Engaging Casual Games That Frustrate You

An Exploration on Understanding Engaging Frustrating Casual Games

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ABSTRACT

This paper is an exploration on why it is possible to have gameplay experiences that are perceived to be simultaneously engaging and frustrating. In particular, the paper leverages psychological theories on cognitive biases, rewards, frustration, and its neurobiology. In the paper, (1) important terms such as frustration, engagement and casual games are explicitly defined in order to prevent ambiguity. (2) Distinct types of (positive) frustration are informally classified. (3) The neurobiology of rewards is explained in the casual gaming context, in combination with the idea that neurobiologically *wanting* something does not imply *liking* it. (4) The game-design principles of slot machines are stated in the context of addiction, and linked to design principles in casual games. (5) The previous perspectives are synthesised into a case study in which the casual game Flappy Bird is analysed through the lens of neurobiology and findings from research on cognitive biases. (6) Within the context of a (casual) game, three game mechanics are discussed as to how they constitute an engaging-frustrating experience (randomness in a slot machine game, movement in Flappy Bird and time in Super Mario Bros.).

(1) and (2) are presented to define and debunk the current views about frustration. It is arguably an unpleasant feeling. However, it is not a negative element for game-design per se as it can amplify: meaning, determination of the player and the feeling of almost winning. (3) Shows that sub-conscious wanting and liking are anatomically separate. Furthermore, operant conditioning and near-misses are mainly involved with the wanting-pathway. (4) and (5) present that the interpretation of game events are possibly modified by cognitive biases; this idea has been used by slot machine designers ever since the slot machine industry became big. The results from (6) indicate that game mechanics can contribute differently to game dynamics. On the other hand, game dynamics need to stay the same, otherwise the aesthetic player experience changes. It furthermore, describes an example on how to tweak Mario Bros. into a potentially frustrating-engaging game.

Derived from the presented perspectives and the investigated psychological theories, we suggest that a potent explanation for some games being perceived as simultaneously engaging and frustrating, is a *(purposely?) dissociated neural activation of the liking- and wanting-pathways*. That is, the current state of psychological literature suggests that in engaging frustrating casual games, the neurobiological conditions may be created in which, informally speaking, the dopaminergic wanting-pathways are being stimulated (e.g., via operant conditioning and the effects of near misses), while the liking-pathways are not being stimulated. We discuss that such behavioural conditioning may be enforced via several important cognitive biases. Indeed, this calls for drawing another parallel between drug addiction, and play behaviour in which liking may be barely exhibited (cf. [27, 71, 74]).

Keywords

Psychological foundations, Neurobiology, Engagement, Frustration, Casual Games

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1. INTRODUCTION

The present paper aims to contribute to the psychological foundation of game design principles, by providing an understanding on the interplay of engagement and frustration. Particularly, the paper provides an exploration on why is it possible to have gameplay experiences that are perceived to be *simultaneously engaging and frustrating*.

Indeed, in the field of psychology this is a still under-explored phenomenon. The literature in this field has the perspective that frustration is a negative emotion (i.e. negative affect) (*cf.* e.g., [57]). Furthermore, and interestingly, while so-called flow states have been well investigated [20], frustration in itself is not a widely studied phenomenon. That is, frustration is primarily considered for the frustration-aggression hypothesis [57, 11, 53, 39], which states that aggression is the result of blocking, or frustrating, a person's efforts to attain a goal.

However, numerous recently released games have demonstrated – seemingly paradoxically – that simultaneous engagement and frustration can positively affect the gameplay experience. Examples of such engaging yet frustrating games are Dark Souls, Flappy Bird, and Swing Copters. The popularity of these games is not new. Even games that are foremost frustrating can become popular and a commercial success. For example, in 1986 the game Takeshi no Chōsenjō (Takeshi's Challenge) was released in Japan; it became a commercial success (it sold 800,000 copies), and gathered a cult following around its reputation of being one of the worst games in history [26]. Because of this cult status, numerous game players purposely set out to beat the game.[1]

In terms of scope, the engagement and frustration that is explored in this paper, is focused on *simple casual games* such as Flappy Bird. Indeed, these games are more readily analysable than the generally more multi-faceted AAA titles such as Dark Souls. Furthermore, only the player playing the game is analyzed; spectators or social processes beyond the game are not. This means that this exploration is mostly suitable for use cases where players play alone and offline. The results and ideas presented in this paper may help subsequent analyses that would include spectators and other social processes that could occur.

