Play With Your Emotions: Exploring Possibilities of Emotions as Game Input in NERO

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ABSTRACT

This work presents NERO, a game concept using the player's active emotional input to map the emotional state of the player to representative in-game characters. Emotional input in games has been mainly used as a passive measure to adjust for game difficulty or other variables. However the player has not been given the possibility to explore and play with one's emotions as an active feature. Given the high subjectivity of felt emotions we wanted to focus on the player's experience of emotional input rather than the objective accuracy of the input sensor. We therefore implemented a proof-of-concept game using heart-rate as a proxy for emotion measurement and through repeated player tests the game mechanics were revised and evaluated. Valuable insight for the design of entertainment-focused emotional input games were gained, including emotional connection despite limited accuracy, influence of the environment and the importance of calibration. The players overall enjoyed the novel game experience and their feedback carries useful implications for future games including active emotional input.

CCS CONCEPTS

• **Human-centered computing** → *Interaction paradigms.*

KEYWORDS

game design, player experience, biofeedback game, emotion input, heart rate

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1 INTRODUCTION

Nowadays, games enable a great range of experiences and have been used in a variety of fields such as art [13], education [14] and therapy [10]. Recently, there has been rising interest in the role of emotions in gameplay [2, 15, 21]. With the development of game input devices, new interaction possibilities have arisen, including using emotion measures as game input. For example, by using Brain-Computer Interfaces (BCI) [37] or physiological measures, emotions can be processed with increasing accuracy through the application of machine learning [30]. In previous research, the player's emotions have been measured to adjust certain game variables such as difficulty. Those are so-called affective games which adjust the game state based on bio-sensor input to 'tweak' the game towards a target player experience [24]. On the other hand, there are serious games in which the player can actively use their emotions as game input to control certain game mechanics [9, 32]. However, as such games usually focus on training emotion control or regulation, the ludic potential of active emotional input in a game setting is largely unexplored.

To address this gap, this work presents NERO, a game in which the emotion control mechanic is used as a ludic element allowing the players to explore their own emotions in the environment. NERO is a 2D platformer game which matches emotion states to characters with varying abilities that help overcome the obstacles in the environment. We used heart rate as a proxy for emotional input as we wanted to explore how players would try to attempt the emotion control rather than accurately measuring emotions. We tested the game in several player tests and evaluated the last version in regards to future design implications for games using active emotional input. We aimed to create a game where emotion is used as an active game input and where players can enjoy and create their own personal experience. Through testing our game concept and prototype, we provide insights into the possibilities and difficulties of games using active emotional input from a player experience perspective.

2 RELATED WORK

2.1 Biofeedback games

Biofeedback games are games which use biosensors in place of, or in addition to, conventional game input modalities such as keyboard and mouse to control certain game mechanics [24]. A popular subfield of biofeedback games is affective gaming. In affective games, the player's state is measured and then those measurements are used to again affect the player's state, creating an affective feedback loop. In this way, the player experience is shaped towards a target experience. [24] The input is collected passively and often used to adjust game variables, most commonly difficulty [1, 6, 7, 16, 34]. In contrast, the goal of NERO is not to shape the player experience towards a specific direction but to have the players create their unique personal experience. We therefore aimed at designing a biofeedback game, but not an affective game per se. Also it was previously observed that direct physiological control is preferred to indirect one [25] which supports our rationale of active emotional input.

2.2 Emotion input games

While there is extensive literature on how video games can *evoke* emotions [2, 15, 21] the possibilities for the player to use their emotions actively as game input is much less explored. Often games using active emotional input have a target related to emotion regulation training [3, 18, 31, 38]. Usually those games have one specific emotion whose control should be learned by the player. For example, there are several games targeting relaxation [32, 39] including commercial meditation games such as Art of Zen[1]. Some other approaches include games which promote positive emotions as in Bernhaupt et al.'s work which uses positive facial expressions to make a virtual flower grow [5]. There are also attempts at measuring multiple emotion states and matching them to game states which the player needs to achieve such as in Charisis et al.'s work [9]. However, while they consider multiple emotional states through EEG technology, their goal is emotion regulation for improved artistic expression rather than the enjoyment in the playing experience. Lastly, there have been prototypes such as Menti's Journey [12] which was developed for children to understand and regulate their emotions, using facial recognition to change characters and solve mini-games. In comparison, while we also applied an exploratory approach, we focused more on the emotions that are actually experienced rather than the ones visually expressed.

