The Anger Games

Exploring the Concept of Anger as a Game Element

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1 Introduction and Concept

It is a known phenomenon that video games cause emotions, anger and aggression being perhaps the the most discussed among them. On one end of the spectrum, research tries to determine whether violence in gaming can cause violence in the real world. On the other side, sports psychologists try to help professional players channel their inner emotions to achieve titles in eSports competitions, which are quickly becoming mainstream events both in popularity as well as considering business numbers involved. But all of these considerations assume a strict barrier between the actual gameplay and the player: Their emotional state does not interact with the software directly.

In this project, a novel idea is explored: We investigate whether emotions - specifically anger - can be used as a proper element of the game, using it as additional input that influences one or more gameplay elements. The rationale behind choosing anger out of the list of possible emotions is that a better perception of one's own anger can result in a reduction of said emotion, as was discussed in Wongtongkam, Ward, *et al.* (2014).

It is therefore conceivable that a game which involves a person's anger can have this effect if two conditions are met: The player needs to be aware that their emotional state drives the gameplay, and staying calm needs to be encouraged. The latter can be achieved by increasing the difficulty for the angry player, or by otherwise giving them a visible disadvantage upon loosing their temper. In theory, the player should want to avoid the punishing state and should be more aware of their current emotional state.

To realize the project, several questions have to be answered: How can anger be measured in real time? How can anger be triggered in a player? How does a game need to be designed to incorporate the aforementioned ideas into its gameplay?

The following sections will detail answers to these questions, design approaches taken, and evaluations made, after a short literature review, which further motivates the approach.

2 Literature Review: The Physiology and Psychology of Anger

From a psychological point of view, anger is a particularly interesting emotion, since it is caused by the violation of some basic psychological needs, as Przybylski, Deci, *et al.* (2014) argue. They describe the desired state of mind as a feeling of competence, autonomy and relatedness. The term *competence* refers to "the experience of efficacy", whereas *autonomy* consists in "the sense of choice and volition" and *relatedness* is "the feeling of connection and belongingness with others" (p.441). People have been observed to be more prone to aggression when the fulfilment of these needs is prevented. Intriguingly, these needs make a crucial contribution to psychological health when they are satisfied. Therefore, one can wonder if anger is adequately perceived as a subconscious attempt to regain and guarantee a healthy psychological and physical condition. (cf. *The Value of Anger: 16 Reasons It's Good to Get Angry* (2017))

The goal being set, it is necessary to examine how human anger can be observed by technical devices and how this can be involved in our game setting. According to Jha, Prakash, *et al.* (2018), the same situation can be encountered with different reactions by different people, which displays the absence of generalizable parameters to mood detection. Since anger and stress are capable of affecting health in a negative manner, they consider it crucial to identify unique features which allow for reliable emotion detection in every individual. They suggest there are psychological, behavioral, physiological, and ergonomic indicators of anger, heart rate variability (HRV), biological impedance, body surface temperature and skin conductance among these. Anger appears to show effects on the human brain immediately, which initiates increased blood flow to the skin. As a result, the body surface temperature changes abruptly, a process that can be observed and, similar to HRV, allows conclusions about anger. Furthermore, they argue that stress changes the electrical behaviour of the skin, such as sweat and hydration, leading to a change of galvanic skin response (GSR), a measure for skin conductance.

As D. Jones (2018) explains, stress and sympathetic arousal lead to increased heart rate (HR) and can be observed using the blood volume pulse (BVP). BVP observes blood volume in the arteries and capillaries, enabling the measurement of heart rate and heart rate variability, with the help of a photoplethysmography (PPG) sensor. Changes in BVP indicate changes in the blood flow, usually caused by heartbeats, and thus provide a valid measure of the heart rate. The time between two heartbeats is called the inter-beat interval (IBI). However, he also points out that electrocardiography might be a more adequate measure for moving subjects.

The IBI observed in this way can be used to identify patterns of the heart beat, which can be seen as indicators for external influences, as Perakakisa, Joffilyb, *et al.* (2010) point out.

In addition to the physiological measures, anger detection is also possible on a visual level. As Young, Thorstenson, *et al.* (2018) point out, red face color tends to increase the perceived level of anger. However, it remains unclear if the color alone has implications about emotions or if this observation is only valid in context with other facial traits. Stenberg, Campos, *et al.* (1983) derived anger from certain features of eyebrows, forehead, eyes, eyelids, mouth and nose. Lowered eyebrows which are drawn together and vertical lines between the brows indicated anger in their study. They also inferred anger from eyes with a "hard stare and [...] a bulging appearance" (p.183), just like from tensed lower and upper lids and an optional lowering of the upper lid, due to brow movement. Moreover, they assumed that the lips of an angry individual are either pressed together with downward facing corners of the mouth or open and tensed. The latter stems back to its similarity to shouting.

3 Anger Detection

As pointed out above, various physically observable characteristics of the human body allow us to draw conclusions about the individual's emotions. Thus, there are several approaches to automatically detecting anger from different input modalities. First of all, we used a Convolutional Neural Network to analyse facial expressions, as the latter seem a reasonably reliable display of emotions and can be observed in a noninvasive manner and without technological equipment other than a camera.

