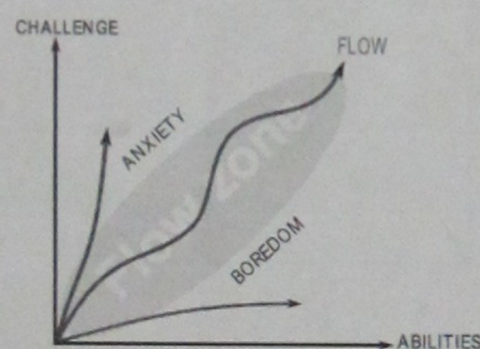
~~From the above items,~~ An activity doesn't necessarily require all the eight components to inspire the flow experience. ~~In fact as far as~~ We will constrain our analysis to ~~are concerned with gameplay in video games~~, the first item which relates to the challenge and the skill level ~~is what we should pay attention to.~~ Figure 3.1 shows Csikszentmihalyi's flow model in terms of challenge and skill ~~level~~.

Figure 3.1: Mental state in terms of challenge level and skill level, according to Csikszentmihalyi's flow model [25]



Although there are many components that go into a great player experience, games at their core motivate players by giving them the opportunity to demonstrate mastery over game challenges [94]. To feel accomplishment over mastering game challenges, designers ~~change many~~ adapt parameters to create gameplay that resides somewhere between too easy ~~to be~~ and boring and too hard ~~to be~~ and frustrating [53]. The ~~Flow~~ flow zone is ~~an inspiring~~ a concept in flow theory and is illustrated in Figure 3.2. ~~The~~ The flow zone suggests~~,~~ that in order to sustain players' flow experience, designers must ~~is to~~ balance the inherent challenge of the activity and the required player's ability ~~(skills)~~ ? to address and overcome it [20]. ~~It~~ Good design avoids the activity ~~to become~~ becoming so overwhelming ~~by~~ a challenge ~~beyond player's ability and consequently~~ that it generating anxiety~~. Also~~ and avoids failing to engage the player ~~and becomes~~ that it becomes so boring due to a lack of challenge ~~level less than player's ability~~. ~~However, this should be mentioned, we fortunately have tolerance for a temporary lack of stimulation, with an assumption of more is on the way~~. One ~~should~~ can consider the flow zone as a fuzzy ~~safe zone~~ area where the activity is not ~~yet~~ too challenging or boring [24].

Figure 3.2: Flow zone, the area where challenge and skill level match.



repetitive.

~~As far as the content and premise of the activity is inherently appealing to the audience, the design of the interactive experience, such as video games, boils down to keeping the user or the player in the flow zone throughout the activity.~~ ~~While~~ Because playing a video game should gradually increase~~s~~ a player's skill level, the designer should increase the required skill level by changing the challenge level of the game at the same pace to keep the player in ~~the~~ flow zone. However, the rate of skill acquisition varies individually. ~~Though acquiring skills gradually happens differently in various individuals. In fact,~~ Designing such a balance between the challenge and skill level becomes a greater and greater challenge for the designer as the size of the targeted audience grows. For example, when designing a game for kids, this balance would have a wholly different rate of change than when designing it for adults~~, And therefor balancing a game targeting both kids and adults using the preset static methods looks impossible~~.

3.2 Dynamic Game Balancing vs. Static Game Balancing

Many video games offer only a simple, narrow and static experience, which is ~~shown with the~~ denoted by a red line in Figure 3.2. This statically preset path might keep the typical player in the flow zone but will not be fun for the hardcore or novice player [20]. For example simple skills for typical players such as walking in a 3D space and looking around by controlling the camera can ~~be~~ be easily found new and ~~quite~~ cumbersome to ~~many~~ casual players who are ~~only~~ used to 2D ~~side-scroller~~ games. This frustrating introductory challenge potentially.

intended game

combined with the ~~main~~ challenges ~~of the game~~ can ~~totally~~ turn ~~the~~ casual gamers turn away. One should note that frustration due to lack of skill during game play is not necessarily same as frustration caused by difficult game levels. In fact, Kiel ~~pointed~~ identifies two ~~kinds~~ types of frustration during games, the at-game-frustration and in-game-frustration. The first is due to lack of skill during game playing and the second in caused by difficult game levels [42].

Figure 3.3: Adapted flow zone

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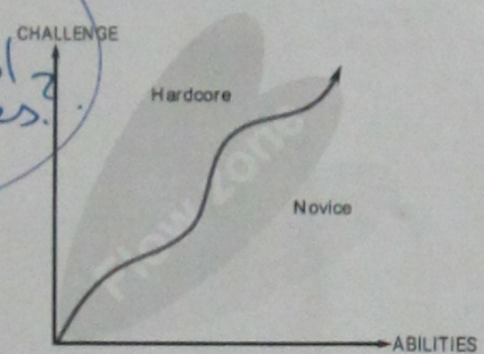
What about broken control schemes?



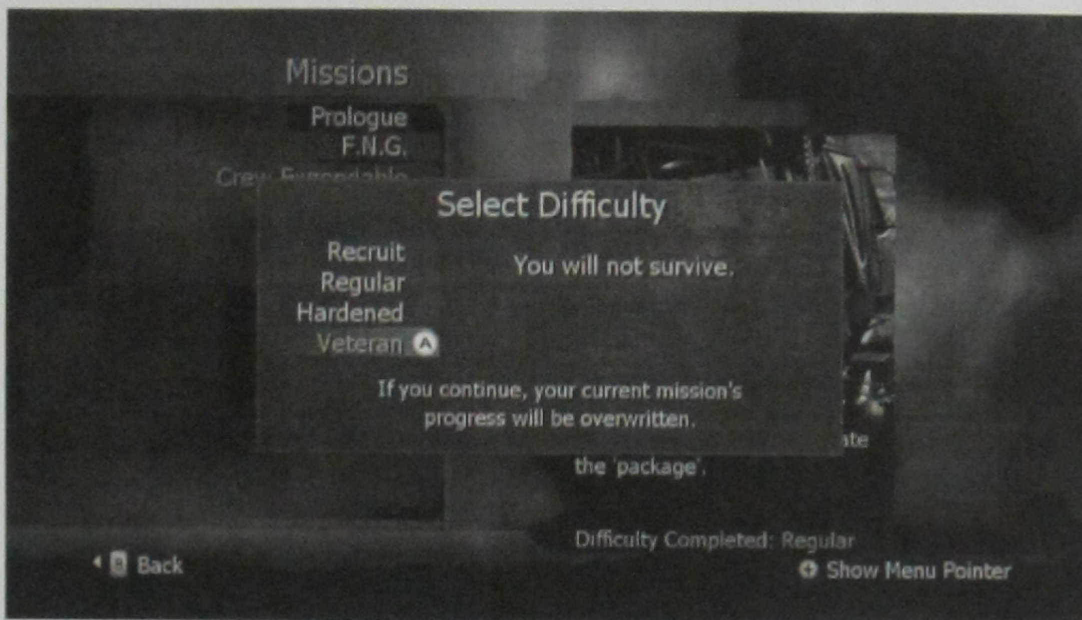
~~Addressing these game balancing issues.~~ For many years, game designers aimed to provide some customizations, for example by letting players choose a difficulty level upfront or including progressive difficulty levels during gameplay, based on a player's performance; ~~however~~ More advanced methods that work in real-time are less common, as most designers predefine levels of game challenge for players with different skill levels. ~~The player then decides in which of those levels to play.~~ Another approach to address this balance issue is by techniques known as rubber-band artificial intelligence (AI) [19]: When falling behind, the player suddenly gets an enormous boost in speed, which allows for catching up again (and vice versa for the competing cars).

need to expand this kind of example. the car thing appears out of nowhere.

Designers work on many different aspects of the game to make it ~~more~~ balanced. Game balancing in terms of difficulty level and player experience is only one aspect of balancing a game. Another important balancing issue is the concept of fairness in the game. A primary issue in competitive games is that various settings of properties for different characters should have equal chances to win the game based on rules and starting positions [85]. Balancing fairness may involve manipulations of different game elements - for example initial resources and abilities allocated to different player types like Orcs or Humans in WarCraft. This type of static balancing is often carried out through repeated playtesting of the game mechanics and parameters such as tuning the capabilities of individual weapons or units [11, 85].

In computer games development, designing agents whose behavior challenges human players adequately is a key issue. The idea of a dynamically adapting agent behavior or ~~in other words~~ dynamically balancing a game ~~dynamically~~ during game play through AI difficulty. is not new [4]. Dynamic game balancing (DGB) also known as dynamic

Figure 3.4: Menu content for difficulty selection, Call of Duty: Modern Warfare (Wii)



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difficulty adjustment (DDA) is the process of automatically changing parameters, scenarios, and behaviors in a video game in real-time, based on the player's ability, in order to avoid them becoming bored (if the game is too easy) or frustrated (if it is too hard). The goal of dynamic difficulty balancing is to keep the user interested from the beginning to the end and to provide a good level of challenge for the user. Dynamic balancing, considers a fully continuous spectrum of play, from the starting point of the game to its end. Dynamic balancing differs from static balancing because the interaction of the player or players with the game should be considered, and different units and parameters in the game configuration should be adapted based on the current state of the game [113] rather than at the start of play based on player models. Variable frequency of enemies in Diablo 3 and variable power of enemies in Assassin's Creed 4: Black Flag are examples of dynamic balancing during game play.