1.1 Contents of Paper

The exploration that is presented next is structured through various perspectives. First, we outline the methodology of this paper (Section 2). Second, we provide a working definition of engagement and frustration (Section 3). Third, we present the types of positive frustrations that a player can experience (Section 4). Fourth, we discuss how rewards are related to certain areas in the brain (Section 5). Fifth, we explore the relevant similarities between slot machines and casual games (Section 6). Sixth, we synthesise our theoretical findings via an analysis of the simple casual game Flappy Bird; leveraging established psychological theories (Section 7). Seventh, we analyze how three chosen mechanics (randomness, movement and time) could be tweaked for a frustrating-engaging game experience (Section 8). Eighth, we suggest a psychologically-founded explanation on the seemingly paradoxical engaging frustrating game phenomenon (Section 9). Finally, we discuss some implications, future work and limitations in the discussion (Section 10).

[1]An impression of this highly frustrating game is available on http://www.youtube.com/watch?v=m6MIlJYiJUs

2. METHODOLOGY

As stated before, the main question of this paper is: why is it possible to have gameplay experiences that are perceived to be simultaneously engaging and frustrating? Our approach to answering this question is guided by three academic – and related – disciplines: psychology, neuroscience and game studies. These three disciplines are suited to have an individual player (and its brain) or game (mechanics and dynamics) as the unit of analysis. So each discipline has its own distinct role to play.

The next section will outline and justify the approach of how the main question will be answered (2.1). Then, an elaboration how psychology, neuroscience and game studies interrelate to this question will be presented (2.2). Furthermore, a relevant introduction to neuroscience is given in order to make later research findings more understandable (2.3). From the field of neurophilosophy, it will be argued why brain scans and studies on the brain can be seen as a materialistic version of the study about the mind (2.4). Finally, in order to have a shared vocabulary about game-design and game analysis, a framework will be explained and slightly adapted to make the vocabulary more univocal (2.5).

2.1 Approach to answer main question

The framework that we have chosen is: define → debunk → explain → apply. At first, *definitions* need to be given in order to have a good understanding of what important terms mean for the question at hand. Then, the misconceptions of current notions about frustration need to be stated (i.e. *debunked*) through counter examples and the experience of frustration itself will be nuanced. After the debunk step, any relevant *explanation* available for the existence of these counter examples need to be given. These explanations will not be comprehensive, because perhaps there is no possible explanation for a specific counter example. Finally, a new theory emerges and it needs to be shown how this theory *applies* to the current issue at hand.

More specifically, in our paper we start by defining the most important terms related to what constitutes a frustrating-engaging gameplay experience (Section 3). After key terms are defined, an initial exploration exemplifies how frustration can enhance any experience (Section 4). Then, a neuroscientific review will explain how some examples and related processes work in the human brain (Section 5). Furthermore, this will be supported by showcasing best practices from an unexpected game-design discipline that has tacit knowledge about the main question (slot machines, Section 6). Moreover, a case study shows how most of these theories can be seen in a casual game (Section 7). Finally, the ideas from previous discussed chapters will suggest how specific game mechanics could provide a simultaneously engaging and frustrating experience (Section 8).

A second role – which is a process that runs parallel to the main framework – is to continually explore. For example, it might be the case that neuroscience shows insights into distinct new counter examples compared to the previous chapter. So sections 4 to 8 have two functions, which are to support previous and future chapters and also to expand on the current body of knowledge presented in previous and future chapters. The advantage of this broad approach is that more distinct elements of an engaging-frustrating gameplay experience can be found. A disadvantage is that each element has not the same level of scientific explanation.

The specific questions and chapters are summarized in table 1. Furthermore, the respective disciplines with relevant findings for these questions and its primary role in the framework are stated as well. Only the disciplines that the authors have extensive knowledge of are stated. Other possible disciplines that could have been of use are: art, sociology, media studies, anthropology and language studies, but findings from these disciplines were not taken into account for this first exploration.

The reader is supposed to be a bit familiar with social science, psychology and game studies, since human-computer interaction draws heavily from these disciplines. If this is not the case then the book Social Psychology from Myers, Abell, Kolstad and Sani is recommended [53]. It is recommended to read sections about biases and operant conditioning. If the reader only wants an introduction to cognitive biases in general (discussed from Section 5 and onward), then the article of Kahneman and Klein is recommended [36] for a quick overview. There are no recommendations with regards to game studies besides the references found in this paper. Perhaps this is because the field is too idiosyncratic and too young to fit in a book or in one article.

