Ultra Violet: Using Biofeedback to Augment Traditional Controls and Player Enjoyment

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Abstract
Designing games in novel and fun ways is always a challenging thing to do. In this study, we used physiological input to augment traditional controls and enhance player experience. To find out if players would enjoy using biofeedback, we conducted a study comparing 2D platform game play with various biofeedback inputs to game play without biofeedback. The results show that participants preferred playing the game with physiological controls. This has a few implications not just on designing games with physiological input in mind, but on game design in general: (1) Physiological input should be designed in an intuitive manner, but it's okay to combine the physiological input with a traditional input if it gives the player more control over the mechanic; (2) Tracking the player's emotional state during game play can provide immediate responses, but should not be overdone as to make the difficulty of the game too easy.

Author Keywords
Games, game design, biofeedback, affective gaming, eye tracking, facial expressions, HCI

ACM Classification Keywords
H.5.2 [Information Systems]: User Interfaces; K.8.0 [General]: Games; J.3 [Life and Medical Sciences]: .

1. Introduction

Video games today have been becoming increasingly more popular than ever before. In order to keep up with demand and draw in even more consumers many companies such as Nintendo, Microsoft, and Sony have been trying to develop new ways for players to control their games. Many of these examples include the many variations of the Nintendo DS, Nintendo's Wii MotionPlus and Wii Fit controllers, the Xbox Kinect, and PlayStation VR. We've even come so far as to have not just virtual reality (VR) but full-body-tracking VR courtesy of the HTC Vive.

In addition to these controls, there are games out there like *Nevermind* that use indirect physiological inputs such as heart rate or galvanic skin response as control inputs for various mechanics of the game [2]. The next step to create more immersive systems is to incorporate more physiological inputs that could be directly controlled by the player [3]. These mechanics should augment traditional controls rather than replace them as traditional controls are still good for doing things like player movement and menu selection. For example, with the HTC Vive or Oculus Rift while you can move your head to look at things and move your body to move the character in the game, a bulk of movement is still done with the controllers themselves rather than using the sensors. Unless the game is designed to use non-traditional movement like in Chicken Scream (Perfect Tap Games, 2017) where the player uses their voice to move, movement should be done with traditional controls.

In recent years as laptops become more advanced and subsequently cheaper, more and more people have access to computers that have web cams. In addition to web cams and facial expression tracking, eye and head tracking are becoming increasingly popular as well. Eye tracking can come in the form of a USB near-infrared (NIR)[1] camera, a laptop with a built-in NIR camera, or a monitor with a built-in NIR camera. The standalone USB camera is relatively cheap selling for $149.99 as opposed to the HTC Vive or Oculus Rift that retail for close to $1000, making eye tracking more readily accessible. Eye and facial expression tracking require very little setup to get working, so with the increasing popularity of eye trackers we're not far off from seeing the majority of homes with both systems.

To look at the viability of the possible outcome above, we need to look at following two questions:

1. What do users think about using biofeedback to augment traditional controls in a way that they get to choose when to use the biofeedback input?

2. How do users respond when power ups respond to the user in real time rather than to specific game events?

In order to examine our research questions, we took advantage of the above facts to design a 2D side-scrolling platform game similar to that of the Super Mario franchise (Nintendo, 1985) and Shovel Knight (Yacht Club Games, 2014) that uses traditional controls as the primary input. We did this by using facial expression tracking and gaze location to augment traditional controls. We then used this game to conduct a two phase study where each participant played with a different combination of controls for each phase.

2. Related Work

There many different genres of gaming than ever before. There are even a good amount of games that are designed to be difficult as a throwback to the old generation of

[1] https://www.tobii.com/tech/technology/what-is-eye-tracking/

games when there were no guide lines or examples of fair level design and difficulty. Fortunately many games do adhere to the general thought of fair level design and game play.

Using Frustration in the Design of Adaptive Videogames

Game developers can take advantage of this fact by utilizing the player's current physiological state to influence the game [4]. Gilleade et al. proposed to call this kind of system affective gaming which is a highly used term by the academic community [1]. Affective gaming can provide a much more enriched gaming experience when done correctly. In some cases it can be used to detect player frustration levels which could be useful in beta testing stages of a game to see what parts of the game frustrate the player more than it probably should.

Biofeedback Game Design: Using Direct and Indirect Physiological Control to Enhance Game Interaction

Previously Nacke et al. studied the effects of direct physiological inputs versus indirect physiological inputs on player enjoyment. It was found that most participants enjoyed using direction biofeedback more than indirect. It was noted by a few of their participants that some mechanics, like their Medusa's Gaze, caused some unwanted side effects as the player could not control when to use the powerup once acquired.