Many different approaches are found to address dynamic game balancing, In all cases, it is ~~always~~ necessary to measure the difficulty the user ~~is~~ is facing during the game, which ~~This~~ can happen either implicitly or explicitly. This measure tries to identify the difficulty the user is facing at a given moment. This measure is usually performed by a heuristic function, ~~which is~~ usually ~~known as a~~ called the challenge function. Given a specific game state this function can specify how easy or difficult the game feels to the user. Many different in-game properties such as the rate of successful shots or hits, the numbers of won and lost pieces, life points or time to complete some task, can be used for this measure.

Huniche et al. [47] controlled the game environment settings in order to increase or decrease the level of challenges. ~~It is more likely for the~~ The player is more likely to get more ammunition and ~~more frequent~~ life points if the game is too hard rather ~~than when the game is easier~~. Another straightforward approach is to combine such environmental manipulations with some mechanisms to adapt the behavior of the NPCs or intelligent agents controlled by the computer. This adjustment, however, should be made with moderation, to avoid the rubber-band effect. explain

Using behavior rules is one of most popular traditional implementations of such intelligent agents. For example, in a typical fighting game, a behavior rule would state "kick the opponent if he is reachable, chase him otherwise". Extending such an approach to include opponent modeling can be made through Spronck et al.'s dynamic scripting [107] which assigns a probability to each rule. Rules probability weight can be dynamically changed and adjusted through the game according to the opponent skills, leading to adaptation to the specific user. ~~For example,~~ Rules ~~can~~ that are neither tool strong nor too weak for the current player can have higher probability to be picked.

3.2.1 AI in Dynamic Game Balancing

Works in the field of DGB is usually based on the hypothesis that interactions between player and opponents ~~compared to the audiovisual features,~~ is the major component that contributes the majority of the ~~the quality features of~~ entertainment in a computer game [100]. In recent years, many high quality games ~~to a large degree~~ rely on high quality AI as an important selling point [37]. ~~Many researches have been done on utilizing game AI to dynamically adjust the difficulty level~~. Xiang et al. in their work on dynamic difficulty adjustment by facial expression [124] have employed Gaussian Mixture Module and multi variate pattern ~~thing~~ to model the player's reaction pattern [59, 21]. They have also controlled NPCs behaviors ~~by~~ using reinforcement learning algorithm [107, 3]. Hunicke [47] used the Hamlet system to predict when the player is repeatedly entering an undesirable loop, and help them get out of it, ~~They have explored computational and design requirements~~ ok keep for a dynamic difficulty adjustment system using probabilistic methods based on the Half Life game engine. Joost [119] proposed an adaptation approach that uses expert knowledge for the adaptation. They used a game adaption model and organized agents to choose the most optimal task for the trainee, given the user model, the game flow, and the capabilities of the agents. Hom [46] used AI techniques to design balanced board games like checkers and Go by modifying the rules of the game, not just the rule parameters. Olesen has explored neuro-evolution methodologies to generate intelligent opponents in Real-Time Strategy (RTS) games and tried to adapt the challenge generated by the game opponents to match the skill of a player in real-time [69].

Demasi and Cruz [28] developed NPCs employing genetic algorithms techniques to keep alive those agents that best fit the user skill level. Further studies by Yannakakis and Hallam [125] have shown that artificial neural networks (ANN) and fuzzy neural networks can better recognize player satisfaction level than a human-designed one. Given appropriate estimators of the challenge and curiosity (intrinsic qualitative factors for engaging gameplay according to Malone) [61] of the game and data on human players' preferences,

what? NN? AI alg.?

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3.2.2 Dynamic Game Balancing in Recent Games

In recent years many well known game titles have integrated more complex dynamic game balancing mechanisms. The 2008 video game Left 4 Dead integrated a new AI technology called *The AI Director* [23]. The AI Director monitors individual players' and groups of players' performance and their progress in the game, and how well they work together ~~as a group~~, and then dynamically determines ~~the details on~~ the number of zombies that attack the player, and when boss fights should ~~to~~ happen ~~, using the collected information about the player~~. ~~It~~ the director also makes some decisions about ~~to control~~ audiovisual elements of the game to attract players' attention to ~~a~~ certain areas or set the ~~a~~ mood ~~for a boss fight~~ [1]. This technique, also called *Procedural narrative*, tries to analyze players' experience in the game and control upcoming events to give the player a sense of narrative. In 2009, Resident Evil 5 employed the *Difficulty Scale*. This mechanism, mentioned in the official strategy guide, grades the player's performance on a ~~number of~~ scale from 1 to 10, and dynamically adjusts NPC behaviors like attacking and ~~the~~ enemy strength, damage, and resistance based on the players' performance. Player performance is estimated based on different in-game variables such as damage dealt, deaths, and critical attacks ~~etc.~~ The statically selected difficulty levels of the game locks players at a certain number; for example, the Normal difficulty locks player performance at grade 4, ~~though yet~~ but will dynamically change based on a player's performance between 2 (if player is doing poorly) and 7 if doing well. ~~Leading to some overlaps between different difficulty levels~~ [40]. Fallout: New Vegas and Fallout 3 are of other well known game titles utilizing dynamic difficulty adjustment techniques. In these titles players would encounter more challenging combatants while progressing in the game. The system is designed to retain a constant difficulty level while the player's skill increases ~~during the game~~.

Addressing the game balance problem using predefined difficulty levels ~~obviously~~ cannot incorporate the ~~needs~~ behavior of all potential players ~~of the game while merely~~ using a player's in-game ~~generated~~ data and employing artificial intelligence ~~sometimes~~ can generates predictable behaviors which reduce the believability of the non-player characters (NPCs). Furthermore, human players enhance their skills while playing a game which necessitates an adaptive mechanism ~~that covers the player's need~~ for more challenging ~~NPCs~~ during play [69]. We should also mention, even with all the development ~~of~~ AI in computer games, ~~game~~ players often still find playing against human controlled opponents ~~(via a network)~~ more interesting ~~rather~~ than computer controlled ones [118].

3.3 Emotionally Adaptive Games

While adjusting the challenge level is crucial to ~~every entertaining~~ video game design, what styles of gameplay is appealing differs from person to person. ~~the appealing gameplay might strongly differ per individual.~~ For example skill level differences between different players might make a difficulty level which is enjoyable by a novice, but ~~totally~~ boring for an expert player; Games therefore need psychological customization techniques [95]. Game adaptation that is solely based on in-game performance can only have limited success, because ~~there are many different types of players~~ it adapts to performance not experience [7]. Each type of player has his/her own goals, preferences and emotional responses when playing a game. ~~Hence, for~~ To optimizing ~~the~~ a players' experience, successful psychological customization requires a game to take the emotional state of the player into account. Games should become emotionally adaptive (Figure 3.5) [114].

~~The importance of emotions in computing is widely argued for (e.g. [75]).~~ Affective computing can have a major impact on not only video games but any form of computing ~~with demand of human interaction~~ reliant on human interaction.
The concept of affective gaming was first introduced by Wehrenberg, ~~Charles~~ through using Biofeedback to control a game based on relaxation level. It was one of the earliest studies on correlating a game with player's biofeedback. After years of research the project was first implemented in 1984 for Apple II computers. The results of that study proved that human arousal level can actually be measured through GSR and employed to control a game [117]. Different emotion theories as described in chapter 2 can be utilized for analysis and estimation of human affect state while interacting with computing ~~machines.~~ s because a ~~While~~ user's affect state can dynamically change during an interactive experience, an ~~effective~~ emotional human-computer interaction ~~from an emotion perspective~~ works in ~~terms of~~ an *affective loop* [109]. Polaine in his work on the flow principle in interactivity [78] argues that true is a feedback loop of action-reaction-interaction and involves collaboration or exchange (with real or computer agents). Our work ~~also~~ is based on a similar feedback loop in a game context ~~to~~ which dynamically adjusts a game's difficulty level by ~~looking at~~ measuring a user's affect state. Figure 3.5 [114] shows a schematic view of this closed affective loop ~~of~~ for an emotionally adaptive game. In this closed loop, by continuously looking at the gamers emotional state the game influences the player's experience and emotional state by providing the right game mechanics [48]. Ideally, during play, the emotional state of the player (measured in terms of emotion-data), is continuously being fed back to the game so that the game can adapt its mechanics (e.g. difficulty level) ~~accordingly~~ in real-time, with an eye towards enhancing ~~This all is done to create the optimal experience (which is referred to in literature as e.g.~~ flow [20] or immersion [66].

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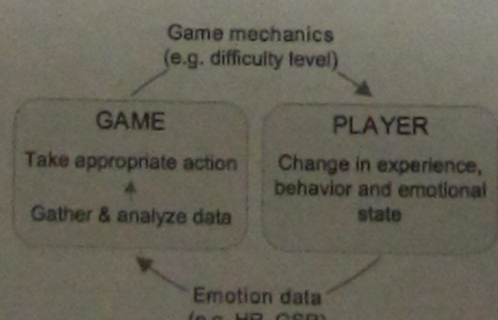
Figure 3.5: The emotionally adaptive game loop, ~~inspired on the affective loop~~ from the affective [109].



~~One should note that, emotionally adapted games with attention to certain psychological demands goes beyond dynamically balanced games.~~ Emotionally adapted gaming can be seen as collection of affectively game adaptation decisions which are parts of the meta-narrative of the game. Therefore ~~a basic~~ approach to

your words?

systematically identify and design these adaptations decisions is to ~~make~~ base them ~~as~~ on psychologically validated templates. ~~In a sense that e~~Each one of these adaptation elements' influence (such as emotional response) on a particular type of user is sufficiently predictable [97]. These adaptation templates may consist of different game manipulation approaches:

- Manipulating the substance of a game at its basic ~~informing~~ level, such as changes in story line and putting ~~the character of~~ the player in different situations.

