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# A Taxonomy and State of the Art Revision on Affective games

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## Abstract

Affective Games are a sub-field of Affective Computing that tries to study how to design videogames that are able to react to the emotions expressed by the player, as well as provoking desired emotions to them. To achieve those goals it is necessary to research on how to measure and detect human emotions using a computer, and how to adapt videogames to the perceived emotions to finally provoke them to the players. This work presents a taxonomy for research on affective games centring on the aforementioned issues. Here we devise as well a revision of the most relevant published works known to the authors on this area. Finally, we analyse and discuss which important research problem are yet open and might be tackled by future investigations in the area of Affective Games.

*Keywords:* Affective Computing, Affective Games, Taxonomy, Review

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## 1. Introduction

This paper presents the field of Affective Games (AGs), a sub-field within the so-called Affective Computing field of research[1]. Videogames have become a mainstream form of entertainment over the last years, becoming one of the fastest growing industry of entertainment. However, due to the increase of competitiveness in the industry, game designers are constantly encouraged to make their games engaging and attractive to the users.

Although developers have traditionally focused their efforts on improving the graphic quality of videogames, in recent years it has been very difficult to stand out in this regard, forcing them to discover new ways of getting attraction to their games. This is where Affective Games come into play, assessing the emotions of players and adapting the gameplay to them as well as triggering the right emotions into the players in order to improve their overall satisfaction.

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This review analyses the initial steps that researchers took towards addressing the aforementioned topic and also the most recent work on Affective Games aiming at sketching out the main research challenges in the field as well as studying what can and cannot be achieved with such methods. A taxonomy that introduces several distinctions between the approaches in the literature is also proposed, and a comprehensive survey of work that we found in the literature is discussed and classified according to these distinctions. First, there is an introduction to this field of research.

Affective gaming was originally conceived as the search of suitable methods for measuring the affective state of videogame players [2, 3]. It began as the desire of translating the advances achieved in affective computing and, more precisely, in the human-computer interaction to videogames. This technology could provide several benefits to the player experience such as adopting new game mechanics depending on her/his affective state and creating game content dynamically to fit and provoke certain feelings to the player, to name a few (see Figure 1).

The main problem that affective gaming tackles is the fact that, since its inception, the interaction between the game and the player has been fixed, that is, for every action performed by the player there is a default reaction in the game, and vice-versa. We are not referring here to the reactions the game is able to select, which can be even randomly selected from a predefined set, but to the (lack of) ability of affective games to create new reactions on their own.

Furthermore, affective games deals with player's emotions [4], which in turn is another issue that has been studied in the literature, that is, how to measure and detect human emotions.

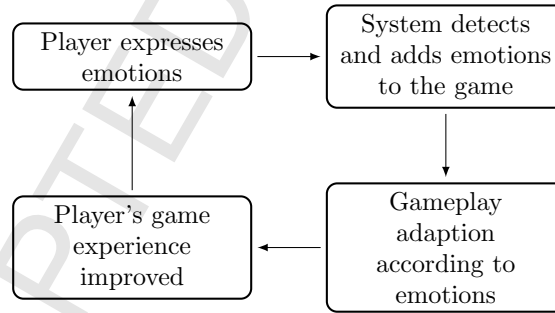


Figure 1: Typical affective game feedback loop

Although there are other papers in the literature that study and review the area, they are very specific. For instance, Chu et al. [5] focused on the user experience when playing games, while Kivikangas et al. [6] and Ng et al. [7], Kotsia et al. [8] targeted the physiological measures and the videogame design, respectively. Regarding the historical survey by Christy and Kuncheva [9], they provided an industry-centred review, focusing on hardware and videogames. On the other hand, Calvo and D'Mello [10] authored a deep survey on affect

detection, however it has a wider focus than the present paper, focusing on how to measure the emotional state of the user from an affective computing point of view as a whole, instead of focusing on affective game. Finally, Dormann et al. [11] presented several videogame design patterns related to understanding emotions, affective representation, and socio-emotional interactions as well as a taxonomy to classify them.

## 2. A Taxonomy for Affective Games

This section aims to draw some distinctions on how to tackle several issues related to affective games in order to characterise every approach on this sense. Note that these distinctions are not discrete but continuous, thus an affective game approach can share features. However, there is always a predominant feature that specify the category within the taxonomy.

Although we tried to be as comprehensive as possible, there is no doubt that, due to the dynamism of the research field, additional distinctions will be deduced in the future and even the current ones should be figured out. Anyhow, our proposed taxonomy might be useful for analysing many affective games approaches found in the literature.