Furthermore, we included the Empatica E4 wristband, which collects information about BVP, GSR, and HRV and makes it available via Bluetooth. These measures change with ongoing arousal and thus allow assumptions about an individual's anger, especially in combination with the CNN on a visual level.

Generally, it appears that heart rate and heart rate variability can be better observed with the help of sensors installed on a chest band. In the present case, however, this would have meant further complicating the network architecture with an additional Bluetooth device, resulting in too much data being sent for the network to operate efficiently.

Expecting little long-term benefit from it, we decided not to draw any conclusions from keyboard input. There is an obvious connection between keyboard input intensity and anger. However, we expect the facial expression in these situations to be meaningful already. Additionally, the measure of BVP has shown to be sensitive to movement, which implies that a high density of peaks in BVP and intense keyboard input would coincide.

Measuring brain wave activity seems the most reliable means to reaching the aim of scientifically measuring emotions. For our purposes, however, it appears too invasive, costly and time-consuming to be appropriate.

3.1 Facial Emotion Detection

According to González-Lozoya, Calleja, *et al.* (n.d.), Facial Emotion Detection consists of three distinct steps:

1. Pre-Processing: Extract the face from image data and normalize the cropped image
2. Feature Extraction: Extract numeric features from the facial image
3. Model Training / Application: Feed feature data to a model to train it or to analyze new data

We mirrored the standard approach of using Convolutional Neural Networks for image classification for the task of detecting emotion in facial expressions. The implementation was done with the Keras[1] framework. Since neural networks jointly learn feature extraction, steps 2 and 3 are merged in this approach. Additionally, we opted for a per-frame approach as opposed to a time distributed

[1] `https://keras.io/`

model for two reasons: The lower computational cost to train such a model benefited rapid development and integration, and the additional framework of the game itself aggregating the outputs of single frame predictions is able to soften the impact of individual misclassified frames.

For training, the FER 2013 data set (Goodfellow (2013)) was chosen. It consists of 29.709 training examples and 7.178 testing examples, split evenly into a public and private test set as used in the original Kaggle[2] competition the data set was released for. The FER data set is comprised of 48 x 48 pixel grayscale images labeled as one of 7 classes: *Angry*, *Disgust*, *Fear*, *Happy*, *Sad*, *Surprise*, and *Neutral*.

Image preprocessing was done with OpenCV[3], using a Haar cascade face detection algorithm, as proposed by Viola and M. Jones (2001). Furthermore, contrast and size of the extracted facial image were optimized to resemble the training data which the neural model had seen to improve the live performance of the system.

3.2 Physiological Measures

According to Empatica S.R.L (2018), the Empatica E4 wristband is a wearable and wireless device that can be worn in daily life. Data is acquired in real time and can be made available instantly using Bluetooth low energy. Alternatively, the data can be saved to internal memory. The second method does not allow immediate evaluation. The wristband measures BVP with the help of a photoplethysmography sensor. From this measure, heart rate, heart rate variability and other cardiovascular features can be derived. An algorithm aims to remove motion artifacts by combining different wavelengths and by tolerating external light conditions. In our experiments, however, the BVP measures appeared to be extremely sensitive to motion despite these attempts. Electrodermal activity (EDA) is observed with the help of two installed silver plates, which are intended to measure sympathetic nervous system arousal. Features related to stress engagement and excitement can be derived from the EDA data. However, the wristband returns GSR values, which are a measure of EDA. A 3-axis accelerometer is supposed to capture motion-based activity. The infrared thermopile can measure skin temperature between -40°C and 115°C with a resolution of 0.02°C and an accuracy of ±0.2°C within 36 and 39°C. Although it is usually recommended to wear the wristband on the non-dominant side in order to reduce motion artifacts, the EDA signals were proven to be stronger on the dominant side recently. As can be seen in section 5, we were able to establish some connections between GSR and events that were likely to cause anger. However, with the BVP measure being sensitive to motion and unsatisfying overall reliability, we decided not to include the physiological data in the anger measurement which is relevant for the game.

[2] `https://www.kaggle.com/ashishpatel26/facial-expression-recognitionferchallenge`
[3] `https://opencv.org/`

4 The Game

4.1 Game Design

The game that is presented here needs to fulfill certain requirements: It should be reasonably simple and easy to learn, it should evoke the player's anger and it needs to be flexible enough to incorporate the measured anger of the player as a game input. These requirements lead us to implement a game that is based on the classic Bomberman[4] game, originally released in 1985. Bomberman is a video game classic in which two players try to eliminate each other by placing bombs in a two-dimensional grid world. The playing field contains obstacles such as boxes and indestructible walls. Each player controls a single character which they can move around the 2D game world in four fixed directions and place bombs on the individual tiles making up the game world. When a player is hit by the explosion effect of a bomb, they loose a portion of their health and loose the game when their health reaches zero. The game play is symmetric in that both players' characters have the exact same basic abilities and have the same goal of bringing the other's health to zero.

We chose a competitive two-player setup because we anticipated that playing against another human player would cause more emotional response than playing versus a computer. Furthermore, the controls and the goal of the game are straightforward and easy to learn, with many potential players already having experienced an installation of the original Bomberman game series. In addition, it is also easy to extend the basic game concept with elements that might increase the emotional response of the player. We make use of this flexibility and included game elements such as collectable items that have a positive or negative impact on the players abilities, built-in traps on the floor that cause damage to the player's health, and we gave the players the abilities to taunt or disturb the vision of their opponent in the game.