2.3 Emotion input modalities

There are various types of physiological measures which could be used to approximate emotion. Navarro et al. provide a useful overview of physiological interaction techniques in biofeedback games [26]. Emotion is a highly complex and debated research field since decades [36]. Consequently measuring and using emotions as game input has been attempted through a plethora of approaches. In this section, the identified three main input modalities and combined inputs are presented which are used in games using active and direct emotional input.

First, electroencephalography (EEG) devices are a promising technology which provide rich data in the form of brain waves. However, the majority of games implementing EEG technology use attention, meditation or motor imagery data and only few attempt to measure emotion [37]. There are several works adjusting game difficulty based on one or two emotional measures such as calmness [11], excitement [4, 35], frustration [4], arousal [7] or positive/negative valence [1, 16, 34]. In one game it is distinguished between 4 emotion states based on high and low valence [9].

Concerning the usability for EEG in a game setting there are differing opinions. On one hand it is stated that "EEG interaction is not ready to leave the lab" [26, p. 268:14] arguing that most interaction techniques have been developed in a controlled environment rather than in a game setting [26]. More optimistic stances emphasize the potential of BCI technology despite its limitations and highlight the game designer's role in exploring new possibilities [27].

Second, there are several attempts at capturing emotions using facial expressions [5, 6, 17, 20]. In Carvalhais & Magalhães's work emotions such as happiness, surprise, sadness, fear, anger or disgust are inferred from facial expressions and used to adjust the game's difficulty [6]. Other games differentiate the facial expressions into positive and negative emotions and link them to game elements such as a growing flower [5, 20] or the behaviour of non-player characters [17]. Facial expressions have the advantage of easy control, but the disadvantage that it can be manipulated without strong connection to the underlying emotion.

Third, heart rate sensors have been used to infer emotional arousal in a game [19, 40]. Kahn et al.'s work on RAGE-Control mentions that heart rate can be a good proxy for emotional arousal in seated situations [19]. Interestingly, heart rate feedback seems to increase player engagement even if it is not accurate [29].

Finally, a number of works combine multiple physiological inputs to approximate emotion measures [8, 22, 23, 28, 33]. Most attempt to measure the player's arousal and valence values using some combination of the inputs previously mentioned, as well as other sensors such as skin conductance [8, 22, 23, 28, 33], electromyography [8, 33], or respiration rate [8]. While combining different measures can increase the breadth of possible input values, it also highers the burden for the player and development resources.

3 INTERFACE INNOVATION

As noted above, we focused on the following questions: What if a player can control the game using their emotions? What if the player's concept of their own emotion regulation could be translated into a game and explored in a playful way? We sought to understand the connection between the player's conceptual model of their subjective emotions and the emotions objectively measured through physiological devices.

In this work, we introduce the concept of using a emotional input strategy based on the existing literature on biofeedback games and input devices. We note that previous research surrounding such games lean towards a more passive approach where emotional states are tracked or evoked, generally as a *response* to the game state. We suggest the concept of using the player's emotional input to actively control game mechanics, where the aforementioned direction of influence is reversed and the game state changes in

[1] https://store.neurosky.com/products/art-of-zen

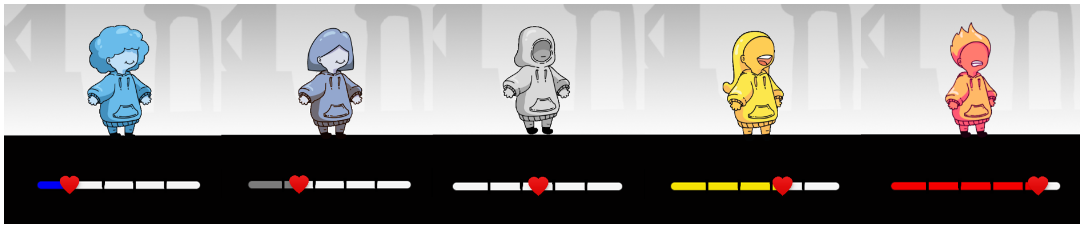

Figure 1: Characters mapped to specific emotional states. From left to right: Relaxed, Focus, Baseline, Excited, Stress

Table 1: Character Abilities and Emotion references

Emotion	Heart rate(HR) reference	Character Ability
Relaxation	(Baseline HR) - 20 <Current HR <(Baseline HR) - 12	Stand on breakable platforms
Focus	(Baseline HR) - 12 <Current HR <(Baseline HR) - 4	Pass through spike traps
Excitement	(Baseline HR) + 4 <Current HR <(Baseline HR) + 12	Push around obstacles in the terrain
Stress	(Baseline HR) +12 <Current HR <(Baseline HR) +20	Faster movement speed

response to the player state. We utilized two modes of emotional game input by allowing the emotions to manipulate the game state both passively (game tracks player's current emotional state) and actively (player consciously controls their emotions to influence game state).