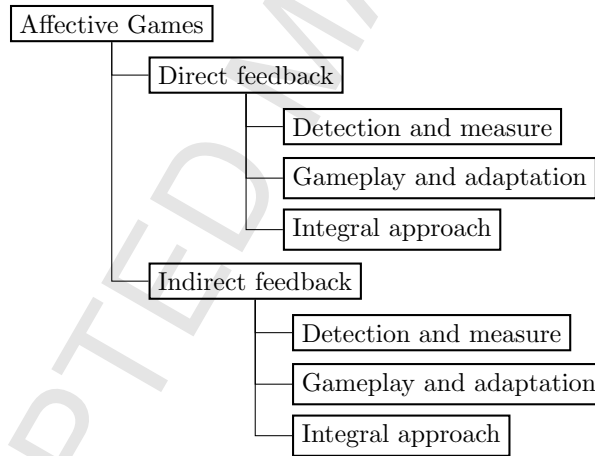


Figure 2: Proposed taxonomy for classifying affective game approaches

### 2.1. Type of feedback

The first differentiation deals with the kind of the feedback used to adapt the game to the emotions and, more precisely, how the game gathers this feedback in order to establish the emotional state of the player. This feedback may be direct or indirect, with regards to the way it is gathered and/or inferred from the player. Direct feedback is obtained through biometric sensors attached to the player such as galvanic sensors and heart-rate measuring devices. The main

idea behind this is the fact that there are many physiological effects related to emotions as sweating, heart-rate, and corporal heat, to name a few. These effects can be measured and analysed to later influence the gameplay, providing a mechanism of adaptation to those affective games that rely on this category.

For instance, a terror themed videogame could benefit of direct feedback, modulating the fear level the player is feeling. To do so, the player should wear a device that monitors her/his beat-rate. This measure could be read by the game engine, computing the fear level of the player and adjusting the gameplay in order to maintain a precise one: if a player has no fear, spawn more monsters or adjust the lightning of the scene, and vice versa if player is too scared.

The main advantage of this approach is the fact that the feedback is gathered using varied monitoring devices, which provides a quantitative measure of several psychophysiological features of the player that can be aggregated in some way to compute the emotional state of the player as a number. However, the use of hardware monitoring devices might be uncomfortable to the player, influencing her/his emotional state, hence distorting the measurements. This is the main issue that is being tackled by the community of affective game research, either by developing less intrusive measuring devices or using machine learning techniques to reduce their use.

In summary, direct feedback approach transforms psychophysiological features of players, measured through hardware devices, into emotional states that, in turn, influence the gameplay of the affective game.

On the other hand, indirect feedback approach tries to overcome the issues of the aforementioned direct approach, that is, the nuisance of using hardware devices while playing as well as the distortion provoked by these devices into the computed emotional state. To achieve this, emotions have to be inferred from indirect features such as how the player is pressing the buttons of a gamepad (keyboard or mouse), or how is she/he moving the main character, making this approach not as straightforward as the former.

For instance, an affective game that estimates a player's level of frustration by analysing the movements she/he makes within the game should rely on this category. Instead of measuring sweating level or heart-rate, the system builds up a frustration model based on the movements and behaviour of the avatar controlled by the player.

As stated before, this approach removes the necessity of hardware monitoring devices, which is an advantage over the biofeedback approach. This situation improves the distribution and infrastructure of affective games, as the emotional state of the player is determined by the game itself. However, the emotional feedback must be correctly defined in order to obtain reliable results, something that is not always possible. So the main disadvantage of this approach is that the definition and tuning of the emotional feedback might be a difficult and time-consuming task.

To wrap things up, the approaches we found in the literature regarding affective games can be defined as direct and indirect feedback, according to how those games estimate the emotional state of players. The former consists of measuring biological features such as galvanic skin response and heart-rate,

while the latter involves emotional modelling as well as analysing the behaviour of the player within the game.

## 2.2. Scope

As stated before, there is a core feature that gives meaning to the term ‘affective’ in this kind of games: the affective game feedback loop, summarised in Figure 1. Basically, the game loop comprises four stages: player expresses emotions, the game gathers them, there is an adaptation of the gameplay and, finally, the player satisfaction is increased. This establishes another distinction over the currently published work on this topic, depending on which stages of the feedback loop a paper deals with.

A work may be focused on how to detect and measure the affective state of the player. This is a very important topic within the community, not only due to the high number of published papers but for the great number of problems still to be solved. In this sense, many researchers have focused on improving and designing new monitoring hardware to gather emotional information from the player in a more precise manner, while others have developed and benchmarked new techniques for emotional modelling. Despite the efforts made by the community within this category, there are still many problems to solve, such as the precision of the computed emotional state as well as the intrusive monitoring mechanisms that alter this emotional state.