We named our Bomberman variation 'Bombangerman'.

4.2 Architecture

In order to create a real-time two-player game, we decide to use a server-client architecture, which was extended by helper programs to measure the degree of anger of the players.

The project implementation was done in Python 3[5], making use of the pygame library[6] for the game server and game client. The central game server receives input events from the two game clients and sends game state updates back to them. The game clients finally draw the game state, using custom-tailored graphic assets. (See fig. 1)

In addition to the aforementioned game server and client programs, we created another server program, which is responsible for collecting and aggregating

[4] `https://en.wikipedia.org/wiki/Bomberman`
[5] `https://www.python.org/`
[6] `https://www.pygame.org/`

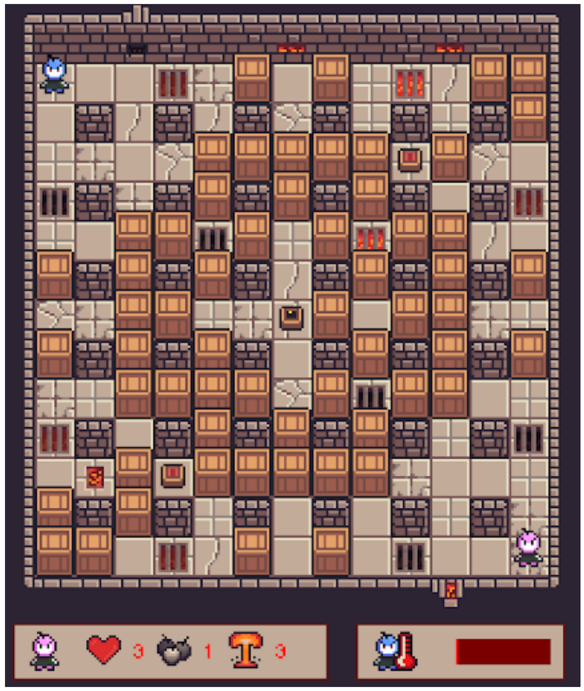

Figure 1: The main screen of the bomberman game. Two players (blue and pink), moving in a grid world, are able to place bombs in order destroy boxes and to defeat the other player. Note the anger meter in the bottom right, showing the opponents anger status.

all anger measurements and sending them to the game server as a single value for each player. This broadcaster server receives the raw data from the Empatica E4 wristband and the output of the facial emotion recognition software for each player. In order to receive the data from the Empatica E4 wristbands, we first have to send their data to an iOS 12 app via Bluetooth, which we built using the Empatica SDK. The iPhone app then forwards the data to the broadcaster server. Furthermore we implemented functionality to save a replay of our game as well as a video of the players' faces and the data received from the Empatica E4 band. This way we are able to relate the recorded data with what happened during the game

The complete system architecture can be seen in Figure 2.

4.3 Including Anger

One of the most important parts of the project is the integration of the player's anger value into the game. Since the effects that the emotion induces into the game are the main indicator for the players to be aware of their own level of

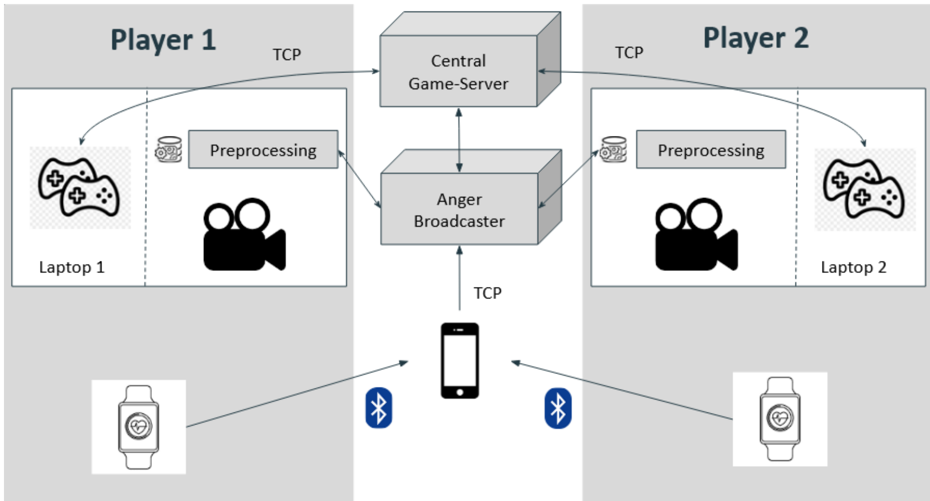

Figure 2: Architecture

anger, the effects must be clearly visible on one hand. On the other hand however, they should also be designed in a way that players still enjoy the game and are not obstructing the gameplay flow by either ending it to quickly or by drawing the attention away from the regular gameplay too much.
To design these game elements, we looked at the basic needs mentioned in section 2 in order to evaluate where we can violate these in the game via a gameplay element that doesn't feel out of place relative to the overall game design. The goal is that by causing anger by interfering with those needs and then punishing anger, the game would make the players realize intuitively that they should mind their emotional state.