2.1 2D Side-scrolling Platform Game

Nintendo has dominated the 2D platformer market for the last four decades ever since the inception of Super Mario Bros. back in 1985. Ever since many developers have put a twist on their format with success leading to the creation of other popular franchises like Mega Man (Capcom, 1987), Sonic the Hedgehog (Sega. 1991), and Donkey Kong (Donkey Kong Country by Rare, 1994). The basics of a 2D side-scrolling platform game usually include the following:

1. A character the player controls to jump from platform to platform.

2. Avoiding or eliminating any obstacles or enemies in the players' path via a selection of weapons or attacks.

3. Some sort of health system.

4. Reaching the end of the level by touching an object, collecting an item, or beating a boss.

While each game has their own quirks they all have one thing in common: they all use traditional controls. While affective game design can be useful in a 3D or therapeutic setting, 2D game can still benefit from it. Many 2D games get stuck just being a generic 2D side-scrolling platform game. Game developers can utilize affective game design to help make their games stand out, and it can provide a whole new scope of opportunities that have not been explored as of yet.

3. The Game: Ultra Violet

As stated before we developed a single-player 2D side-scrolling platform game under the name Ultra Violet. The game was developed using PlayStation 4 controller mappings. This game was designed to take advantage of the availability of web cams and how relatively easy it is to acquire an eye tracker.

3.1 Building the Game

Just like other 2D side-scrolling games the player is presented with obstacles and multiple types of enemies. The player is also given a couple puzzles to solve. The

player also has powerups they can receive to upgrade their weapons or their movement. Checkpoints are also present throughout each level in where the player will respawn in case they were to die, where they gain back all their health but lose their powerups. This should encourage the player to be careful with their health and to be more engaged with the game.

3.2 Game Mechanics

To test our questions we developed 4 game mechanics that could be controlled by biofeedback or traditional controls.

Facial Expressions - Buster Style: Weapon Upgrade
In this game the player has two weapons they can switch between: an upgradeable blaster projectile weapon and an upgradeable sword. Pressing the fire button will shoot a projectile or swing their sword, but activating thei powerup will provide an extra ablity: by holding up and then pressing their fire button. The blaster will shoot two sine wave bullets rather than a single, smaller projectile and the sword will swing upwards and shoot a flaming sword beam (See Figure 1).

Figure 1: The player can shoot a flaming sword beam when the joy meter is activated.

Facial Expressions - Tailwind: Movement Upgrade
In platform games jumping is the most important mechanic along with moving around. When the player activates their movement powerup they can jump about two tiles higher (See Figure 2) and move about 25 percent faster. This will help increase the pace of the game.

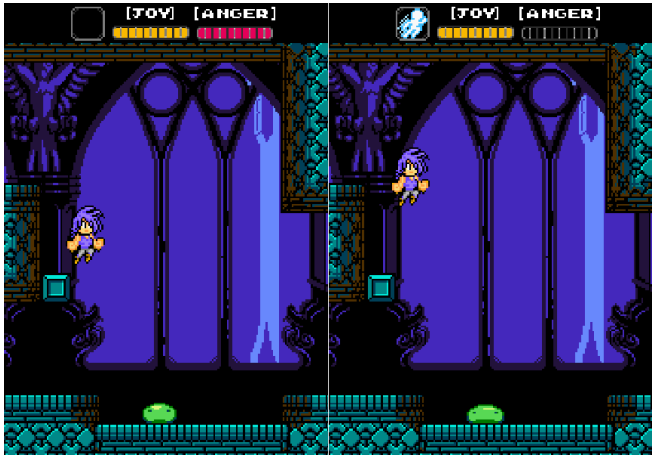

Figure 2: Player movement speed and jump height get increased when the anger meter is activated.

Eye Tracking - Telekinesis
The player has a Telekinesis ability where they can move certain blocks within a radius around the character. Telekinesis can move the blocks to activate special switches (See Figure 3), to reach a platform they normally could not reach, or to safely get over deadly spikes.

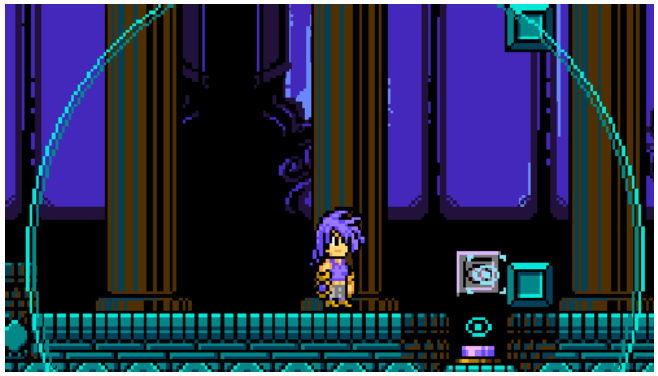

Figure 3: The player uses their Telekinesis ability to move the block onto the purple switch.

Eye Tracking - Soar Eyes
In addition to Telekinesis moving blocks, the player can utilize a similar mechanic to activate or deactivate certain objects. One example is to disable an enemy that chases the player (See Figure 4). In the control condition, the character just has to face the enemy to disable it.