On the other hand, researchers may focus on the ‘game’ part of affective games, precisely on the adaptation stage that adjust the gameplay according to the perceived emotional state. Some examples of this kind of works are developing new gameplay mechanics capable of trigger new emotions on the players, and devising algorithms that adapt the game to the perceived emotional status of the player. Regarding this category, there is an interesting symbiosis between affective games and procedural content generation research communities [12], as the former could use the techniques developed by the latter as a way to automatically create new content for the videogame that is suitable for the emotional state of the player.

Finally, there are some authors that decided to deal with the problem as a whole, providing integral solutions. For instance, an author may present a complete affective game approach that covers both the feedback and the game adaptation.

Putting all together, regarding the scope of the paper, we propose three categories with respect to the stage of the affective game loop they try to solve: detection and measure of the player’s affective state, adapting the gameplay to that state, and an integral approach that deals with both stages.

## 3. Survey of Affective Games

In this section we make a revision on published research regarding affective games. Although we have tried to do our best to keep this as broad as possible, we cannot guarantee that the survey covers all published research in the area.

In order to select which papers in the literature should be part of this review we initially select the paper by Bersak et al. [13] as a seed paper, mainly because is one of the first papers that deals with the concept of *affective games*. Secondly, we reviewed every paper that cited the seed and whose topic is directly related to affective games. Then, we recursively repeat the search over the papers that cited those selected in the previous step until no new paper was found. All the searches have been performed using Google Scholar. Taking into account this paper as the 'starting point', all of the literature revision has been done from 2001 to 2017 for those papers related to affective games (only some few classical citations related to Affective Computing, before this period, have been included).

The survey is structured as follows: firstly, it examines the published work whose feedback is direct and then it proceeds with those that use indirect feedback, following the classification in 2.1. Within each of these categories the survey discriminates the papers according to their Scope, again following the classes described in 2.2. Finally, we tried to analyse the papers in approximate chronological order.

### 3.1. Direct feedback

According to the previously proposed taxonomy, following there is a review and analysis of those papers that are related in some way to gathering the current emotional state of the player through direct feedback from sensors, that is, obtaining values from hardware devices capable of measuring varied biological features.

#### 3.1.1. Detection and measure of the player's affective state

Due to the origin of affective games, i.e. affective computing, early work in this area focused on how to improve the way computers measured emotions. For instance, Scheirer et al. [14] proposed a system capable of synchronizing and gathering data for affective analysis. The system combined physiological data, such as skin conductivity and blood volume pressure, and behavioural data, namely mouse-clicking patterns, to build a Hidden Markov Model classifier of affective features. Skin conductance is a hot topic when dealing with direct feedback, as shown by the large number of papers discussing and using it [15].

In addition to those already mentioned, it is possible to find in the literature other physiological factors susceptible of being employed in the development of an affective game. Mandryk et al. [16–19] deeply studied the efficiency of several physiological measures as evaluators of collaborative entertainment technologies. In this case, the authors used the following measures: galvanic skin response, electrocardiography, respiration, heart rate, inter-beat interval and electromyography<sup>2</sup> of the jaw. The latter was also used by Hazlett and L. [20], who used facial electromyography as a measure of emotional valence and

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<sup>2</sup>Electromyography (EMG) measures muscle activity by detecting surface voltages that occur when a muscle is contracted.

demonstrated its ability to reflect the player's positive emotional state during a simple racing game.

Paper(s)	Topic
Scheirer et al. [14]	Skin conductivity, blood pressure and mouse patterns for affective analysis
Sakurazawa et al. [15]	Skin conductance response as emotional state detector
Mandryk et al. [16–19]	Efficiency of several physiological measures
Hazlett and L. [20]	Facial electromyography
Nacke and Lindley [21], Nacke et al. [22, 23]	Multiple measures and flow between affective states
Perez Martínez et al. [24]	Generality of physiological features
Ravaja et al. [25], Drachen et al. [26], Levillain et al. [27], Wu and Lin [28], Gualeni et al. [29], Vachiratamporn et al. [30], Martey et al. [31], Abhishek and Suma [32], Landowska and Wróbel [33], Li et al. [34]	Applications of physiological measures
Giakoumis et al. [35]	Automated boredom detection
Chanel et al. [36, 37], Nogueira et al. [38]	Machine-learning classifiers for emotional states
Jones and Sutherland [39]	Emotion detection from player's voice
Garner and Grimshaw [40], Nacke et al. [41], Nacke and Grimshaw [42]	Effect of the sound in players' fear level
Christy and Kuncheva [43]	Computer mouse with affective detection

Table 1: Summary of reviewed papers in **Direct feedback→Detecting and measure of player's affective state** and their respective topics.