- Manipulating the game in presentation level, such as visual elements, shapes, colors, sound effects and background music.

- Manipulating the game ~~in~~ at the interaction level. The difficulty level or challenge level of the game may also be continuously adjusted, keeping the skills and challenges in balance which results in a maintenance of an optimal emotional experience and possibly also a flow state [96].

need detail here can't understand how this relates to document.

Figure 3.6: Risen 2 boss fight, gamer supposed to get excited through changes applied to the NPC

3.3.1 Why and How to Emotionally Adapt Games

To manipulate emotions in gaming on the basis of avoiding or approaching a specific emotional state, we can categorize our manipulation goals and strategies ~~to the followings:~~ as

Need a better intro. can't use this form when the subsections are so long.

Global change we to I and our to my and adjust verb tense to match where appropriate. Thesis are single author documents.

Manipulating Emotions Through Narrative Features

There are the transient basic emotional effects of games that are dependent of the phase of the game or ~~some~~ specific events. These are emotions such as happiness, satisfaction, sadness, dissatisfaction, anger, aggression, fear and anxiousness. These emotions are the basis of narrative experiences, i.e. being afraid of the enemy in a shooting game, feeling aggression and wishing to destroy the enemy and feeling satisfaction, even happiness, when the enemy has been destroyed. Emotional regulation systems in these instances most ~~naturally may~~ focus on manipulating the event structures, such as characters, their roles, events that take place and other features of the narrative gaming experience. [96]

Eliminating Unwanted Emotion Experiences Through Basic Game Structure

There are possibilities for emotional management, especially in the case of managing arousal, alertness and excitation. ~~Also~~ One may also wish to manage negative emotions, such as sadness, dissatisfaction, disappointment, anger, aggression, fear and anxiousness. The case for managing these emotions is twofold. On the one hand, one may see that these negative emotions could be eliminated altogether in the gaming experience; ~~This can happen via either eliminating, if possible,~~ by damping the emergence of such ~~an~~ emotions in the game. For example, one ~~can~~ could make a deliberately happy game with ~~level playing~~ monkeys ~~in~~ on a far away island throwing barrels at obstacles ~~and~~ to gather~~ing~~ points. This would include minimum negative emotions. Or, in a game where negative emotion is a ~~basic~~ part of the game, one may wish to limit the intensity, duration or frequency of the emotions via manipulating gaming events and gaming elements so that sadness or fear are at their minimum levels, or that gaming events do not lead to sadness at all. [96]

Similarly, managing ~~level of~~ arousal or the intensity, duration and frequency of select negative emotions may be ~~quite~~ feasible ~~in the case of children as~~ as a form of parental control. On the other hand, one may wish to maximize arousal, alertness and excitation, perhaps even anger, fear and aggression for hardcore gamers.

Avoiding Unwanted Emotions Emerged From Improper Game Balance By Dynamic Adaptation

There are possibilities related to the avoidance of certain types of emotions that are typically indicative of a poor gaming experience. Inactivity, idleness, passivity, tiredness, boredom, dullness, helplessness as well as a totally neutral experience ~~may be~~ indicate~~ing~~ that there is ~~some~~ a ~~fundamental~~ problem in the user-game interaction. This could be due to poor a match between the gaming skills of the user ~~vs.~~ and the ~~difficult~~ challenges of the game or some other factors, such as the user is stuck ~~in an adventure game for too long and can not proceed without finding a magic key to enter the next level or so~~ on a level because it is unclear how to progress. When a gaming engine detects these emotions ~~in the user~~, it may adapt its behavior to offer the user a ~~more choices of selecting the~~ different difficulty level ~~of the game~~ or offer the user ~~some~~ clues as to how to ~~go forward in the game~~ progress. ~~The game can also adapt its level of difficulty to the player's skill level.~~ [96]

All of these possibilities may be relevant. However, the elimination or minimization of certain emotions may be specifically feasible in the case of indicated overly poor gaming experience in which the game may

Again why is this picture here?

Figure 3.7: God of War 2, gamer supposed to get excited through changes applied to player character

adapt its behavior to assist the user. It should be noted that events in games may change quickly and produce complex situations and hence complex emotions that may change rapidly. Consequently, one should better integrate these approaches into the genre or type of the game, such as driving simulator, first person shooter, sports game such as golf, or an adventure game, or a level-playing game for children. [96]

3.4 Related Work

Previous research attempts to create emotionally adaptive software have mainly focused on tutoring systems and workload / performance optimization (see e.g. [102]). Fewer attempts have been made to incorporate a closed-loop mechanism in a games context. Takahashi et al. [111] and Rani et al. [81] created a game that was found to improve player performance by adapting difficulty level to player's physiological state. ~~Concept validation~~ C claims ~~of~~ from these both studies were, however, based on a limited number of participants. ~~Besides these attempts~~ A number of biofeedback games have recently been developed, which ~~have some integration~~ integrate some aspect of a player's physiological data into the game (e.g. [9], [10] and []). These games ~~however~~ focus on stress manipulation rather than optimization of gameplay experience. In this section a number of noticeable works related to emotionally adaptive games are introduced and some of their properties, achievements and limitations are investigated.

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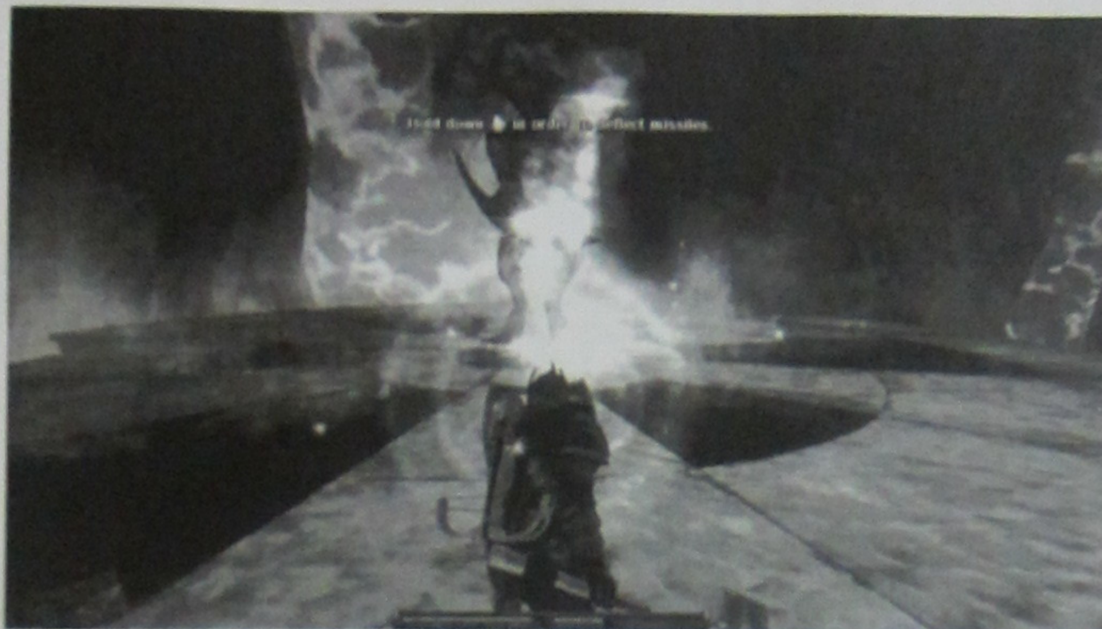
Figure 3.8: Risen boss fight, gamer supposed to get excited through changes applied to environment

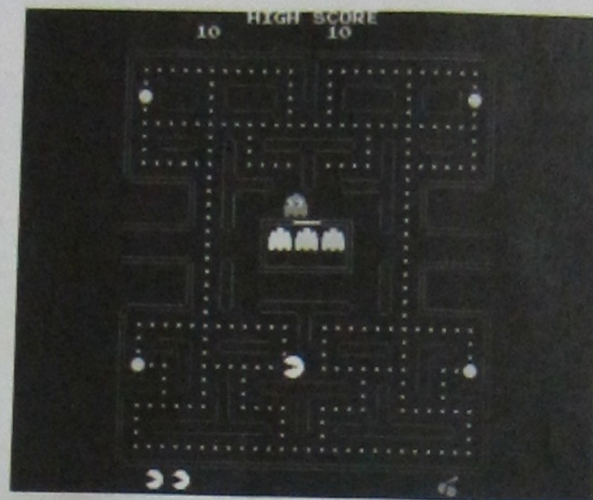


3.4.1 Emotional State and Unguided Player Speed Variation

Tijs et al. in their work on emotionally adaptive games have developed a version of the Pacman PC-game (Figure 3.9) called Stimulus [114]. They chose Pacman for a number of reasons to conduct their study, (1) relatively uncomplicated nature of the game ~~without major changes in e.g. audiovisuals during play~~, which could lead to emotional bias, (2) ~~being~~ it is a well-known game and is easy to pick up and ~~consequently~~ requiring relatively short practice to minimize learning effects, and ~~also~~ (3) because Pacman has a ~~rather~~ continuous flow ~~of~~ action which is beneficial when comparing blocks of game play time ~~the game is played. Similar features of Pacman also has made~~ The game has been ~~being~~ used in other affective computing studies (e.g. [126]). ~~However as their work describes a number of adaptations have been made to the game to suit the experiments:~~ In [xx] the following changes to game play were made. (1) The players ~~have been~~ played the same level of difficulty during the experiment, (2) Entities that were eaten, such as points and pills, respawned ~~returned after a while (added back to the game scene)~~, (3) The speed ~~level~~ of the player changed at preset times (unknown to the player), (4) Eating objects increased the player's score but being eaten by the enemies meant a strong decrease in score, and (5) The overall objective of the game was to score as many points as possible. Their choice for manipulating speed as the difficulty parameter, instead of ~~e.g.~~ the number of enemies has been due to the fact that the number of normal ghosts ~~was constantly~~ changed during the ~~default~~ gameplay as a result to Pacman eating star-shaped pills. This game was played using arrow keys on the keyboard ~~, while all participants have been offered to use their preferred hands to play the game~~ [114].