To induce anger into the player, the following gameplay elements (visually shown in Fig. 3) were added:

- **Falling Boxes:** Continuously and randomly during the game, additional boxes fall onto the field, potentially trapping or crushing a player. These lead to randomly induced moments of frustration and anger.
- **Collectables:** Besides collectibles that are standard for the game (so-called power-ups), negative effect collectables are introduced. These hinder the player's competence in regards to their movement: The 'confusion' collectable inverts the player's directional input and the 'autowalk' collectable removes the player's ability to stop their character. Both negative collectables target the players sense of competency and autonomy.
- **Traps:** Certain tiles of the floor periodically activate traps, harming any player currently standing on these tiles. This gameplay element targets the players' sense of competence by facilitating making mistakes.

- **Slime:** Both players get the ability to trigger a 'slime attack' on the other player. The attack paints a visual slime effect on the game window of the target player, obstructing their view of the playing field until they physically clean their screen using their mouse or wait for a set amount of time. This gameplay element targets the players' sense of belonging by excluding them physically from the game world.
- **Taunting:** The players have the ability to display visual taunts, mocking their opponent. This gameplay element is intended to facilitate interaction between the players, inducing schadenfreude and creating a positive feedback loop for anger induced by events in the game.

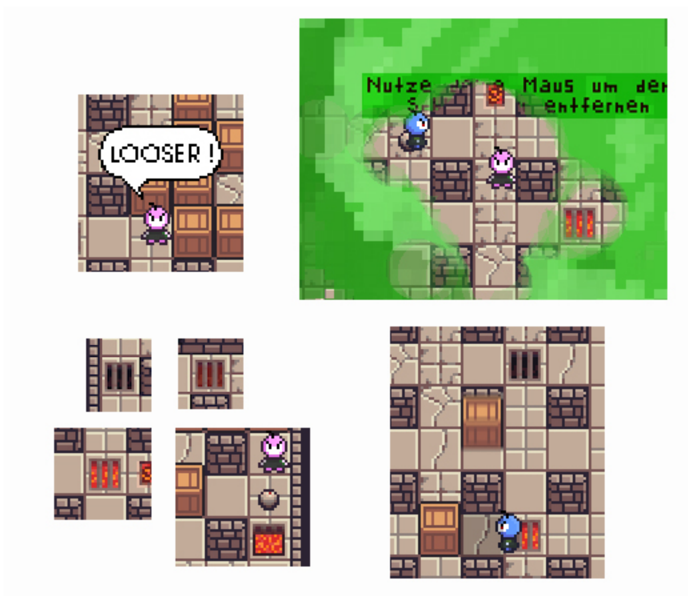

Figure 3: The graphic shows the described game elements (from top left to bottom right) **Taunting**, **Slime**, **Traps** and **Falling Boxes**

Considering the integration of the players' anger values into the gameplay mechanics, we decided to change only one variable within the game. This is supposed to both avoid confusion among the players, as well as make the evaluation of a first prototype easier. We opted to let the anger level of one player increase the movement speed of the other player. Increased pace clearly provides a player with an observable advantage, because they can evade explosions easier, and can also outmaneuver bombs more easily. Most importantly, the speed of an opposing player is immediately recognizable when it becomes unfair compared to one's own speed. So this effect clearly violates the player's basic need for competence, which immediately makes them want to change the situ-

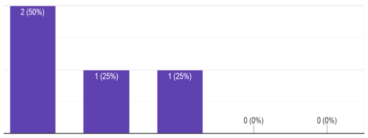

Figure 4: "How often do you get angry in your everyday life?"

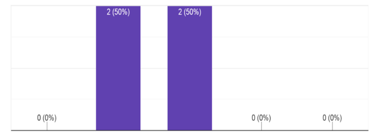

Figure 5: "How often do you get angry when playing video games?"

ation. To further increase the players' awareness of the gameplay element, we introduced a user interface element displaying an 'anger bar' highlighting the opponents' current anger status.

It is important to note that the "unfair" advantage gained by one player can also increase the anger of the other player. However, it is reasonable to assume that a player who wants to win, will learn to control his anger over time in order to regain a balance in the players' capabilities.

5 Evaluation

5.1 User Study

We conducted a small study to test our ideas with real users and to collect data, from which we could draw further conclusions. The study consisted of two pairs of participants who played the game against each other for two rounds. The participants were asked to answer a questionnaire before and after playing the game. During the games we recorded BVP, IBI, skin temperature and GSR of each participant with the E4 Wristband as well as a video of the participants' faces with the webcam. Additionally, we saved a replay of the game and the calculated anger of the players at each point in time.

The results of our questionnaire confirm our idea that people generally get angry more often in video games than in everyday life, as can be seen in Figure 4 and Figure 5. Our approach to use a game for anger management therefore seems to be viable. Additionally the participants seemed to like the idea of playing a video game that includes anger as a game element (Figure 6).

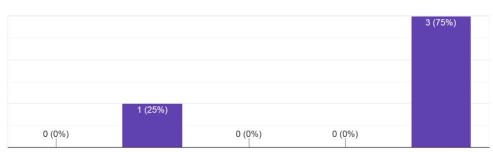

Figure 6: "How did you like that anger had an influence on the game?"