Specifically, we linked the users' emotions to game characters which represent their emotional states. This mechanic enables the player to explore the relationship with their emotions and use it to overcome obstacles in the game. Each game character would have unique abilities that strengthen the feeling of embodiment of the player's emotions. As emotions are very subjective and personal, we aimed on a high degree of freedom in the game and included different possible ways to solve tasks in the game.

4 GAME DESIGN PROCESS

4.1 Design Method

We followed an iterative design approach to our game development process. After the development of our initial prototype, we conducted preliminary user tests with 4 participants to review the gameplay experience and usability of our game. Each session took between 20 and 40 minutes, and we aggregated the feedback from the testing sessions to make adjustments and functional changes to the final version of the game.

As an emotion tracking technology, we chose heart rate sensors. A Polar H10 heart rate sensor was used for our implementation. The choice of technology was made based on the economic accessibility of the device and relevant software. To enable real-time emotional input, the sensor data was sent via Bluetooth using a heart rate plugin for Unity[2]. The data was subsequently used to determine the emotional state as described in the below section. We aimed to approximate the experience of using biophysical readings through 1) wearing a sensor and 2) manipulating the game state roughly based on the physiological state of the user. We go into more detail about the limitations of the device and possibility of using various other technologies to implement games with similar concepts.

4.2 NERO: Mechanics

Nero was developed as a 2D platformer game on the Unity platform. We chose this genre for its variability and to emphasize the differences of the characters through their movements and interaction with the environment. The objective of the player character is to navigate through a platform level to reach a puzzle door, which would progress the player to the next level upon solving. While a level design concept with multiple levels and increasing number of characters was devised at first, at the current stage of development, only one level (the final level of the game) has been implemented. The level contains all types of objects that each emotion character can interact with, to demonstrate the characters' abilities. The game first provides a tutorial level, where the mechanics and basic controls were introduced, and then progresses to the main level.

4.2.1 Character Changes Based on Player Emotions. The main mechanic of the game was based on the automatic change of the playable character depending on the current emotional state of the player. The player had 4 possible emotion states that they could take: Relaxed, Focused, Excited and Stressed (Figure 1), and an additional baseline state. The emotions were chosen based on the technological limitations (are they measured or supported by biofeedback devices), their intuitiveness regarding the player's perception of each emotion, as well as perceived ability to be able to control the emotion.

Each emotion character had a specific ability that aided their journey through the level. For example, the character for the relaxation state would be able to jump on breakable platforms without falling down, which allowed users to navigate more easily through the terrain. On the other hand, the Excited character would be able to push around certain obstacles in the terrain, creating new routes or removing blockage from the level. The specific emotions and how they were mapped to the heart rate are depicted in Table 1.

[2]https://assetstore.unity.com/packages/tools/input-management/heart-rate-plugin-8497

For example, if the heart rate baseline is 70, the range for getting the Excited character would be between 74 and 80. The range for the emotion was chosen by first finding the maximal range which the heart rate can take when controlled by the player, from most calm to most excited. This range was iteratively adjusted through repeated play tests. The eventual maximal range was a difference of 40 in heart rate. This range was then divided into equal ranges of 8 around the baseline. Players were able to adjust and calibrate their baseline heart rate during gameplay through a specific sequence if they desired. In this case, a 10-second calibration sequence would initiate, and the average heart rate calculated during the 10-second window would be set as the new baseline for emotional calculation. Note that this calibration could be deliberately manipulated by the player, such as forcing a higher heart rate during calibration, which we didn't counteract to encourage free and creative play.

4.2.2 Collecting Emotion Gauges. Throughout the level, users collect emotion gauges. For each emotion, there would be a 10-step gauge that would fill up each time the automated emotion readings would match a certain emotion. After gaining 10 steps, the user would gain a 'spirit' for the emotion. The collected spirits would be used at the end of the level puzzle, where the player was asked to provide a specific sequence of spirits based on their collection (Figure 2, above). Additionally there are 'wildcard' spirits which can be used as a spirit of any emotion and are distributed throughout the level for the player to collect, intended to adjust the difficulty of the levels.

4.2.3 Using Accumulated Emotions as Currency. Users would also be able to use the accumulated emotions as currency to activate additional game mechanics. This was to allow diverse use of the emotions beyond simply collecting them and provide a cost-consequence mechanism for emotion use. It also was to balance the difficulty of the game, similarly to the wildcard mechanic. As users might have trouble achieving certain emotional states or collecting enough of an emotion, using spirits that they had already collected to help gain other emotion gauges or spirits gave them a way to adjust the difficulty. There were 2 ways to use emotions as a form of currency: charging up atmosphere boost times and by forcing change into a specific character.