Tijs et al. study on Stimulus has shown the unguided adaption of players speed has resulted in the slow-

Figure 3.9: Pacman - The original game used by Tijs et al.



mode being too slow and the fast-mode being a ~~bit~~ too fast for some players, ~~but for others the right speed level~~. ~~It has~~ They suggested that the speed level in the normal-mode might not be optimal either, but the players' experiences are better in that mode than in the other two.

They have described their work on induction of boredom, frustration and enjoyment through manipulation of the game mechanic speed partly successful. Nearly all players ~~have shown~~ indications of boredom during the slow-mode, however, the fast-mode was found more enjoyable than frustrating. As they demonstrated in their work, players knew the game speed was going to change, and also they knew it only lasted for a limited amount of time. ~~Besides the speed changes were rather abrupt~~. Finally, they concluded nearly all participants describing the normal-mode as the most enjoyable of the three.

3.4.2 Emotion and Different Difficulty Levels

Aggag and Revett in their work on affective gaming ~~with use of the~~ based on GSR signal, have developed a basic first-person shooter (FPS) that was supposed to be played in two different interleaved difficulty levels ~~interleavingly~~ [2]. They ~~have~~ considered players' stress level as a function of the difficulty of the game. They synchronously recorded players' GSR response ~~to the difficulty level~~ and then mapped this signal to what happened during the game as difficulty level was manipulated. During the experiment they ~~have~~ set the difficulty level randomly such that ~~the play was interleaved and balanced between difficulty levels~~ the players all experienced the same distribution but not presentation of difficulty. Their principal idea was to acquire the score ~~from the player~~ during ~~low~~ boring and challenging play periods in order to see if there was any difference that could be attributed to level of difficulty [2].

~~As Aggag and Revett described the result of their study,~~ They ~~have~~ observed a~~ll subjects deployed in their study report~~ that the game did induce feelings of stress at the same time points during the play through players self report. The players' GSR signal that was recorded during play was pooled according to difficult/non-difficult regions and the data was analyzed with respect to the frequency and amplitude of the responses throughout the two phases of the game for each phasic response. Their result indicate that during the stressful periods (higher difficulty level), the skin conductance level increase and the frequency of the spontaneous GSRs ~~increased somewhat~~ increased (from 0.5 to 2.3 per minute on average). ~~Looking at the GSR values, the report it is clearly evident which phase of the game the player was involved in within 60 seconds of recording inspection.~~ ~~For next steps of their study,~~ Aggag and Revett hoped to use the recorded GSR signal to provide subjects with a balance between basic and advanced play, ~~such that the player feels comfortable with the level of difficulty as measuring using GSR. This is accomplished~~ by ~~providing the results of the~~ feeding back GSR level ~~back to the game, whereby~~ through the game logic ~~uses the value of~~ to manage the affective state of the player ~~to adjust the difficulty level according to a player-centric requirement~~ [2].

Aggag and Revett could not determine if level of arousal had any effect on players' score, as a reflection of player performance, but ~~Though what they observed is that~~ that the affective state of the player can influence performance. In their study, ~~the~~ increased difficulty level ~~was usually along with~~ corresponded to increased score (performance). While they find it seemingly a counter-intuitive result, they suggest it should be due to increased engagement of the player which in turn may enhance their overall sensitivity to audio-visual stimuli and enhanced their reaction time. However, due to the limitations of their study they refused to draw a ~~clear line of~~ strong conclusion in this regard [2].

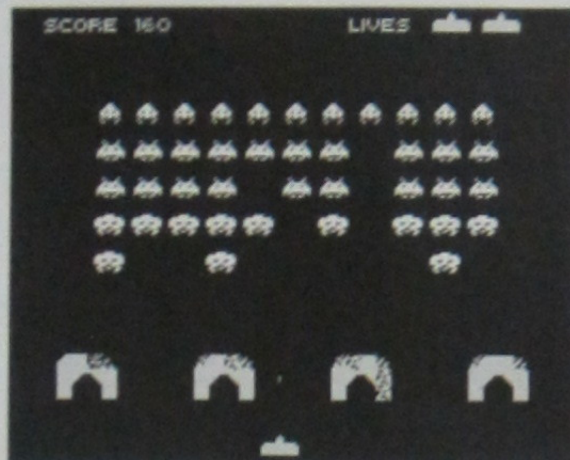
3.4.3 Emotion and Standard Game Input Devices

Sykes and Brown in their work on measuring emotion through a gamepad [110], both from a marketing perspective and also targeting current generation of video-games and available gaming technologies, suggesting to use current video game technologies to measure affect rather than introducing new ~~paraphernalia to the gaming experience~~ equipment. They ~~have~~ used modern game consoles' controller analogue buttons which indicate the pressure used when playing a game. The possibility of detecting a person's emotion through finger pressure [22], makes the analogue buttons on the gamepad a possible resource for collecting data.

In their study, Sykes and Brown ~~have~~ showed that data from gamepad pressure correlates with a player's level of arousal during game play. They ~~have~~ developed a ~~remake~~ variant of the classic arcade game 'Space Invaders' (Figure 3.10) for their study. Players needed to shoot alien spacecraft as they march down the screen toward them. It was possible for the players to move to their left or right to avoid offensive attacks. They could also return fire by pressing a button on the gamepad. They have ~~conducted~~ employed three levels of difficulty ~~were meant~~ to change the players' level of arousal ~~in different levels~~: easy, medium and hard. For the medium level the alien craft would march twice as fast, and the player would have the benefit of only two barriers. In the hard level the tempo of the alien craft was increased by a further factor of two, and the barriers were removed completely [110]. Players have played different levels in random order and the amount of pressure exerted by the player on each button press has been recorded by the game.

Although Sykes and Brown in their study do not investigate the effect of NPC and environmental factors separately but based on their results, they conclude it is possible to determine the level of a player's arousal by the pressure they use when controlling the gamepad.

Figure 3.10: Space Invaders - The original game used by Sykes and Brown



3.4.4 Difficulty Level and Facial Expression

Xiang et al. [124] in their study on dynamic difficulty adjustment by facial expression provided an emotion based dynamic game adjusting prototype named Emotetris, which utilizes facial expression captured using a camera ~~and then detect~~ to assign the emotional state of the player ~~between four different states of~~ to frustrated, relaxed, excited ~~and~~ or bored. Their prototype adjusts game difficulty level dynamically according to these emotional states. Their method of dynamic adjustment combines the in-game performance and facial expressions of players to dynamically adjust the game difficulty. In their study they have shown how better the dynamic difficulty adjustment can attract players' attention when they were bored and release the pressure when they were frustrated.

They have adjusted Tetris to evaluate the performance of player. In their prototype the speed of dropping items is the parameter to be adjusted as it directly affects players. ~~In their study they used 20 participants, from which 16 players thought the game could make in-time adjustment when they were frustrated or bored. Also 14 players among them considered the expression based game adjustment is better than in-game performance based adjustment in brining them better game experience.~~

Participants prefered the facial recognition adaptation to standard performance based adaptation.

Chapter 4

Affect Engine and Emotion Aware Gaming

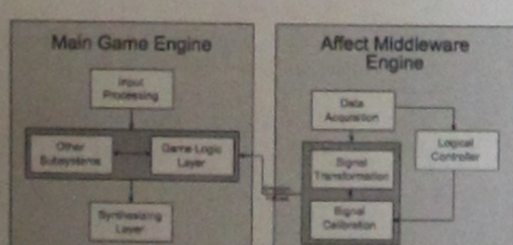
Our goal is to adapt gameplay based on a player's affective state. Although there have not been studies investigating our particular question of how player experience is impacted by applying different mechanisms for affect-driven adjustments in games, there has been related work that can inform our research. Affective gaming has been defined by Gilleade et al. as an activity where "the player's current emotional state is used to manipulate gameplay." [41]. Researchers have created and studied games that replace traditional game controls with affective game controls (e.g., the GSR-controlled dragons racing in 'Relax-to-win' [10] or the Electroencephalography-controlled balls rolling in 'BrainBall' [45]). Researchers have also investigating augmenting traditional game controls with affective game controls. For example, the Death Trigger side-scrolling shooter was played with a traditional gamepad and control scheme, but also adapted game elements (e.g., length of the flamethrower, size of the enemies, and the density of snowfall) using different physiological signals [68]. Finally, researchers have investigated adapting games using affective input. In work closest to ours, Dekker et al. [27] developed a game modification using the Source SDK and Half-Life 2, in which GSR and HR were used to control game shader graphics, screen shaking, and enemy spawn points (the number of locations in which enemies are put into the game world). Kuikanniemi et al. [54] studied how awareness of the manipulation affected player experience in a first-person shooter (FPS), where affective input modulated character walking and turning speed, aiming direction, recoil amount, and firing rate. Their work~~s~~ revealed that players preferred to be aware of the adaptation.