The evaluation of most of the data from the E4 wristband generally couldn't be used reliably to predict the anger of the players. The data was generally too

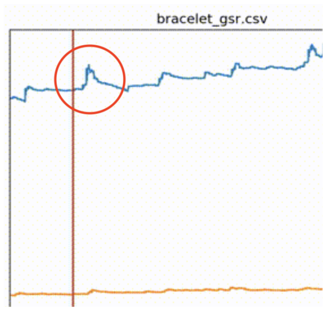

Figure 7: GSR peak 1

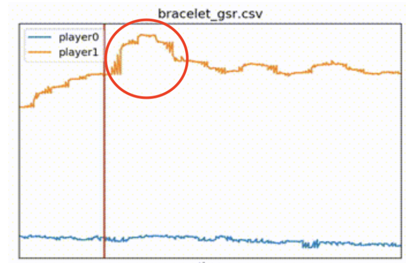

Figure 8: GSR peak 2

noisy and differed widely from user to user. The only measure that seemed promising in predicting anger is the GSR. Here, we found a correlation between events in the game that are very likely to cause anger or arousal and a significant spike in the GSR value, as can be seen in Figure 7 and Figure 8.

5.2 Anger Detection Performance

As discussed in section 3.2, we decided against a direct involvement of the E4 Wristband data into the anger aggregation pipeline of the game. However, we did track the players during testing and found the GSR value to be of promising quality, provided more data can be acquired (cf. section 5.1).

The neural facial emotion recognition has been evaluated both qualitatively and quantitatively. Experimental evaluation of the CNN architectures for binary classification and for the full seven classes showed that the seven-class model performed better in the game's pipeline, even though the binary model could achieve slightly better testing results. The reason for that user-driven assessment is likely to be the unique circumstance that for the special game setting, false negatives are much less disruptive than false positives, of which the seven-class model produced fewer cases. Figure 9 shows a confusion matrix of the 7 class model performance on the combined test sets of the FER data set, totalling over 7000 labeled samples.

The FER data set showed to be sub-optimal for the task at hand. With it being created from web-crawling, the general image quality and annotation quality are mediocre at best, and the low 48 x 48 resolution is a hard limit to the amount of information the neural net could access. Especially the presence of beards or glasses posed a great challenge for the systems trained on the FER data set. Interestingly, images showing people with beards had a very high chance of being labeled as 'angry'.

We believe, however, that the replay and recording functionality we included into the game could be used to generate new and better data for facial anger detection in a similar setting.

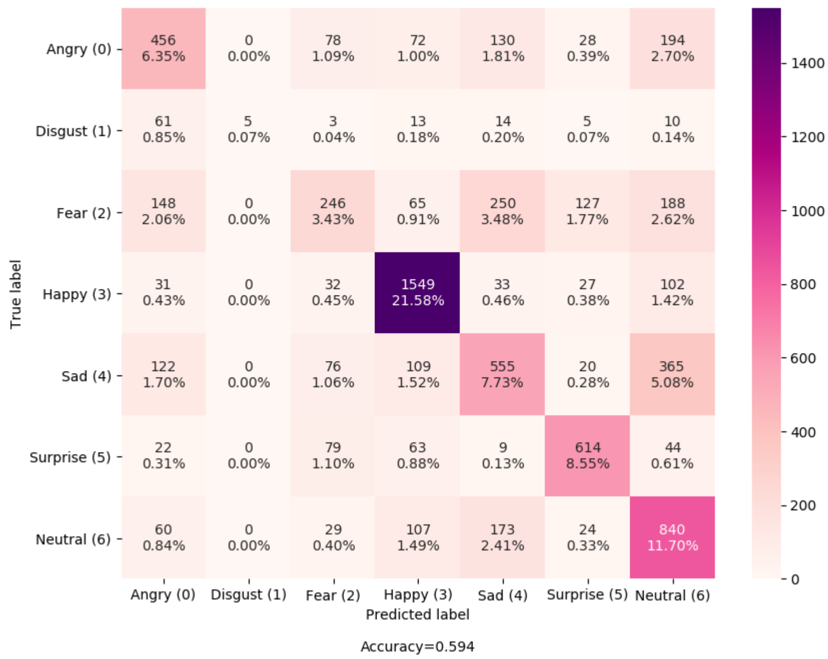

Figure 9: Confusion matrix of the 7 class CNN architecture trained on the FER data set.

6 Applications

While Bombangerman could be used just for fun or for entertainment purposes on video streaming platforms like Twitch[7], we also think that it has potential to be useful for other applications, the main one being to help people with anger management. When trying to help people with anger problems, one of the most crucial steps is for the person to recognise their anger. Since our game provides a context in which anger is more likely to be triggered, it gives players the opportunity to train their anger management in a safe environment. Because the players get a direct negative feedback when they get angry, it is easy for them to recognize moments of anger. Staying calm is directly aligned with their interest to win the game and makes it therefore preferable for them. Therefore, we think that by playing our game over and over again, the players can train to be more aware of their emotions and can learn to control their anger problems.

In a more academic vein, games like Bombangerman could be used to generate large amounts of good emotion tracking data, benefiting further research in the area.