Going a step further, Nacke and Lindley [21], Nacke et al. [22, 23] studied how to measure the global player experience while playing a game analysing the same physiological metrics as before: electromyography, electrodermal activity and so on. Regarding the player experience, the authors measured the flow between varied affective states, such as anxiety, apathy and boredom. In line with the previous work, Perez Martínez et al. [24] performed an study on the generality of affective preference models built on physiological features using two dissimilar games as test-beds. They found that the minimum and average heart rate are able to produce good estimators of players' emotional state.

There are many other papers that use and study those physiological factors as well, although they describe primarily the application of these factor to varied



games and/or learning methods: Ravaja et al. [25], Drachen et al. [26], Levillain et al. [27], Wu and Lin [28], Gualeni et al. [29], Vachiratamporn et al. [30], Martey et al. [31], Abhishek and Suma [32], Landowska and Wróbel [33], Li et al. [34], Giakoumis et al. [35] with the automated boredom detection, Chanel et al. [36, 37] presenting a classifier for emotional classes, and Nogueira et al. [38] with a classifier of different levels of arousal and valence.

In addition to those broadly studied measures, Jones and Sutherland [39] presented a system capable of calculate 40 acoustic features from the voice of a player, such as pitch, gain, and intonation. According to those features the system can infer the emotional state of the player, namely boredom, frustration, sadness, happiness and surprise. The system was evaluated with a custom game and the results showed that it is able to recognise the emotion portrayed by the player adequately. The sound is a key element also in [40–42]; the authors analysed the effect the sound of a videogame has on the player's fear level.

In an attempt to reduce the obtrusiveness of measuring devices, Christy and Kuncheva [43] designed a fully functional mouse capable of measuring clean physiological signals from the player in real time while playing a videogame. The mouse contains sensors for the temperature, galvanic skin response and heartbeat frequency.

As summarised in Table 1, several methods to measure and detect emotional information from the player have been presented and analysed in the literature. All of them share the same fundamental problem, the obtrusiveness, so this is the main problem the community should tackle during the next years.

### 3.1.2. *Gameplay and adaptation*

Regarding this approach, Gilleade and Allanson [44] described a Software Development Kit (SDK) to enable the interactions between machine and man hence monitoring the player's psychological condition and modifying the game in consequence. Precisely, there are three exploitable gaming components: difficulty, story and music. Regarding player states, the SDK detects the following: bored, tired, content, excited and ecstasy, according to the player's heart-rate. The same author published a paper in 2004 [45] discussing how to use frustration in the design of adaptive videogames as well as the ongoing research into its detection and measurement. Furthermore, they found two dimensions of gaming frustration: at-game and in-game. Their experiment monitored error rates, button pressure, gamepad grip and tilt, vibration, swing and game progression, in order to measure the frustration of the player.

Two years later, Gilleade et al. [46] described the fundamentals of affective gaming from a physiological point of view. It also grounded these findings using a biofeedback-based affective game. The main contribution of the paper are three game design rules tightly related to affective games that may help the designers: assist me, challenge me and emote me (ACE). This kind of games should identify the player's frustration and help her/his (assist me). On the other hand, an insufficient level of challenge may lead to the player losing interest in the game (challenge me). Finally, affective games should succeed in providing an effective emotional experience.

Paper(s)	Topic
Gilleade and Allanson [44] [45]	SDK for emotional feedback loop Player's frustration detection and game's adaptation to it
Gilleade et al. [46]	Game design principles for affective games
Dekker and Champion [47]	Horror-games enhancing through af- fective detection
Liu et al. [48], Rani et al. [49]	Automated difficulty level adjustment through player's anxiety
Tognetti et al. [50]	Affective Games data benchmark
Balducci et al. [51, 52]	Level design evaluation from affective analysis
Martínez et al. [53], Yannakakis et al. [54]	Affective camera control in 3D games

Table 2: Summary of reviewed papers in **Direct feedback→Gameplay and adaptation** and their respective topics.

Dekker and Champion [47] focused on how to enhance a horror themed video-game using biofeedback gathered from the player, namely heart rate variability and skin response information. The authors come out with some enhancements to the game at two levels: gameplay and artificial intelligence of the non-playable characters. Regarding the former, the speed of movement of the avatar and its invisibility was based on the player's heartbeat and skin response, respectively.

On the other hand, dynamic difficulty adjustment is an active research topic within the community. As a mechanism to adapt the game experience to the player, Liu et al. [48], Rani et al. [49] described in their paper a system that adapts the difficulty level of games according to the anxiety measured from the player using the canonical physiological factors.

Tognetti et al. [50] compiled a dataset of physiological data, questionnaire answers, preferences and video logs gathered from players of a racing videogame. This dataset can be used as a data benchmark in which varied techniques should be applied and validated.