2.2 The relationship between psychology, neuroscience and game studies

Psychology explains the mental processes and behavior of humans. Since the experiences of frustration and engagement are psychological phenomena, it is a well suited perspective to use. Especially the concept of frustration seems to be mostly studied in psychological literature, whereas the concept of engagement seems to attract a more equal balance of game scholars and psychologists (e.g. a literature review on engagement by game scholars [9] and flow theory from psychologists [20, 55, 54]). This means that psychology is able elucidate implicit assumptions that game scholars and especially game-designers might have about frustration and to a lesser degree about engagement.

Neuroscience aids in the understanding of psychological concepts by studying brain processes. In this exploration it performs two functions. (1) It replicates the findings of psychology and explains possible causal mechanisms. And (2) it might present new findings that are harder to study by merely looking at behavioral and mental processes. Psychology has this function as well in relation to neuroscience, an example of this is that cognitive biases are more easily studied through a psychological lens than a neurosientific one. So both disciplines strengthen and complement each other into answering the main question.

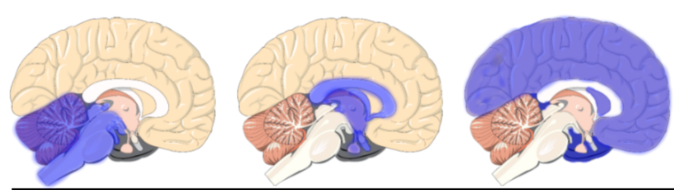
Game studies is the study of games and its players. So it allows us to understand how people interact with games and how games are well-designed for various purposes. The broad research goal of the field has resulted in it being an interdisciplinary science. People from computer science, artificial intelligence, psychology, literature studies, media studies and sociology (among others) are researching games and using game studies research results for various reasons. With regards to answering the paradoxical main question, game studies helps to connect the psychological and neuroscientific theories to the domain of games.

2.3 An introduction to neuroscience

The fundamentals of Human Neuropsychology of Kolb offers an introduction to neuroscience applied by psychologists [39]. As such, the most relevant ideas about the fundamentals of neuroscience were sourced from this book. The ideas in this section are meant for readers who are a bit unfamiliar to the field in order to interpret the results later on. The following information of 2.3 and its more specified sections (e.g. 2.3.1) all comes from that book, unless otherwise specified.

2.3.1 The organization of the brain

One of the most effective approximate explanations of how the brain works is a model of the brain called the triune brain by MacLean [48]. It proposes that the brain itself (spinal cord not included) is organized in three layers. The lowest layer, also called the reptillian complex, regulates processes such as (subconcious) breathing and one's hearbeat. The middle layer, also called the limbic system, which plays the biggest part in regulating emotion. The top layer of the brain, also called the neocortex, regulates every process that includes higher forms of reasoning, such as: spatial reasoning, language reasoning, vision and planning.



Reptilian complex	Paleomammalian complex	Neomammalian complex
Brainstem & Cerebellum	Limbic system	Neocortex
Breathing, heart rate, body temperature, fight or flight (neural response)	Emotions, memories, habits, motivation, fight or flight (hormonal response)	Language, integration of reasoning and sensory inputs (tertiary areas), visuospatial awareness, abstract thought, reasoning

Figure 1: The triune brain. The functions listed[39] are not comprehensive but serve as an example.

Our organization will borrow ideas from MacLean and how Kolb organizes the brain in his book [39]. This organization has four levels, which are called: the brainstem, the basal ganglia, the limbic system and the neocortex. The reptillian complex is divided in two parts. This is because the

Table 1: Summary of questions and reference to chapters.
GS = Game Studies, Psy. = Psychology, Neu. = Neuroscience and Sec. = Section.

Sub-question	Academic discipline	Role	Sec.
What are the definitions of the most important terms?	GS & Psy.	Define	3
What types of positive and negative frustrating might exist?	Social science	Debunk	4
What is the neurobiology of rewards and frustration?	Neu.	Explain	5
What are the general game-design principles for slot machines?	GS & Psy.	Explain	6
Why is Flappy Bird an engaging and frustrating game?	Psy. & previous sections	Explain & apply	7
How could game mechanics add to an engaging-frustrating experience?	Sec. 6 & 7	Apply	8

brainstem regulates functions, which are not important to analyse. Furthermore, the basal ganglia, which plays a role in stimulus-response learning, reward-processing and movement has an intimate connection with the limbic system, unlike the brainstem. The most interesting brain systems that will be discussed about are neuroscientific results about brain regions situated in the basal ganglia (e.g. striatum and nucleus accumbens) which is situated in the limbic system.