This chapter explores various aspects of the affect engine developed and used in our study. We would show how the generic design of this system can be incorporated with any game engine and how can it be expanded for any other type of sensor and biofeedback data not necessarily used in this work. The first section talks about the overall design and different modules of the affect engine; the ~~N~~ext sections describe different modules in detail~~s~~ giving examples of different settings used for our particular study. In final sections we ~~would talk about~~ present the game engine ~~we~~ used in this work, and how we incorporated the affect engine in ~~this particular case~~ our experiments. ~~We would talk about~~ Details of Study ~~design decisions we made for our study~~, and game Play design differences we ~~plan to investigate in our study~~ in Chapter 5.

4.1 Emotionally Adaptive Game System Design

We will now present a basic system schematic of an emotionally adapted game in Figure 4.1. A typical game engine depicted on the left-hand side of the diagram, continuously captures user input which is usually collected using gaming controllers such as gamepads or mouse and keyboard. This input data is then processed and transferred to the layer that handles the game's internal logical state, and the user input may influence the game state. After the logical state of the game is defined the system alters the actions of the synthetic agents in the game world. ~~For example, these~~ include the actions of computer-controlled non-player characters. The complexity of this AI layer varies greatly depending on the game. Based on the game state and the determined actions of the synthetic agents, the physics engine determines the kinetic movements of different objects within the world. Finally, the game world is synthesized for the player by rendering the graphical elements and producing and controlling the audio elements within the game [96]. The proposed emotional regulation can be implemented as a middleware system that runs parallel to the ~~actual~~ game engine. The input processing layer of the game engine can receive a data flow of captured and pre-processed sensor data. The real-time signal processing may consist of different forms of amplifying, filtering and feature selection on the psychophysiological signals. This data flow may directly influence the state of the game world, or it can be used by the signal transformation sub-module to extract emotion values. This module consists of the fuzzy rules for transformation of physiological signals into arousal and valence space and then the transformation from the arousal and valence space to emotion variables such as excitement, boredom and frustration. In addition, it contains a collection of design rules for narrative constructions and game object presentation within the game world. The outputs of the affect engine may then be applied to various different ~~levels of~~ the actions of the game engine: i) the narrative state of the game world may be re-directed, ii) the game mechanical elements relating to the challenge balance ~~of the game-play~~ might be altered or iii) the game might be adapted in its presentation layer such as visual or sound effects (non game mechanic elements). ~~A basic system schematic of an emotionally adapted game is presented in Figure 4.1~~

Figure 4.1: Emotion adaptive game system design



The purpose of the current initial study is to investigate physiological and other affect-related responses in relation to an experimentally induced change in game mechanics. Note that in this study the affective loop is closed, that is, real-time affective indicators are directly influencing the game mechanics. The research question for the current investigation evolved around the components of our affective adaptation decisions: What game mechanics (player, NPC or environmental changes) lead to what kind of emotional state. This was investigated by means of a controlled experiment, as explained in the next section. In other words the purpose of our study [5] is to evaluate the effects of design choices for affect-generated game adaptation on player experience. To compare different in-game adaptation approaches, we needed to implement three components:

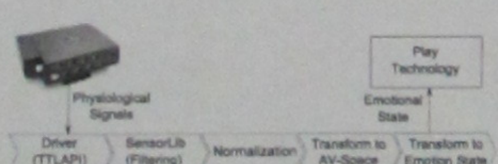
- **Affect sensing**: An affect-detecting middleware engine (AME) to translate between physiological indicators of affect and actionable game input.
- **Game Environment**: A game system with parameters suitable for adaptation via output from the sensed affect.
- **Experience Evaluator**: A series of validated instruments integrated with the game environment to determine user experience during the experiment.

Fig. 4.1 shows a schematic flow diagram for the first two components, where an affect detection system depicted on the right feeds data to a typical game engine depicted on the left-hand side of the diagram.

4.2 Affect Middleware Engine

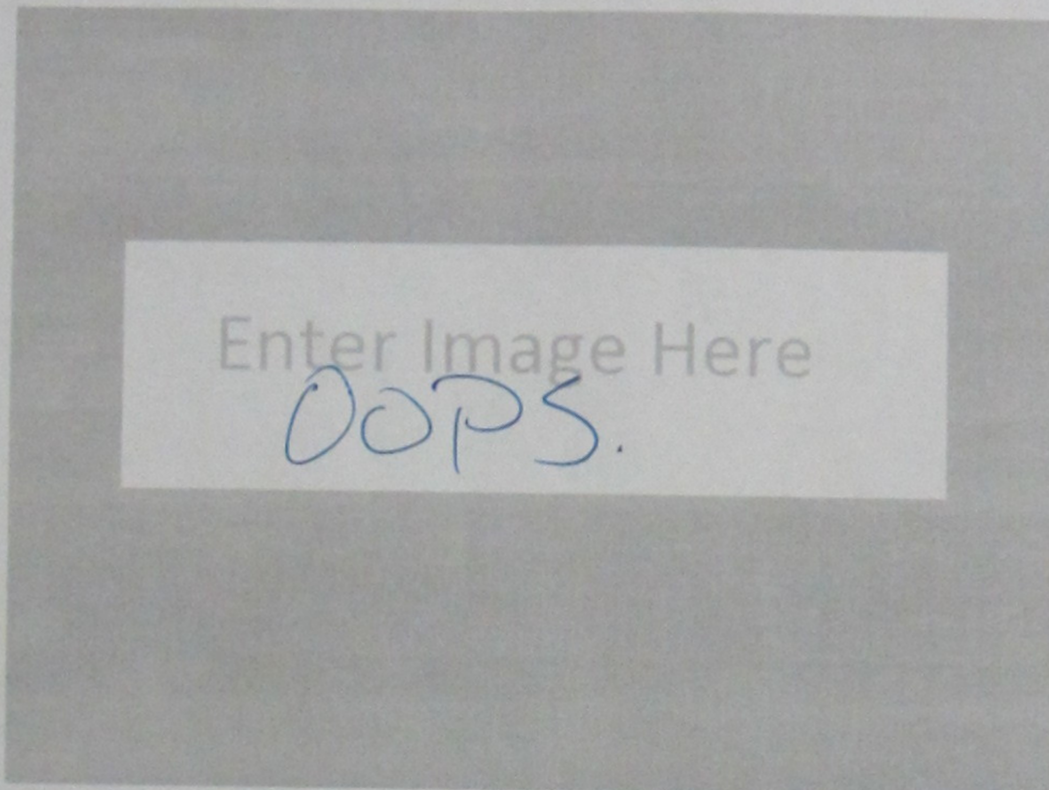
The Affect Middleware Engine or AME is the software unit developed to transform collected physiological data into usable emotional states in real-time. While it is generally agreed that emotions can be inferred from three sources: subjective experience (e.g. feeling joyous), expressive behavior (e.g. smiling), and physiological activation (e.g. arousal) [103], our affect engine provides a framework for transformation of physiological activations and some expressive behaviors. Fig. 4.2 is a schematic view of the signal transformation pipeline.

Figure 4.2: Affect engine modules



Applications such as games can easily integrate the affect engine where emotion recognition can offer adaptive control to maintain user interest and engagement. Once connected via sensors to the emotion recognition system, the affective state of the user can be captured continuously and in real-time, and used as a secondary input for an enhanced interaction experience. The AME runs in two states, calibration and

Figure 4.3: UML diagram of the Affect Middleware Engine

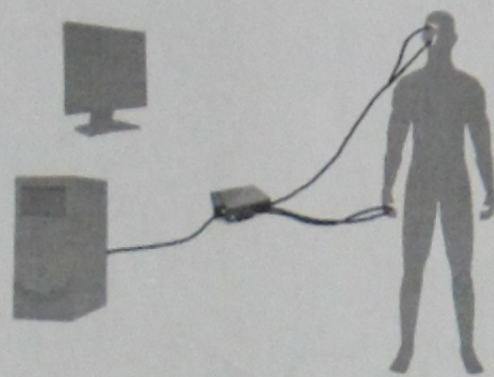


adaptation. When calibrating, the system waits for user input, attempting to discern sensible boundaries for physiological normalization according to the process described in [63]. After a set period of time, the system enters adaptation mode, where data is fed into the signal transformation stage, and from there into the game engine. For longer play sessions, the system will periodically re-enter the calibration state to compensate for drift in the physiological signals. In this manner the system compensates for the difficulty of globally bounding physiological signals by approximating a series of local temporal bounds. ← A sentence goes here.

While the affect engine is capable of interpreting multiple physiological signals and performing a full fuzzy logic-based emotion inference according to the approach described in [63], we constrained ourselves to a simpler linear mapping for this experiment. Specifically, GSR signals were measured using a Thought Technology ProComp Infinity, connected to PC through a USB cable. Through the SensorLib API [68], raw physiological inputs were received and basic filtering operations were performed. After the calibration period described above, the AME system began reporting normalized GSR signals to the game engine as a measure of player excitement or arousal [2, 114]. Fig. 4.4 shows a schematic view of a sample connected system components.