Beyond using physiological metrics to adapt the videogame to the player emotional state or induce emotions to her/his, it is possible to find in the literature additional applications. For instance, Balducci et al. [51, 52] used several affective metrics to evaluate the level design of *Neverwinter Nights 2*, a role-playing game. In this case, the authors used brain signals measured with a cheap neuro-signal acquisition and processing wireless headset known as Emotiv EPOC Headset. Another example is the paper by Martínez et al. [53], Yannakakis et al. [54], who studied how to control the camera in a 3D videogame depending on the psychophysiological measures obtained from the

player.

Table 2 summarizes the contributions in this category. The point is that papers in this category have, in essence, two objectives: defining new gameplay mechanics and software libraries that ease the adaptation of the affective game to the emotional feedback, and checking if they are working properly.

### 3.1.3. Integral approach

One of the the first research paper that provides a comprehensive approach appeared at the beginning of this century, precisely 2001. Bersak et al. [13] presented a direct feedback demonstration through a simple videogame called ‘Relax-to-Win’. In this game, each player take control of a dragon in a virtual race-track. Players’ stress level is measured by their galvanic skin response, that is, measuring the level of sweating. Depending on that, the dragon moves slower or faster. A similar approach is described in [55], that is, an affective game that used biofeedback to measure the stress level and training relaxation.

The velocity of the character is also adapted to the emotional state of the player in EMO-P, an adaptation of Pac-Man developed by Tijs et al. [56]. In this case, there is a difficulty adjustment according to the biofeedback perceived from the player. Although this paper includes some kind of indirect feedback, most of the variables taken in account are physiological, hence is should be considered as an integral approach not in 3.2 but this section. Another use of Pac-Man can be found in [57], in order to induce frustration to the player and analyse the effects on the electroencephalogram.

Paper(s)	Topic
Bersak et al. [13], Chittaro and Sioni [55]	Games based on player’s stress level
Tijs et al. [56], Reuderink et al. [57]	Affective versions of Pac-Man
Becker-Asano et al. [58], Becker-Asano [59]	Card game with an affective virtual agent
Toups and Graeber [60]	Rogue-like predator-pray game controlled by the stress level
Munekata et al. [61]	Action game affected by player’s stress level
Bontchev and Vassileva [62]	Game whose lightning is affected by player’s affective state

Table 3: Summary of reviewed papers in **Direct feedback→Integral approach** and their respective topics.

Becker-Asano et al. [58], Becker-Asano [59] followed also an integral approach, creating a card game as an interaction scenario for a 3D humanoid empathic agent. The work is divided into two independent building blocks: an emotion simulation system to enable Max, the empathic agent, to express

emotion to the player; and a real-time system to gather physiological user information. See [63] for a review on intelligent virtual humans.

Toups and Graeber [60] developed a prototype videogame, PhysiRogue, that integrated psychophysiological measures within the gameplay and in which players are divided into predators and preys, so the former should catch the latter. The game used electromyography and electrodermal activity to measure the stress level of players, which also adjusts the desirability of preys in a way that those players with higher stress levels are more likely to be captured by predators.

Another integral approach was presented by MuneKata et al. [61] as a biofeedback game. Players have to kill flies moving a game controller with the shape of a katana. In the meantime, physiological measures are gathered to assess the player's level of relax, if it is high or low enough, flies will disappear or come back, respectively.

"Rush for gold" [62] is defined by its authors as an emotionally-adaptive applied game that uses the galvanic skin response of the player to assess her/his arousal level. The game uses this information to apply a positive affective feedback loop for dynamic adjustment of difficulty and ambient light intensity.

As shown in Table 3, there have been several proposals that used an integral approach. After reviewing them, we can conclude that, although interesting, they represent only the initial steps towards the development of commercial-like affective games. We think that this should be a priority target within the research community in order to attract new researchers and the gaming industry to the field.

### 3.2. Indirect feedback

Following, the reader can find a review of those papers from the affective game research community that follows an indirect feedback approach, as defined in Section 2. Indirect feedback refers to computing the emotional state of the player without gathering biological features from her/him.

#### 3.2.1. Detection and measure of the player's affective state

Opposite to the direct feedback related papers, indirect feedback goes a step further in the detection and measure of the player's affective state. In this case, researchers developed techniques that are not as straightforward as those reviewed in 3.1. Sykes and Brown [2] were able to determine the level of a game player's arousal only by the pressure they use when controlling the gamepad and pushing buttons. It was difficult to find out if this arousal state was positive or negative, though. The experiment was designed as follows: ten players were asked to play three levels with different difficulty in random order and then, the pressure used by the player was gathered and compared to the difficulty level. As with the gamepad, Park et al. [64] used the pressure made by the player over a touchpad to detect the player's affective state.