The Atmosphere Boost mechanic is an indirect way of manipulating the player state, using ambience and music elements to influence the emotional state of the player and help them achieve a certain emotion (Figure 2 below, Figure 3). It also included a directional boost of the measured heart rate metric towards the range of the selected emotion. For example if the selected emotion is in a lower heart rate range the atmosphere boost would subtract 10 points from the current heart rate. Players were given 10 seconds of each boost to start with, and once the 10 seconds were all used up, players could use the spirits that they have collected to charge up the time and use the atmospheres longer. This should help players feel an emotion while also giving them a numeric advantage in the measurement.

As a more direct manipulation tactic, a Force Change mechanic was used. Users could 'pay' a spirit to force transition into a specific character. While the player character usually reflects the player's current emotion, the Force Change will sustain a chosen character for 10 seconds regardless of the player's current emotional state.

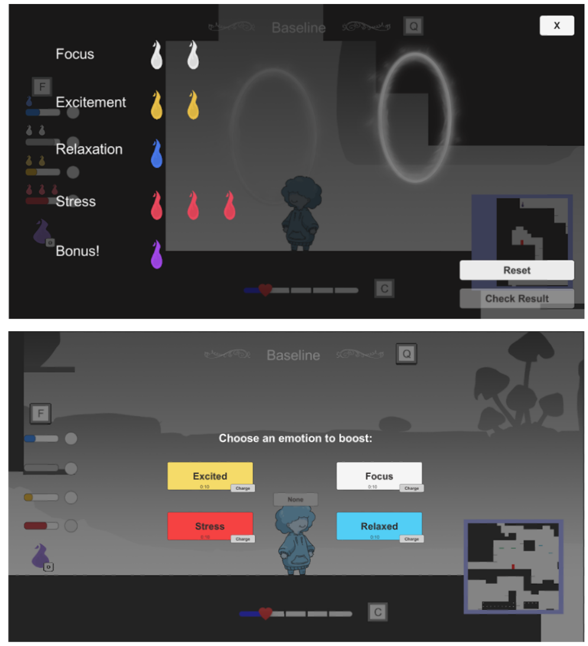

Figure 2: Display of Collected Spirits. (Above) Door Puzzle Interface, (Below) Atmosphere Boost Interface

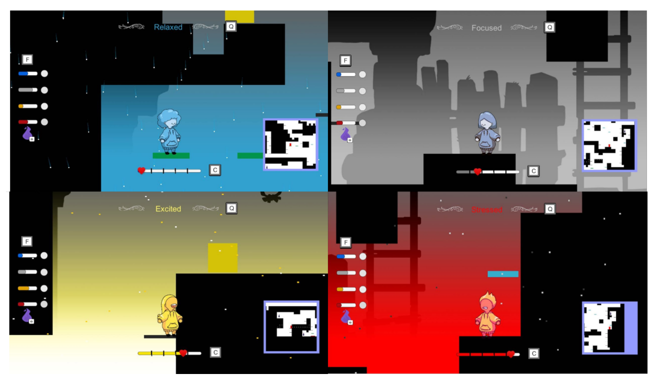

Figure 3: Atmospheres from top left to bottom right: Relaxed, Focused, Excited, Stressed

Players were required to use up a spirit of the specific emotion that they were trying to change into. For example, if the player wanted to transform into the Focus character to avoid traps in the level, they would have to spend a Focus spirit.

5 EVALUATION

The application of emotions as a game input is challenging as it is difficult to measure and interpret them. Since our main interest is the playing experience rather than the accuracy of the input, to design game mechanics which plausibly project the player's emotions in the game, play tests were crucial. For both play tests, a short semi-structured interview was used in order to collect qualitative feedback. The purpose of the first play test was to assess the player's familiarity and overall understanding of the use of emotions as a game control, as well as to check the operation of game mechanics. At this stage, the goal was to evaluate enjoyment of the game process, intuitiveness of using the mechanics and to get recommendations for their improvement. Based on the players' feedback, the game mechanics were augmented and the mapping of heart rate to character activation was modified. The main goal of the second test was the evaluation of the concept of emotional control in the game.

5.1 Game play session and feedback: structure and process

We held two play tests with a total of 7 participants (M = 26), one with 4 participants(2 female, 2 male) and a second with 3 (2 female, 1 male). Each session was 40 minutes long on average. The first test was run as a preliminary test for better adjusting of the game, and such balance changes were applied in the second run. The play test procedure was as follows: Players were first given a description of the experiment and instructions on how to use the heart rate sensor. After putting on the device and its calibration, players started the game with a training session (included in the game). After its completion they started the main game. After completing the game level or after around 15 minutes playtime (or at the request of the player), the participant was questioned according to the structure described above. Taking each player's feedback on the game into account, potential improvements to each aspect of the game were identified.