~~AME consists of four~~ major ~~components~~: ~~Sensor Module~~, Fuzzification Module and Emotion Monitor

Figure 4.4: Sample connected system with GSR and EMG sensors attached



~~At the following a brief description on these components is provided.~~

4.2.1 Sensor Module

Heart rate (HR), blood pressure, respiration, electrodermal activity (EDA) and galvanic skin response (GSR), as well as facial EMG (Electromyography) are of physiological variables correlated with various emotions ~~most~~. ~~Regarding~~ for cardiovascular ~~(heart)~~ activity, tonic (long-term, as opposed to phasic) heart rate (HR) is known to increase with sympathetic nervous system activity, such as emotional arousal and cognitive effort and stress. On the other hand, increases in attention (mediated in the parasympathetic nervous system) lead to a decreased heart rate [82]. The authors of [127] found HR features to correlate with self-reported fun in games. Skin conductance ~~level~~ is known to increase with information processing and the frequency of non-specific skin responses increases with arousal [82]. Facial EMG is frequently used as a metric for valence. The sensor module consists of a Thought Technology ProComp Infinity encoder [60] Figure 4.5, connected to PC with a USB cable, SensorLib as the basic application programming interface (API) receives raw physiological inputs from the encoder driver and provides functionalities to apply different filters such as low-pass, high-pass, smoothing and shifting to the signal.

4.2.2 Fuzzification Module

Interpreting physiological measures into emotion state can be difficult, due to noisy and inaccurate signals, however recent on-going studies in this area by Mandryk and Atkins [63] presented a method to continuously identifying emotional states of the user while playing a computer game. Using the dimensional emotion model and ~~the~~ fuzzy logic, based on a set of physiological measures, ~~in its first phase,~~ ~~their~~ the fuzzy model transforms GSR, HR, facial EMG (for frowning and smiling) into arousal and valence variables. In the second phase another fuzzy logic model is used to transform arousal and valence variables into five basic emotion states

Figure 4.5: Thought Technology ProComp Infinity Encoder

remove this picture.

add ref to Regan's original work on this

Fig ?

including: boredom, challenge, excitement, frustration and fun 1.1. Their study successfully revealed self-reported emotion states for fun, boredom and excitement are following the trends generated by their fuzzy transformation. ~~The advantage of continuously and quantitatively assessing user's emotional state during an entire play by their fuzzy logic model is what makes their model perfect to be in incorporated with real-time play technologies. Therefore extracting user's emotional state as a new class of unconscious inputs to the play technology.~~ Because their system responded in near real time, it is a promising candidate for use ~~as an~~ as the basis for an adaptive engine

already said this

~~This module functions through two separate phases. Then filtered signals are fuzzified using a set of fuzzy rules in the first phase of transformation. Then generated arousal and valence values are transformed into emotion values using another set of fuzzy rules in the second pass [63].~~ A sample set for fuzzy rules used in the first and the second phase can be found in Appendix A and B.

→ move this sentence

4.2.3 Emotion Monitor

Emotion monitor is a debugging and administrative module. (A) ~~the module which is usually used for debugging purposes.~~ Using this module emotion values along with basic physiological signals and transformed arousal and valence variables can monitored in real-time. This module also shows AME state while switching between calibration and adaptation states making it easier for designers to see how changes in AME states might affect various game-play situations.

add a screenshot.

4.3 Game Environment

To evaluate the impact of feedback on player experience, it was also necessary to implement a game environment that could be linked to the output of the AME. We chose to implement a straightforward zombie

Table 4.1: Adjustment Strategy

	Player	NPC	Environment
Excited	Increase player speed Increase grenade rate	Decrease zombie speed Decrease zombie crowd	Decrease fog density Increase med-pack rate
Not excited	Decrease player speed Decrease grenade rate	Increase zombie speed Increase zombie crowd	Increase fog density Decrease med-pack rate
Adaptionequation	$P_{speed} = 0.65 + 1.35 * Arousal$ $G_{delay} = 40 - 20 * Arousal$	$Z_{speed} = \frac{1}{0.30 + Arousal}$ $Z_{crowd} = 3.75 - 2.5 * Arousal$	$F_{start} = 70 + 380 * Arousal$ $F_{end} = 500 + 1000 * Arousal$ $M_{delay} = 100 - 60 * Arousal$

survival game based on the Half Life 2 engine in the genre of first-person shooters (FPS). A custom map (shown in Fig. 4.8) was implemented. Using the Source Software Development Kit (Source SDK). The map was composed of a small outdoor area and three buildings. Zombies (Fig. 4.9) spawned in waves from one of 10 points, and would undertake standard Half Life 2 zombie AI behavior, looking for the player and attacking with either thrown objects when distant (weakly damaging the player) or a melee attack when close (heavily damaging the player). A good default strategy for the player was to keep the zombies at a distance, eliminating them with their moderately powerful machine gun, and not allowing them to close to melee range. The player is tasked with surviving as many waves of zombies as possible, and accrues a score based on the number of zombies killed. The player is equipped with a machine gun with unlimited ammunition and a limited number of grenades. Health packs, which restore players from received damage, and additional grenades are available at defined locations. If a player presses a button at that location, a health pack will dispense and the button will be disabled until a cool down timer has expired (Fig. 4.10).

Farhan, can you double check if this is true? I'm still not sure if there were 2 bands or 3 bands?

Aspects of the game can be adjusted in real time based on the output of the AME system. In the implementation used in our study, the system could be in one of three states based on the normalized GSR value supplied from the AME. If players fell below a threshold of excitement as indicated by normalized GSR, then the system inferred that they were bored and increased the difficulty of the game. If players were above a threshold of normalized GSR, the system inferred that they were over-stimulated and made the game easier. If neither of these states were true, then the system assumed that they were playing normally and no adjustment occurred. The equations by which the game parameters were adjusted are also shown in Table 4.1. While no action was taken unless normalized GSR was in the excited or bored band, once in that band, the game parameters adjusted continuously with the value of the GSR. Constants in the equations and the threshold values for excited and bored were adjusted manually, based on design experience and play testing prior to the experiment.

4.4 Game Adaptation

The game can be adapted in numerous ways based on the output of the AME. Our research interest is in how different in-game adaptation mechanisms affect ~~resulting~~ player experience. To explore in-game adaptation, we adapt either the player's abilities, the zombies' abilities or the environment. Table I shows the types of adjustments that can occur, which we describe next.

4.4.1 Player

Player modifications are any modifications that directly affected player state, even if the environment mediated those modifications. Specifically, to adapt the player's abilities, we vary the player's speed (at which they can move around the environment) and the rate of grenade respawn in the player's weapon. Higher player speeds enabled the player to more easily escape the zombie melee attacks. The respawn rate of grenades impacted the player's ability to inflict damage by essentially giving them more powerful weapons.

4.4.2 NPC

To adapt the non-player character zombies (NPCs), we can vary the speed at which the zombies move and the number of zombies (the size of the attacking crowd). The number of zombies spawned per unit time obviously increases the difficulty of the game. Increasing the speed of the zombie with respect to the player made it more difficult for the player to evade the zombie melee attacks. This manipulation is interesting as it is similar to the player speed adjustment from the perspective of game balance (i.e., the relative speed of the player and the enemy varies using both approaches), but applying the adaptation to the player or the NPC could result in ~~very~~ different game experiences.

4.4.3 Environment

To adapt the environment, we vary the density of ambient fog ~~displayed~~, which was proportionate to the distance that the player could see. By constraining the players' viewing distance with increasing fog, zombies could approach closer, leaving the player with less time to target them before they closed to within melee range. We also varied the rate at which health packs respawned in the environment. Giving players the ability to find more health packs affected their ability to take damage; however, this required player interaction with the environment (i.e., picking up the health pack) as opposed to better equipping the player directly (e.g., ~~giving the player more powerful weapons or shields~~).

having player health regenerate over time.

4.5 Evaluation System

Evaluation of the system was carried out in three ways. First, all physiological signals were logged to ensure that the system was working correctly and as a basis for comparison. Second, game events were logged to track how the player reacted to adaptive game mechanics. Finally, players were given experience surveys after the completion of each level. ~~In this analysis, the player experience surveys are the primary evaluation method because they directly link the resulting experience to the in-game adaptation manipulation.~~