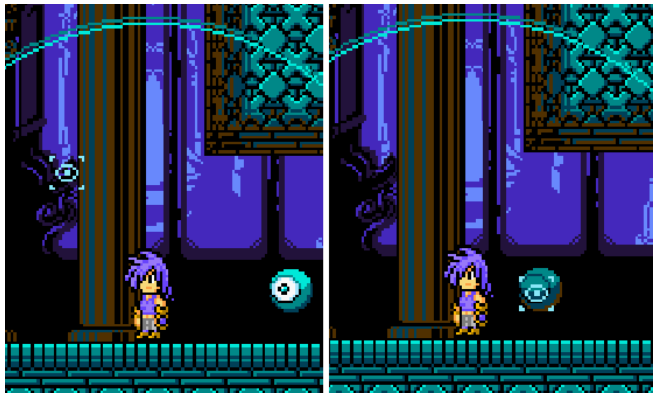

Figure 4: The player uses Soar Eyes to disable the chasing Eye enemy.

4. User Study

We carried out our study on 3 participants, 2 e, all with varying levels of experience in 2D side-scrolling platform games. Each participant took part in both phases: Phase 1 being the control condition with no biofeedback inputs, and Phase 2 with facial expression tracking and eye tracking. During each phase the participant would play through one of two levels until they reach the end of the level. Each phase had its own corresponding level to keep results consistent. After each phase each participant took a questionnaire to rate how fun each mechanic was to use. They were also asked to provide general feedback on each mechanic and the game overall.

5. Results

Each participant was asked to rate their enjoyment of each mechanic on a scale of 1 (not enjoyable) to 5 (very enjoyable). A Friedman test was carried out for 2-related samples showing the differences in players fun ratings depending on game condition ($X^2 = 7.0$, p $= .0081$). We found that all participants had more fun using it. Participants commented that their favorite mechanic was the eye tracking: *It was new! I don't think I ever had an experience of playing game that incorporated eye tracking (Participant 1, female).*

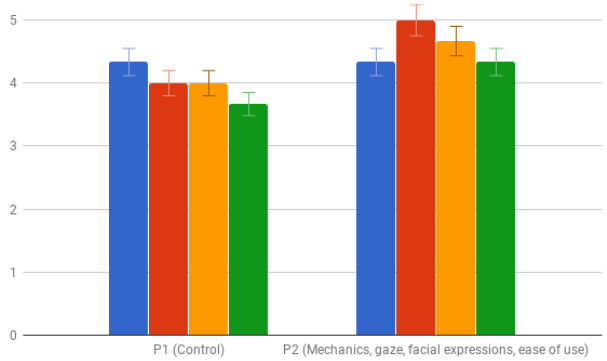

Figure 5: Analysis on fun ratings of each mechanic.

Each participant was also asked to rate their overall enjoyment of each phase. All participants preferred game play in Phase 2. Most of the participants liked the powerups: *The powerups are the most fun mechanic (Participant 3, male).*

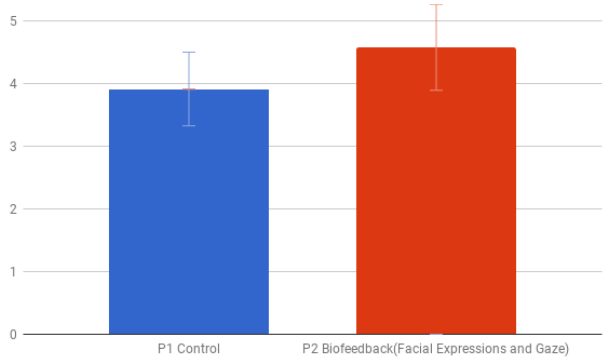

Figure 6: Insert a caption below each figure.

Limitations

As we built our system we experienced different challenges game developers face every day when trying to develop a game. One participant commented saying that we: *could possibly have more obstacles and monsters to kill (Participant 3, male).* Most participants also suggested that the powerups could have been clearer:

Clearer explanation of how we could obtain the powerups would be great! (Participant 1, female).

I'd like more guidance. (Participant 2, female).

Finding a good balance between letting the player figuring stuff out on their own and spoon-feeding them information is always challenging. For future cases, making a powerup system that is easy to pick up on would further increase player enjoyment. In addition to making the powerup system clearer, the facial expression tracking was more sensitive than we had hoped making it really easy for participants to gain powerups. It would be interesting to see a more accurate assessment of player physiological state during game play. This could be done by adding sensors that could track the player's heart rate or electrodermal activity in addition to facial expression tracking.

6. Conclusion

Building a 2D side-scrolling platform game doesn't have to be mundane. Adding such relatively simple mechanics to a relatively simple game increased player enjoyment significantly. Participants liked the fact that they could still use traditional controls while using biofeedback at the same time. Augmenting traditional controls with other inputs such as biofeedback is the way to go as traditional controls while traditional still provide a lot of flexibility to let the player play how they want. With eye tracking on

the rise and the equipment being relatively cheap, it wouldn't be surprising to see some AAA games use eye tracking in the future.

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