Following a similar approach, the paper by van den Hoogen et al. [65, 66, 67] studied the relationship between player's emotional experience and their behavioural measures, that is postural movements and button pressure patterns.

Paper(s)	Topic
Sykes and Brown [2], Park et al. [64]	Gamepad and button pressure to detect emotion
van den Hoogen et al. [65, 66, 67]	Postural behaviour and pressure patterns
Marsh et al. [68]	Detecting game design problems through player behaviour
Asteriadis et al. [69]	Player's face and expressions
McQuiggan et al. [70]	Prediction of the physiological response
Yang et al. [71]	Position, triggered events and point of view
Tychsen and Canossa [72], Canossa [73]	"Play-personas": models of how players interact with the game
Kim and Doh [74]	Detection of patterns of players' emotional responses

Table 4: Summary of reviewed papers in **Indirect feedback**→**Detection and measure of the player's affective state** and their respective topics.

Adjusting the level of difficulty, they found automatically captured body movement and pressure on the interface device to be highest in the most difficult level. Another approach to player behaviour modelling was presented by Marsh et al. [68]. Precisely, the authors described an automated way to identify design problems in games through the aforementioned player behaviour.

Imagery of human faces and expressions have been also used to assess the emotional state of a player, as in the paper by Asteriadis et al. [69]. The authors aimed at identifying player frustration and engagement as well as the challenge imposed by the game to adapt the game.

On the other hand, McQuiggan et al. [70] focused on predicting the physiological response of the player instead of trying to model her/his behaviour. They proposed a two-stages framework: training data acquisition using some of the biofeedback techniques in 3.1.1 and learning predictors for the physiological response using machine learning methods.

Yang et al. [71] devised a system to collect, analyse and reason about the player experience and behaviour when interacting with immersive videogames. The authors focused primarily on players' position, triggered events and where they were looking at. In line with this work, Tychsen and Canossa [72], Canossa [73] used game metrics such as position and play style of players to build what they called "play-personas", which are modelled representations of how players interact with the game that can be used to measure their emotional experience.

There is a recent paper by Kim and Doh [74] in which a user-oriented dynamic system to determine qualitatively and measure quantitatively the patterns of players' emotional responses is presented. Furthermore, game de-

velopers may use the system to detect differences in emotional patterns, adding the feedback from the latter into the narrative.

The main trend followed by the papers in this category is how to detect and analyse certain behavioural patterns and relate them to the emotional state of the player. This is an advantage over the intrusive methods devised in the category of direct feedback, since the player does not even have to know that she/he is being monitored. However, researchers might focus their efforts in improving a better relationship between those behavioural patterns and also how they link to emotions. Refer to Table 4 for a summary of the contributions.

### 3.2.2. *Gameplay and adaptation*

Initial studies on modelling the behaviour of the player and how to design adaptive videogames were performed by Charles et al. [75] and Sykes and Federoff [76] in 2005 and 2006, respectively. On the other hand, Hudlicka [77], Hudlicka and Broekens [78], Hudlicka [79] performed a deep study on how to model emotions and improve the consistency between it and gaming architectures. The papers then discuss how these computational building blocks can provide a basis for the development of more systematic guidelines for affective model development. In the end, the papers provide a computational analytical framework and design guidelines to emotion modelling. In line with the aforementioned papers, Baharom et al. [80, 81] presented a conceptual framework of emotional design to assist in the development of affective games.

Paper(s)	Topic
Charles et al. [75], Sykes and Federoff [76]	Initial studies on adaptive game design
Hudlicka [77], Hudlicka and Broekens [78], Hudlicka [79]	Design guidelines to emotion modelling
Baharom et al. [80, 81]	Conceptual framework of emotional design
Shaker et al. [82, 83]	Dataset: game events and recorded video sessions
Pereira et al. [84]	Contagion of emotions between non-playable characters

Table 5: Summary of reviewed papers in **Indirect feedback→Gameplay and adaptation** and their respective topics.

Furthermore, Shaker et al. [82, 83] published an interesting approach in 2011: a dataset of game events and recorded video sessions from human players while playing a videogame. This dataset can be used by other researchers to analyse the relationship between the game context and the players' behaviour and affective state.

Although most of the work in this area focuses on the modelling of the

player's emotions, there is a paper [84] that changes the focus to the non-playable characters. In this paper, the authors presented a system that models the contagion of emotions between the intelligent agents. This way, players perceive a more natural behaviour from the agents hence improving their game experience and the way the game induces emotions to them.