[7] `https://www.twitch.tv/`

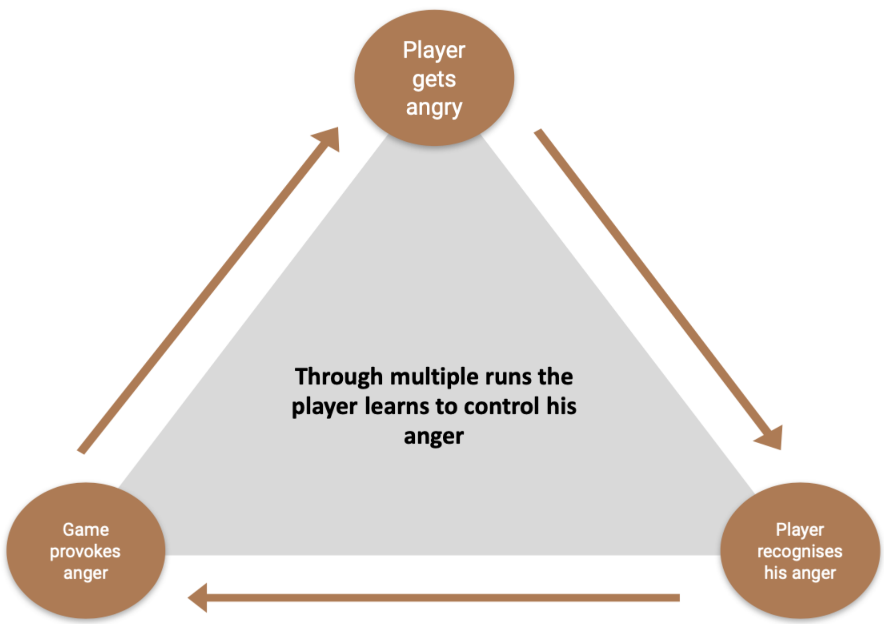

Figure 10: Triangle of anger

7 Conclusion

We proposed a game framework that aims to create anger in the players, measures the player's emergent anger and is in turn influenced by these observations. Anger is caused by the violation of basic psychological needs. The measurement relies on facial emotion recognition and its outcome influences the pace at which the opponent moves. The other tested peripheral devices intended to aid in tracking the players' emotions could not provide sufficiently accurate and consistent data to be included in the final system architecture. So far, however, technological devices and machine learning algorithms appear to perform surprisingly poor on emotion recognition tasks. Accordingly, the integration of affective states into game contexts will become an even more interesting and promising task when more reliable systems are available.

8 Future Work

The main focus of further developing our idea is to make the detection of anger in a player more accurate and robust. This could be done by further improving the performance of the neural network for facial emotion detection, as well as using a multi-modal approach. Different measurements should be incorporated and appropriate weights for each modality should be used to combine them to a scalar anger value. These could be the physiological data we already collected via the Empatica E4 wristbands, as well as other measures, like the keyboard typing behavior or an analysis of the players voice and speech.

Furthermore, when playing the game more often, only changing the speed with increased anger might become boring to the players. It would be worth evaluating additional user studies to determine whether it makes sense to have additional existing or novel elements of the game controlled by anger.

9 Responsibilities

While all four project group members worked jointly on almost all tasks and features, this section is to highlight core areas the individual members took a leading role of.

- Alexander Perzl: iOS development and integration of the Empatica E4 Wristband, replay function development
- Manuel Zierl: Game architecture, replay integration and networking
- Michaela Bachmaier: Research, anger value aggregation methods and key gameplay features
- Yannick Kaiser: Facial Emotion Recognition, game engine development and game art.

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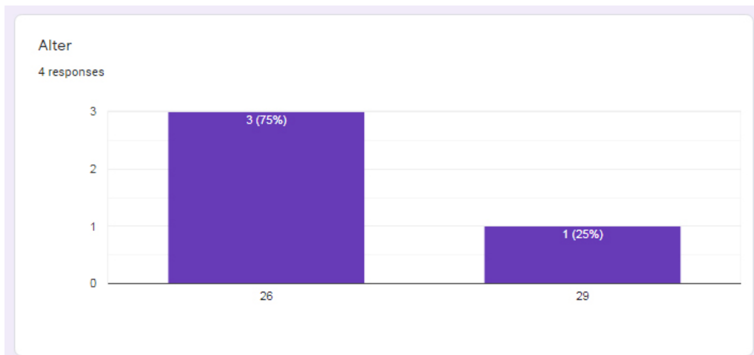
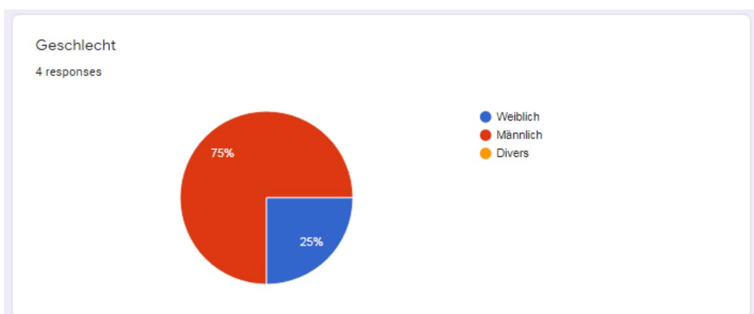
Appendix