Figure 4.6: DotFuzzy Application

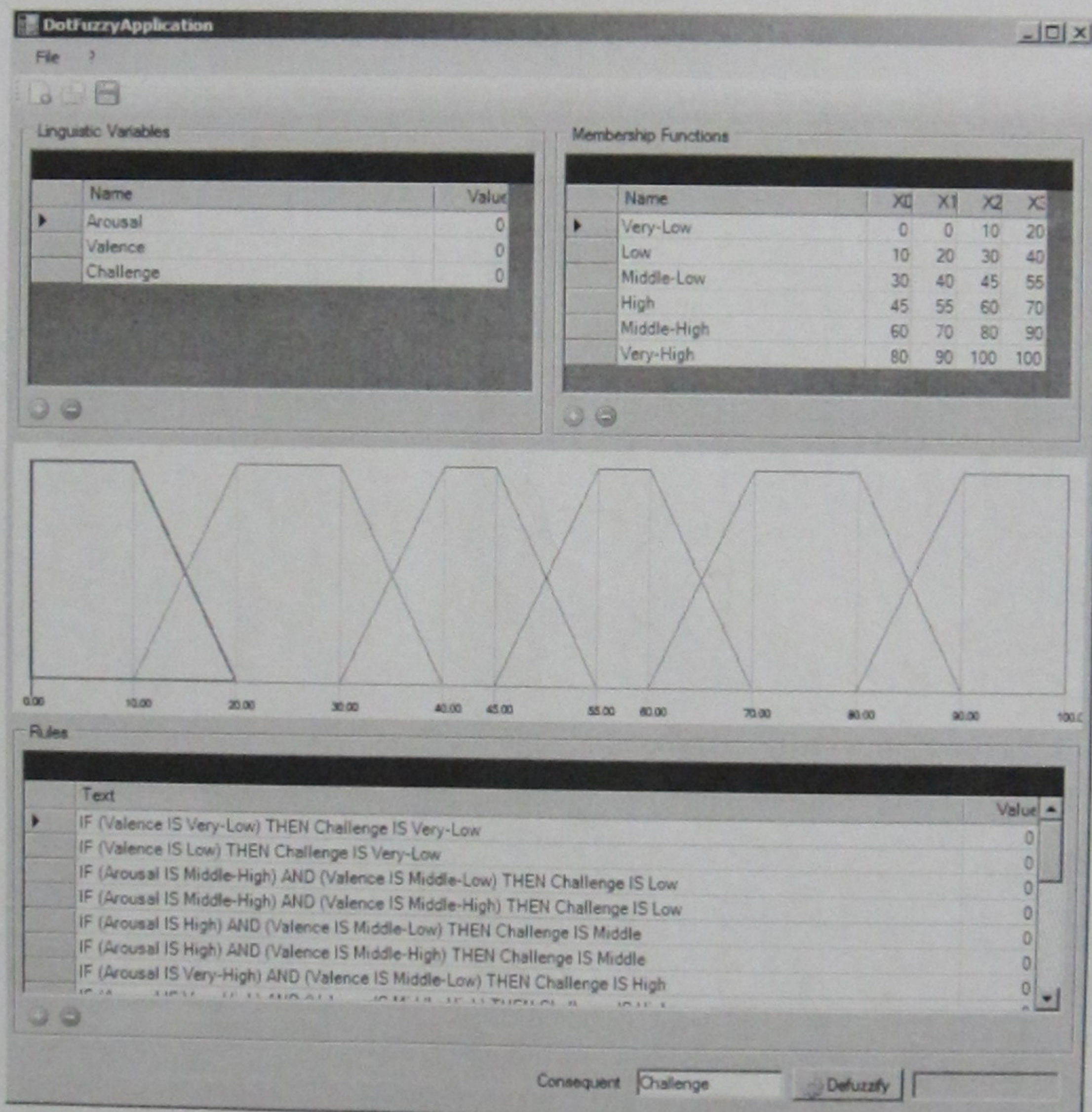


Figure 4.7: Emotion Monitor

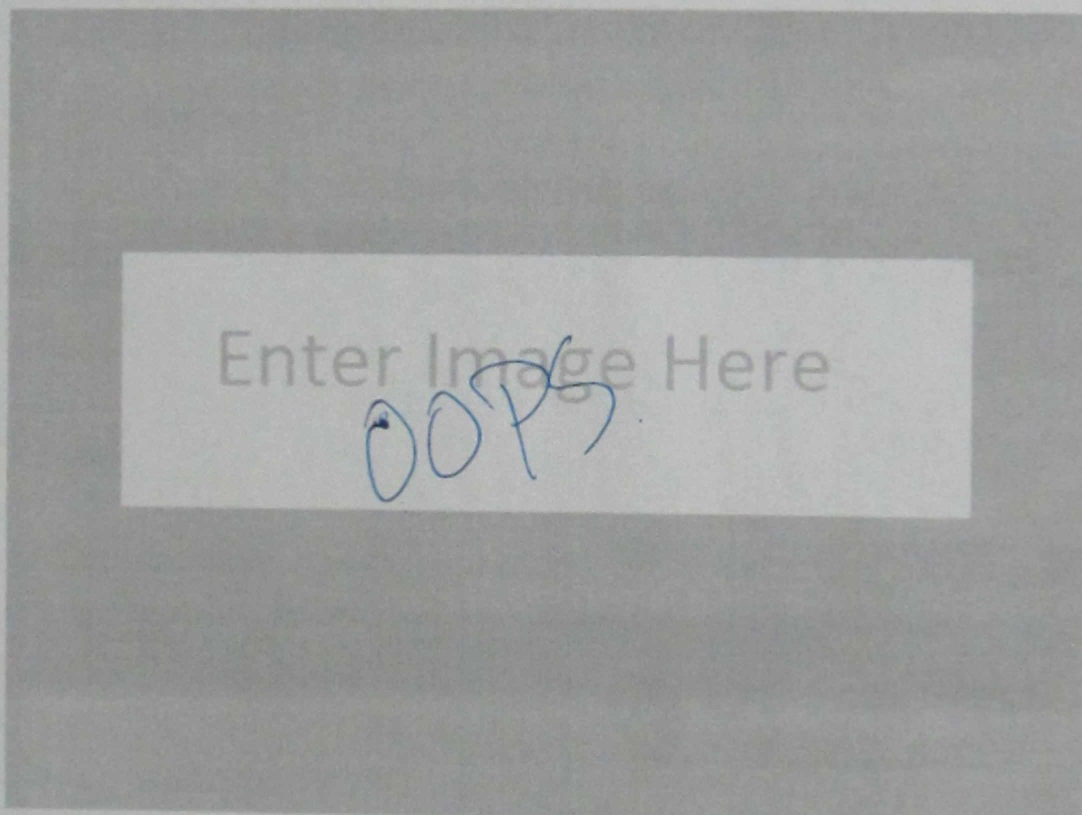


Figure 4.8: Map level created using the Source SDK and Half-Life 2

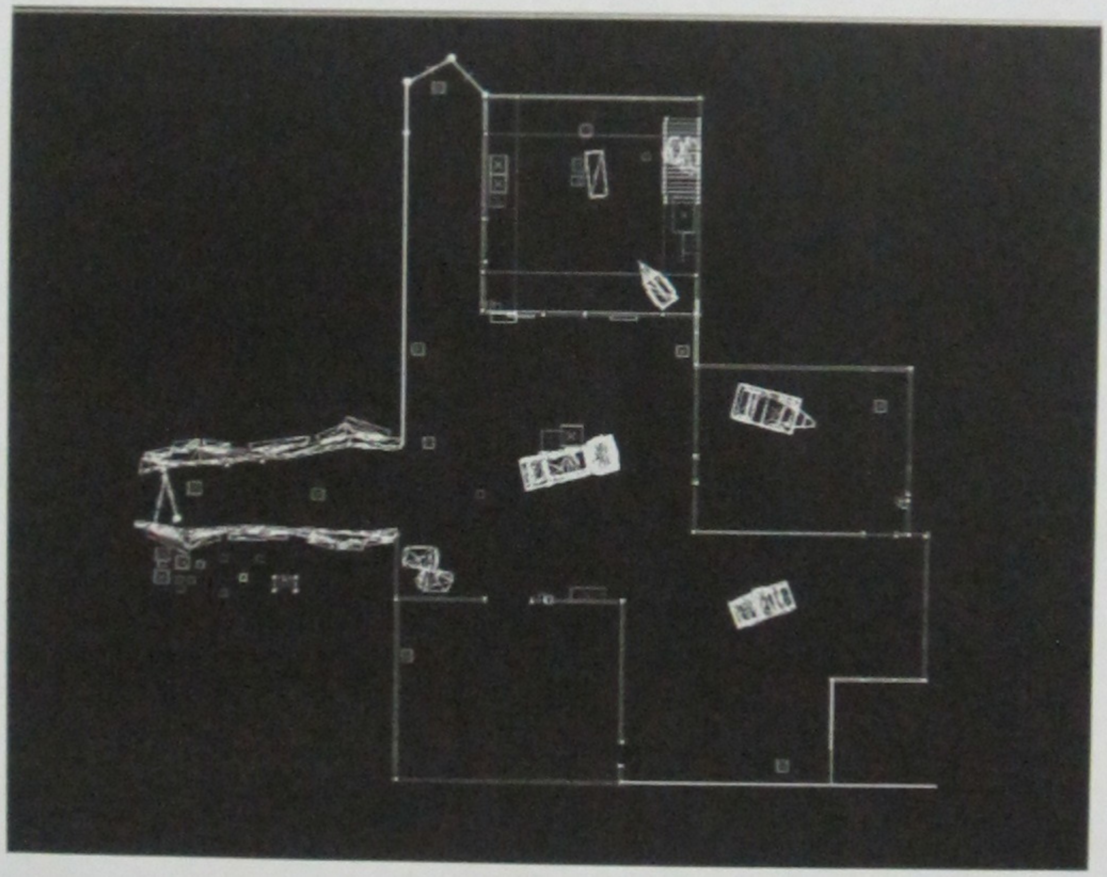


Figure 4.9: Zombie model

Figure 4.10: Health pack dispense button

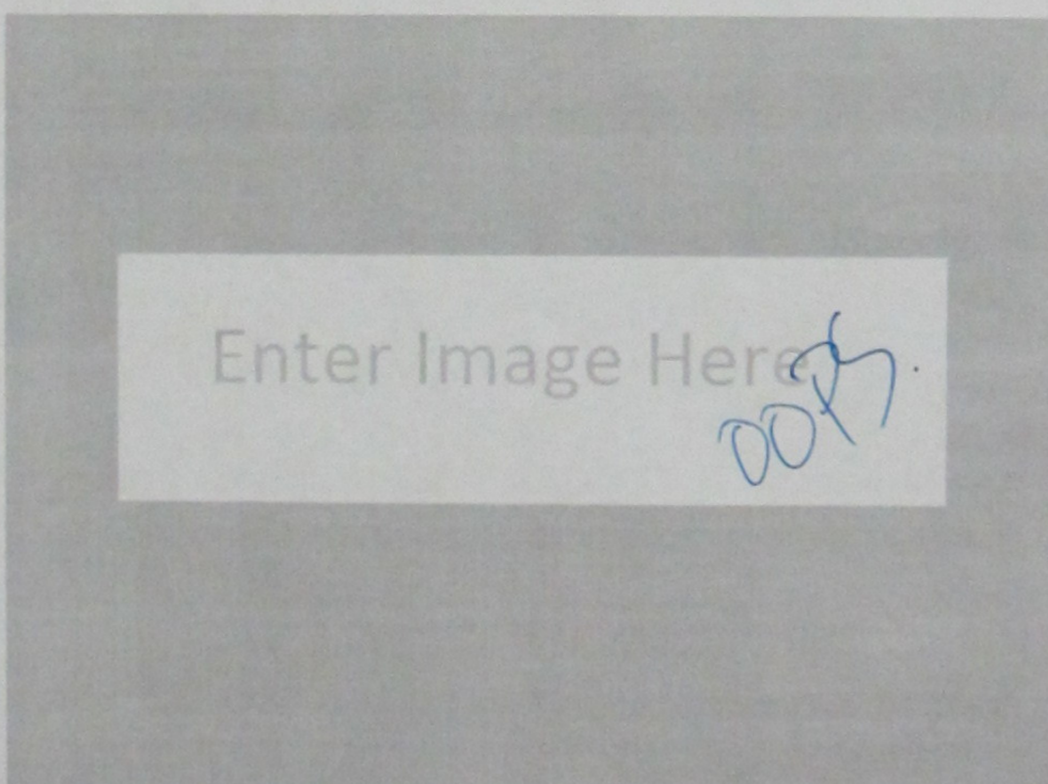


Figure 4.11: Hammer level editor

```
time, raw, transformed
811913, -0.784929931163788, 78.1241008746691
812026, -0.784929931163788, 76.2492447347221
812135, -0.784722805023193, 75.6241728046956
812243, -0.784515619277954, 74.3742087697088
812349, -0.784515619277954, 74.3742087697088
812459, -0.784515619277954, 74.3742087697088
812571, -0.784515619277954, 74.9992806997353
812680, -0.784515619277954, 75.6243526297618
812790, -0.784515619277954, 77.499388594775
812880, -0.784515619277954, 74.3742087697088
```

Figure 4.12: In-game GSR log reporting about raw and transformed GSR values

```
time_millisecond, arousal, player_speed, zombie_speed, fog_start_dist, fog_end_dist, ↩
    current_round, zombie_threshold, zombie_increase_power, max_zombie_alive, ↩
    number_of_alive_zombies, number_of_killed_zombies, grenade_regen_delay, medic_regen_delay, ↩
    calibrating, adaptation_condition
870368, 0,         1,         1, 300, 1000, 2, 8, 1.3, 7, 7, 6, 30,        30, 0, 2
870369, 0.9242272, 1.897707, 1, 300, 1000, 2, 8, 1.3, 7, 7, 6, 30,        30, 0, 2
870369, 0.9242272, 1.897707, 1, 300, 1000, 2, 8, 1.3, 7, 7, 6, 30,        30, 0, 2
871373, 0.9304435, 1.906099, 1, 300, 1000, 2, 8, 1.3, 7, 7, 6, 21.51546, 30, 0, 2
871373, 0.9304435, 1.906099, 1, 300, 1000, 2, 8, 1.3, 7, 7, 6, 21.51546, 30, 0, 2
872379, 0.9327956, 1.909274, 1, 300, 1000, 2, 8, 1.3, 7, 7, 6, 21.39113, 30, 0, 2
872379, 0.9327956, 1.909274, 1, 300, 1000, 2, 8, 1.3, 7, 6, 7, 21.39113, 30, 0, 2
873382, 0.9732862, 1.963936, 1, 300, 1000, 2, 8, 1.3, 7, 6, 7, 21.34409, 30, 0, 2
873382, 0.9732862, 1.963936, 1, 300, 1000, 2, 8, 1.3, 7, 5, 8, 21.34409, 30, 0, 2
874389, 1,         2,         1, 300, 1000, 2, 8, 1.3, 7, 5, 8, 20.53428, 30, 0, 2
```

Figure 4.13: In-game metrics log reporting about different adaptation details in each condition

Chapter 6

Discussion

The results of our design probe show that adapting the game resulted in higher arousal, but that not all methods were equally effective. In this section, we discuss how game developers and designers can apply our results, consider the limitations of our work, and present the opportunities for future research in this area.

6.1 Applying the results

Our work suggests that adapting games based on a user's affective state can increase player arousal (excitement) and can potentially automate balancing the difficulty of the game with the affective state of the player. By increasing the challenge of the game when players are not aroused, we can personalize the game experience, drawing the player in. Conversely, by decreasing the challenge when players feel overwhelmed (too aroused), we can keep the game difficulty manageable and maintain player engagement.

Our work aims to investigate how to adapt games based on a player's affective state with the goal of keeping players optimally engaged with the system. Previous work has examined dynamic difficulty adjustment (DDA) for the purposes of balancing multiplayer game play (e.g., [8]). Previous research has shown that when multiplayer games are unbalanced (i.e., one player is much stronger than another), players do not have as much fun [116], and thus there is a need to provide assistance to one player (or hindrance to another) to better balance play. Different approaches have been used to adjust difficulty for player balancing (see [8] and [116]); however, research has not systematically examined whether adjusting the abilities of the player, enemy, or environment affects game enjoyment or player perception. Our work suggests that these different approaches change player experience and thus there is an opportunity to extend our work into the domain of DDA for balancing multiplayer games.

6.2 Why adapting the NPC enemy reduced enjoyment