5.2 Play test results and insights

Overall impression of the emotional game control concept. The overall impression of the idea of emotional input to control the game was rated as interesting and novel. The participants indicated that the emotion concept made the game more interesting. Also all participants noted that they had no experience with biofeedback gaming nor imagined they could use emotions as a game mechanism. P2 also pointed out that the game was exciting in that she could see her emotions visually represented.

Emotional connection between the player and the game character - the game "understands" me. Even though the active character did not correspond to the player's feelings all throughout the play session, players generally reacted favorably to the match of their emotions with the character in the game. P3 commented: "Even though the character does not always respond to my feelings, sometimes I really felt as if it was understanding me." This indicates some connection exceeding the actually implemented emotional data input.

Influence of the environment on player behavior. After the play session, P1 pointed out that it was a bit hard to 'reveal' emotions due to the environment settings. It was especially difficult to achieve a calm character while being subjected to testing, which caused additional psychological pressure. Thus, the style of play and the player's ability to achieve a certain emotional state depends in part on the environment in which the player is: playing alone, in the conditions of the experiment, with friends or with strangers.

Calibration challenges. One of the most difficult tasks was to find the optimal heart rate input calibration so that each character can be reached with a comparable level of effort. Since each participant had a different baseline and predominant emotion, as well as a different level of sports training (which affects the average heart rate), the ability to control the heart rate was different. This caused difficulties in reaching certain states. Thus, for P1 and P3 it was troublesome to reach a low heart rate state to activate the Calm character, when for P2 this problem turned out to be the activation of the Stress character.

Suggestions on possible future applications. In addition to the general feedback, ideas for future development were also received. P3 suggested to change the character concept of "Excitement" to "Athletic Activity", as one way of activating the "Excitement" character was for the player to increase heart rate by jumping or running in front of the computer. It was even proposed to change the concept to a sport-activity based game. Furthermore, as mentioned earlier, emotions can be influenced by the environment, and P1 pointed out that this could be used to expand the game. By supplementing the game with a multiplayer mode, players could compete against each other, disturbing and distracting each other from achieving the right emotion to complete a level. Lastly, P2 suggested that players could be allowed to assign the abilities to each emotion character themselves. Then, from the list of available skills and characters, the player can independently match them, considering which one they think fits better.

6 DISCUSSION

Emotions are highly complex. How they are expressed is greatly individual, and the strength and type of physical reaction varies. Through the development of more sophisticated sensing technology it is possible to more 'accurately' measure emotions, but that accuracy merely describes the accordance of the measure to the operationalization of a theoretical concept. How much this coincides with the individual's understanding of the emotion likely varies across individuals and cultures. In NERO, the objective is entertainment and a joyful exploratory experience rather than objective accuracy, thus the subjective entertainment experience is more important than objective play results. In other words, it is more important how players *think* they feel and how they *think* it can be measured, than what the 'real' emotion or measure is. Therefore, when it comes to the selection of a fitting emotion input, we focused not on the most accurate and reliable technology, but the technology which is most intuitive and 'fun' to control.

In our player tests, we saw that even though heart rate only partly relates to actual emotions [19], the players were quite willing to accept the concept and mapping of the emotions as a game play mechanic. We could also witness individual differences in how players try to induce and think about emotions by how they tried to manipulate the input. Some move around, some think of something specific, some regulate their breathing. This diversity is something we intended to create through an exploratory novel experience.

However, diversity also comes with a drawback, as we could see in the calibration difficulties during the play tests. In future development and in games including active emotional input, it is important to find a balance between giving the player the freedom to act out their personal emotions while accommodating all kinds of players in the game.

The influence of the environment on the player's emotions should also be considered. This indicates that the game is able to reflect the player's surroundings to a certain degree and the player can also gain insights through that. This has interesting implications for the use of active emotional input for other game environments and genres. For example, in a competitive social setting, players could try to prevent their opponent from reaching the right emotion. It could also be used in RPG games, creating an exclusive set of characters based on individual emotional data and activating them upon a certain emotional state.

Finally, while emotion control can be useful in dealing with one's daily lives, over-controlling one's feelings could have potential negative consequences for the user. For example, one might create the habit to adjust their emotions to suppress - sometimes necessary - negative emotions, or end up feeling a lack of genuineness in their emotions. Such potential issues should be considered when creating games based on the use of emotion-driven mechanics.

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