First Survey

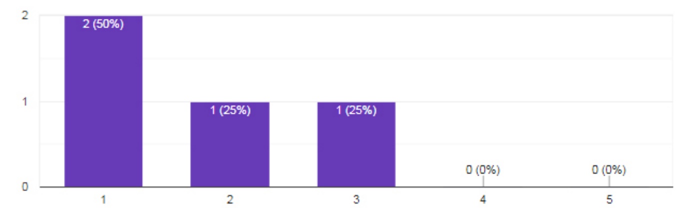
The first survey was conducted before the participants played the game in order to obtain general information about the individuals and their experiences with anger, especially regarding video games. The results are listed below. The order of the survey was preserved.





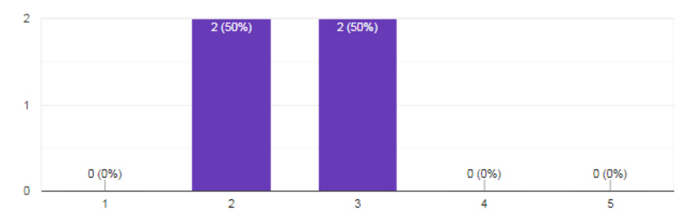
Wie oft machen dich Dinge im Alltag wütend?

4 responses



Wie oft wirst du in Videospielen wütend?

4 responses



Wie äußert sich Wut i.d.R. bei dir nach außen?

4 responses

Schweigen

Genervtheit, Fluchen

Gesichtsausdruck konzentriert, grimasse; fluchen,

Keine Ahnung, ich versuche nicht so oft die Wut zu zeigen.

Welche körperlichen Auswirkungen spürst du, wenn du wütend wirst?

4 responses

schneller Herzschlag

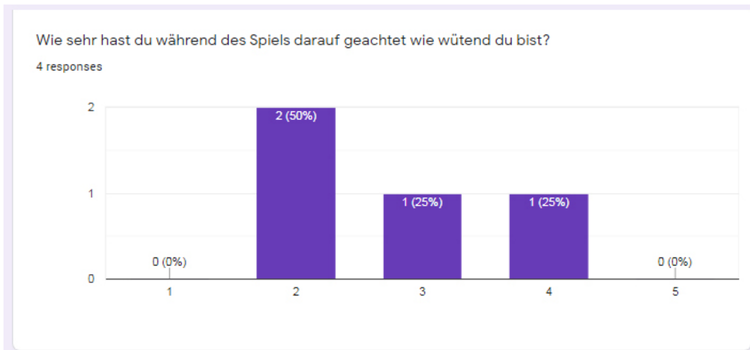
Schweißausbruch

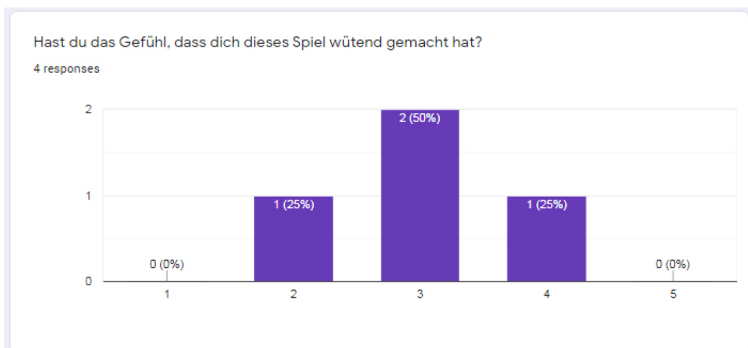
schneller Puls, Aufregung, fühle mich körperlich kalt, kalte Finger

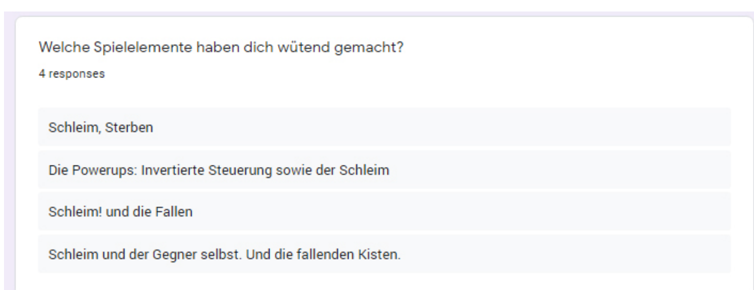
Angespannt

Second Survey

The second survey was conducted after the participants had played two rounds of the game. The Goal was to evaluate if our game has achieved its objectives and how the players dealt with the game. The results are listed below. The order of the survey was preserved.