Our results suggest that helping the player or changing the environment to better support the player are better adaptation approaches than adapting the strength of the NPC enemies. Although a common approach in many games, reducing the difficulty by making the enemies easier to beat resulted in fewer zombie kills (as there were fewer zombies available to kill). This reduction in challenge may have resulted in lower ratings of perceived competence, which in turn reduced players' enjoyment in the NPC condition.

Self-determination theory [92] suggests that we strive to master challenges, and that this mastery over challenges creates a perception of competence which is one of our basic needs that must be satisfied for well-being (along with the need for autonomy and need for relatedness). In the context of games, mastering challenges leads to competence, which ultimately leads to game enjoyment [94]. By adapting the NPC enemies, we give the player less of an opportunity to conquer a challenge, and thus less opportunity to experience competence (and as a result enjoyment). This approach thwarts players from satisfying their needs. Conversely, giving the player enhanced abilities or adapting the environment to support the player in their quest does not seem to negatively affect perceived competence. Adapting the spawn rate or value of helpful items (such as the grenade in our Player condition or the health pack in our Environment condition) does not seem to reduce experienced competence, but allows players to feel like they are achieving in the context of the game.

Recent research in violent imagery in games and the resulting aggression that players experience has suggested that impeding competence in video games fosters aggressive thoughts, regardless of the presence or absence of violent imagery [79]. The authors show how manipulating competence (through manipulating frustrating and complex control schemes, levels of player experience, or game challenges) thwarts need satisfaction amongst players, and increases their access to aggressive thoughts. Although the domain of evaluation (aggressive thoughts) is distinct from our goals, the hypothesis that impeding competence in games thwarts satisfaction of this basic need helps to explain why giving players less challenge to master (as in the NPC condition) does not work as well as giving players the tools and support needed to master greater challenges, as in the Player and Environment conditions.

6.3 Limitations and future work

This design probe represents preliminary work into the domain of affectively-adapting games. There are several limitations in our work that present opportunities for future research. First, the number of participants that we included in our design probe is low ($n = 16$). Conducting a large-scale experiment would increase the power of our experiment and could reveal differences between the approaches or strengthen existing differences (e.g., the planned contrasts). Second, we investigated the adaptation in a single game genre (FPS game) with specific approaches (e.g., manipulating speed and weapons). Investigating whether our results hold in a different genre or with different adaptation choices would help to generalize our findings. Third, we only adapted based on a player's galvanic skin response. ~~Using a more sophisticated model that included~~
Employing the full affective engine to assess arousal & valence.
~~signals to access player valence (e.g., [63])~~ would qualify the player's arousal as either positive or negative in nature. Finally, as noted previously in the discussion, we could consider applying our approach of adaptation based on performance variables, rather than player affect, to examine DDA for the purpose of balancing multiplayer games.

Chapter 7

Conclusion

Drawing a player into an optimally-engaging play experience is a goal of many game designers and developers. We investigated various approaches to adjusting games based on a player's affective state and found that affectively-adapting games were more arousing than the non-adapted version. We also suggest that adapting the NPC enemies is not as effective a strategy as adapting the player or environment, because it reduces the opportunity for the player to experience challenge, rather than giving players the necessary tools or assistance to master a greater challenge.

The results of ~~our design probe~~ research can be used to inform future research in affective games or adaptive games, and can help game designers understand how their choices affect the experience of the player.