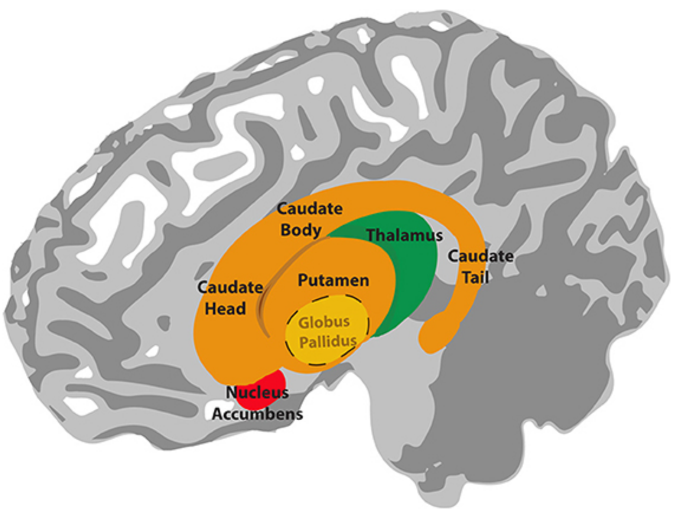


Figure 2: The basal ganglia including its parts. The putamen and all parts of the caudate nucleus are also called the striatum. In the figure they have the same shade of orange.

2.3.2 *Research methods in neuroscience*

While there are many ways of researching the brain, a few methods are of particular importance for understanding the neurobiology of frustration and how it relates to engagement in positive ways. Again, this information is also stated in [39], unless specified otherwise.

The first method is the use of functional Magnetic Resonance Imaging (fMRI). In short, through the use of a magnetic field, an fMRI scans the shortage or surplus of oxygen in the brain. This is possible, because hemoglobin – the main protein that transports oxygen in red blood cells of all mammals – has different magnetic properties when it is oxygenated versus deoxygenated. Unlike other cells, neurons have the unique property that they do not have any internal resources in stock. So every time a neuron fires, the blood flow in that particular area increases, which also means that the amount of oxygenated hemoglobin increases. Through this discovery and the use of statistical methods, researchers discovered they could see which brain areas are more active. The biggest drawback of this method is that causation can never be inferred.

Figure 3: Example of an fMRI scanner.

The second method is an umbrella of methods that involve direct experimentation on animals. The most well-known animal that is used a lot for these type of studies are mice and rats. Methods include single cell recording by drilling a hole in the skull, genetically engineering the brain of a mouse to omit neurons of a specific type in the experimental conditions (also called knockout mice) and damaging certain parts of the brain in order to infer its function (lesion studies).

The advantage of these methods are that causal processes can be inferred, but the biggest scientific disadvantage is the extent to which these results generalize to humans (most of the time they do). For our purposes this disadvantage is not that big of an issue, because every mammal has a basal ganglia and limbic-system that maps pretty well onto other mammals (the big issues arise when the neocortex is involved).

2.4 The justification of using neuroscience

This section will present neurophilosophical arguments as to why neuroscience aids in the understanding of psychological concepts. To do this we outline a very conservative line of thought and try to demonstrate that even then the use of neuroscience is a justified one. This justification is even stronger when a more liberal line of thought is taken (e.g. the mind is the brain). We refrained from doing so, since the conservative approach unravels more implicit assumptions that are then allowed to become explicit. We start out by discussing the idea that the mind and brain are merely correlated through a metaphysical entity. From that position we try to show that this is very likely to not be the case and that the relationship between the mind and the brain is a very close one. We discuss if the relationship is causal or merely correlational. One limitation of this piece, however, is that we are not neurophilosophers. Hence it should be seen as an interdisciplinary piece.

2.4.1 The main argument: the brain and mind are related

At the very least the brain and the mind are correlated to one another. This is very simply shown by looking at all sorts of brain trauma. For example, when someone has a severe traumatic brain injury (i.e. concussion), certain ways of thinking and perceiving become harder or even impossible to do. Every brain injury demonstrates the same principle, an impoverished brain is at least associated with an impoverished mind.