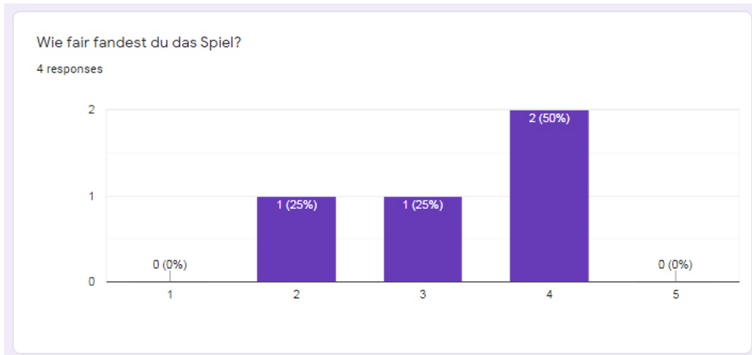

Welche Spielelemente haben dich wütend gemacht?
4 responses

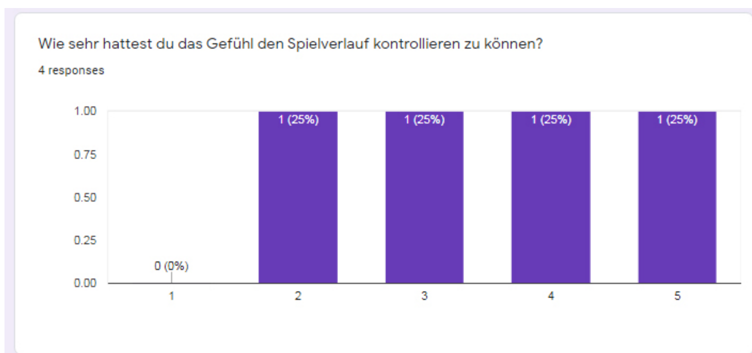
Schleim, Sterben

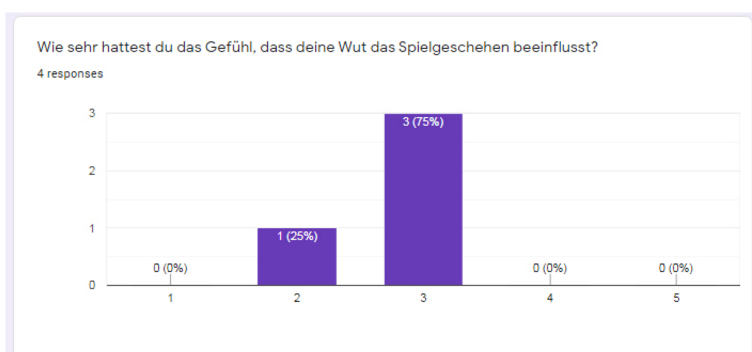
Die Powerups: Invertierte Steuerung sowie der Schleim

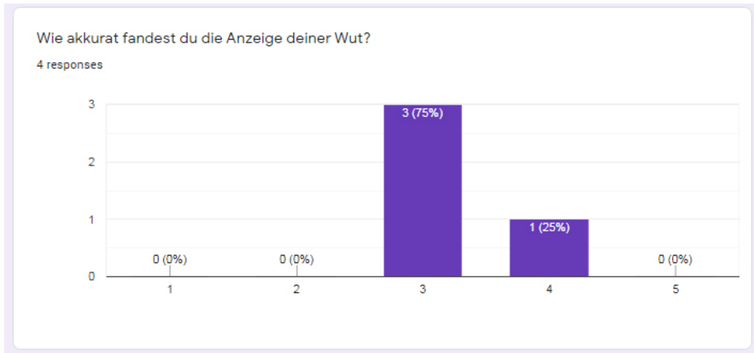
Schleim! und die Fallen

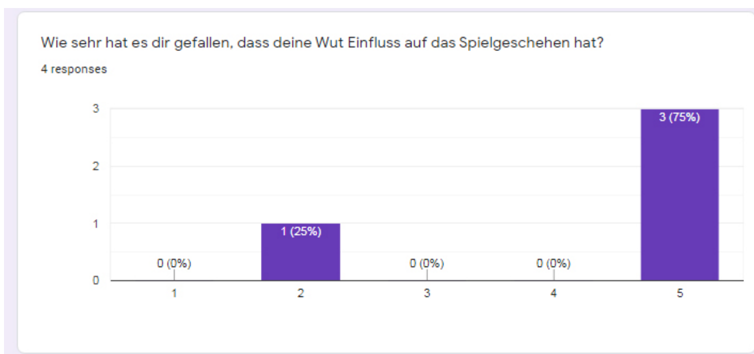
Schleim und der Gegner selbst. Und die fallenden Kisten.


Wie fair fandest du das Spiel?
4 responses
2
1
0
0 (0%)
1 (25%)
1 (25%)
2 (50%)
0 (0%)
1
2
3
4
5


Wie sehr hattest du das Gefühl den Spielverlauf kontrollieren zu können?
4 responses
1.00
0.75
0.50
0.25
0.00
0 (0%)
1 (25%)
1 (25%)
1 (25%)
1 (25%)
1
2
3
4
5


Wie sehr hattest du das Gefühl, dass deine Wut das Spielgeschehen beeinflusst?
4 responses
3
2
1
0
0 (0%)
1 (25%)
3 (75%)
0 (0%)
0 (0%)
1
2
3
4
5





Sonstige Anmerkungen

2 responses

Wenn man es zum ersten Mal spielt, viel um auf alles zu achten (Wut/Spieleokntrolle), aber ansonsten voll cooli!

Keep it coming. Pretty please published es mit Webcam only als Webapp!!! Will es öfter spielen!