In conclusion and, as happened with the direct feedback, most of the papers in this category focus on new design guidelines and frameworks to improve the way the affective game adapts itself to the emotions expressed by the player (see Table 5).

### 3.2.3. Integral approach

Paper(s)	Topic
Lankes et al. [85]	EmoFlowers: indirect feedback to improve user experience
Lara-Cabrera et al. [86, 87]	Automated generation of aesthetic game content

Table 6: Summary of reviewed papers in **Indirect feedback**→**Integral approach** and their respective topics.

We barely found papers in the literature that presented an integral approach using indirect feedback. Lankes et al. [85] combined both an emotional feedback system based on face recognition, icons and game status and a custom videogame, EmoFlowers, to improve the user experience and effectiveness. The videogame was tested in a shopping centre during a three-day experiment. Results revealed that most of the participants reported to have a positive user experience while playing and that the game had an impact on their mood.

On the other hand, [86, 87] described an interesting approach that focuses on the automated generation of aesthetic maps and levels for a real-time strategy game. The idea of generating maps with good aesthetics fits with the objective of the affective games that is provoking certain emotions to the player; in this case, evoking positive feelings through the aesthetics of the maps.

Clearly, this is the least exploited category in the field, with just three papers (see Table 6). As with the integral approach using direct feedback, researchers might focus on this integral approach in order to make affective games an attractive field of research and also filling the gap between academia and industry.

### 3.3. Analysis of the state of the art

After the review of the papers, we conducted a study on different aspects of these papers to get a fuller picture of the state of the art. Firstly, we analysed when were published the papers of the review to find trends as well as to get a glimpse of the activity in the affective games research community. As shown in Figure 3a, there is no clear trend in the number of published papers per year. In fact, the time line is dominated by three peaks in the number of papers

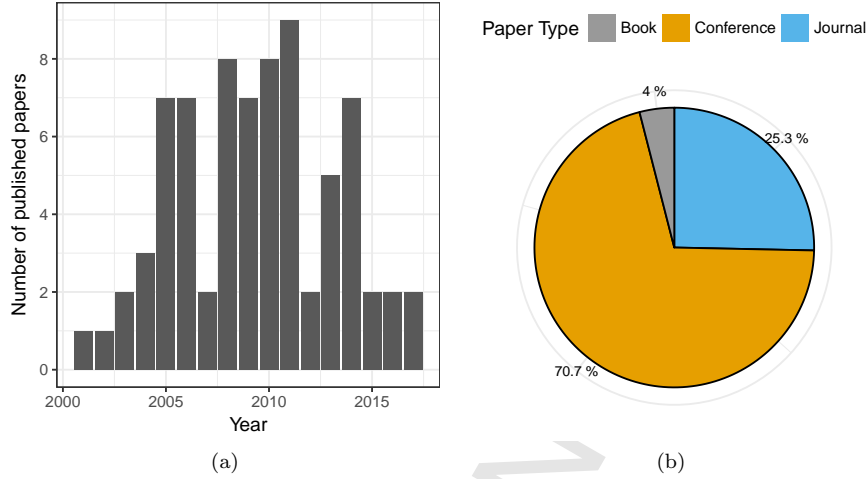


Figure 3: (a) Publication year of the reviewed papers and (b) type of contribution.

around 2005, 2010 and 2014. Although it might seem that the field is losing interest from the research community, as seen in the low number of papers published in recent years, this might be just a side effect provoked by the way the bibliographic databases gather the papers. These observations suggest that, due to its relative novelty, the field is still under development and has not yet reached a critical mass. Hence, making a better dissemination of the results and attracting new researchers to the field is an interesting objective to accomplish.

	Direct feedback	Indirect feedback
Detection and measure	[14–43] (30)	[2, 64–74] (12)
Gameplay and adaptation	[44–54] (11)	[75–84] (10)
Integral approach	[13, 55–62] (9)	[85–87] (3)

Table 7: Distribution of the reviewed papers (and total number of papers per category) according to the proposed taxonomy.

On the other hand, we performed an study on the source of the reviewed works, in a sense of where did they come from: book, conference or journal. Figure 3b shows that nearly a 71% and 25% of the papers were published in a conference and in a journal, respectively. There is a marginal 4% of the publications that are books. This is due to the lack of specialised journals with a high impact devoted to Affective Games. Nevertheless, authors may publish their papers in journals related to Affective Computing.

Finally, in order to obtain the big picture of the state of the art, we performed an analysis on how the reviewed contributions spread over the categories of the proposed taxonomy. As shown in Figure 4, there are twice as paper using a



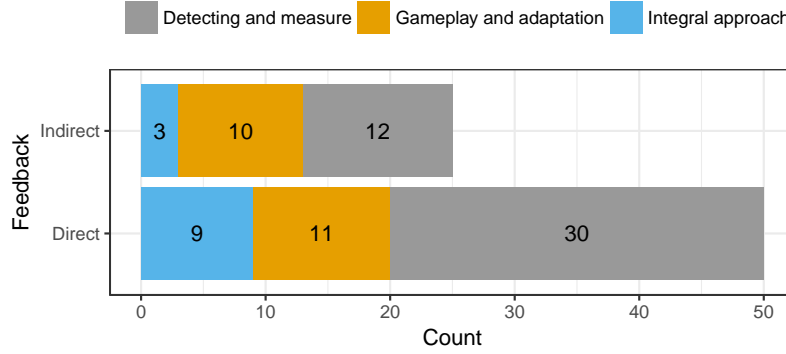


Figure 4: Number of papers for each category: feedback and scope. The number inside the bar is the number of papers categorised as that combination of feedback type and scope.

direct feedback approach than those using an indirect one, which highlights where efforts have been put on in recent years. Regarding the scope, most of the papers deal with the problem of detecting and measure the emotional state of the player, specially in the case of papers with a direct feedback approach. Another interesting observation is the low number of papers with an integral scope, which, in the case of indirect approach, is especially low.

With these observations in mind, it seems appropriate that the authors focus their works on those categories that are least represented within the state of the art, that is, studying integral approaches as well as new ways of adaptation for affective gaming through indirect feedback mechanisms.

#### 4. Conclusions and Outlook

In this paper, we propose a taxonomy for research on Affective Games according to the kind of feedback and the scope of the study. The former category make a distinction between **direct feedback**, which is obtained through biometric sensors attached to the player, and **indirect feedback**, in which the emotional state of the player is inferred from behavioural (game interactions) features. Regarding the scope of the work, there are three sub-categories, according to which stage of the affective game feedback loop is focused on. In this case, the scope might be the detection and measure of the player's emotional state, the gameplay and adaptation mechanics, and an integral approach, dealing with the problem as a whole. Furthermore, we made a survey on published research regarding affective games, whose selection criteria has been previously described in Section 3.

According to the analysis in Section 3.3, it seems that the research field is still under development, due to the relative novelty of affective games. There is also a strong trend to publish in conferences rather than journals and books, with almost three out of four papers published in conferences.

Regarding how the reviewed contributions spread over the taxonomy categories, as shown in Figure 4 and Table 7, most of the papers deal with the detection and measure of the player's affective state using psychophysiological metrics and signals. In fact, most of them used systematically the same signals: galvanic skin response, heartbeat rate, electromyography of facial muscles and brain waves. Furthermore, we found many papers that described the application of those signals to varied videogames in order to check their effectiveness. Related to gameplay and adaptation, there are several works that describe game design principles to assimilate the direct feedback into the gaming-loop and also provides some kind of framework to help the developers. Concerning the last sub-category, we found several interesting integral approaches, although the presented games relied mainly on the stress level, which indicates an interesting field for future work, i.e. incorporating new feelings and emotions to games beyond the stress level.

On the other hand, indirect feedback papers that lies on the category of detection and measure are also the most numerous, although the difference with gameplay and adaptation is not so big. Direct feedback papers, both detection and gameplay adjustment, focused primarily on building a model of the player behaviour, using the players' postural behaviour as well as how they move their playable characters to estimate and compute their emotional state. An interesting observation: we found few examples of papers that follow an integral approach when dealing with indirect feedback, in contrast to those that used a direct approach, which points out one of the possible paths to follow by the community.

Beyond the aforementioned topics for future work, there is an interesting problem to tackle: the obtrusiveness of the data gathering methods, specially those in the direct feedback category. In order to obtain the psychophysiological metrics, players are required to wear complex devices on hands and head, as well as cameras recording your body, which may interfere with their emotional state hence introducing biases to the feedback.

Putting it all together, the main challenges that we have been found for the affective games community are the following: including new feelings to games beyond the broadly used stress level, designing and testing new gameplay mechanics to improve the adaptation of the game to the emotional state of the player, which should be determined with less intrusive techniques and indirect feedback.

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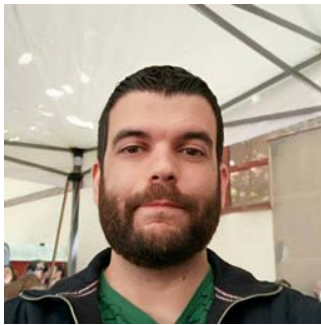
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- This paper proposes a taxonomy for research on affective games
- A review on the most relevant published Works in affective games is presented
- Important research problem that are yet open and might be tackled in future research are described

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