Lets assume for now that the mind and brain are merely correlated. This would have great implications since it would hypothetically allow the mind to be a metaphysical entity. Descartes called it res cogitans in his dualistic framework of how the body and mind influence each other. He furthermore postulated that the pineal gland connected the metaphysical mind to the materialistic body [21]. What the field of neuroscience has demonstrated is that if Descartes claim about the nature of the mind is to be true, then it is the whole brain – and its nerves in the gut and rest of the body – that is connected to the metaphysical mind, not just the pineal gland. It might seem like little progress, but not much more progress could be made, since there are a few problems with the mind-body duality. First of all, how is the claim about the nature of the mind falsifiable? It is not, since metaphysical entities cannot be scrutinized in the physical world. Perhaps our minds live in another dimension and happen to be connected to our brains, we will never know. Furthermore, are there pieces of evidence that hint to the idea of res cogitans? If there is, we missed it. Unfortunately, these questions are outside the domain of science to answer. More importantly, there are interesting alternatives.

One interesting alternative is that the brain causes the mind. Since we are not philosophers it is hard to describe what this exactly means. What we mean by it in the very least is that brain processes cause conscious and sub-conscious experiences within people. For example, evidence shows that cognitive functions like language does not occur when a person is being zapped by magnetic pulses with a Transcranial Magnetic Stimulation device around Broca's area [39]. Another example is Patricia Churchland stating a clinical case of a man having a tumor near a brain area responsible for sexual regulation. He never performed any criminal act, but when he had a sudden sexual interest in children, doctors noted the recent tumor. When the tumor was removed the man's sexual behavior became normal.

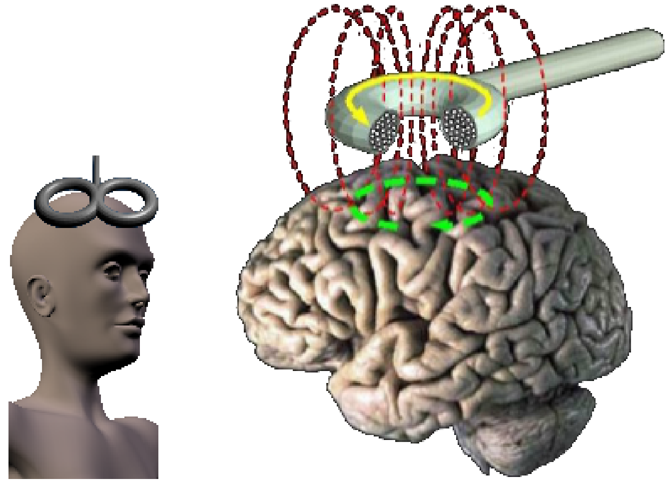


Figure 4: Visual representation of transcranial magnetic stimulation. The left image conveys the therapeutic setting, the right image shows an artistic impression of where the brain is specifically influenced.

On another note, there is also philosophical support through a philosophical line of argumentation called Occam's Razor. It disfavors Descartes idea and favors the idea that the brain is the objective counter part of the mind – the mind itself is the subjective experience of what the brain produces. Occam's Razor roughly means that the most parsimonious model that explains just as much compared to a more elaborate model is the better model of explanation [3]. In this case the idea that the brain and the mind are the same phenomenon is favored through Occam's Razor, because it's the most parsimonious explanation that has not been falsified. Stating that the brain causes the mind seems to be a bit more of a slippery slope, since it is not known how the brain causes the mind or if it is even semantically possible to say that it does. It might become more clear when cognitive scientists and neuroscientists understand how consciousness works since an objective account of consciousness shows insights on the subjective experience of consciousness and the connection between the brain and the mind.

To be pragmatic, we will not distinguish whether the brain causes the mind or if the brain is the mind. We will settle on the position that the mind itself may be an epiphenomenon of processes within the brain, or perhaps the mind is a material substance directly (e.g. the whole brain). There is no res cogitans, only res extensa (material substances). In other words, what we do not know is whether the mind emerges from brain processes or whether the mind and the processes of the brain are the same.

The idea that the mind is something fundamental materialistic is further supported – albeit slightly – by research results on neural networks and perception (mainly computer vision). In the literature review of Yann LeCun, Yoshua Bengio and Geoffrey Hinton [45] it is stated that neural networks on computer vision are performing near human level accuracy on some vision tasks. Andrew Ng talked about researchers who showed data that their neural networks were very close to the biological data of single cell recordings, with regards to vision, sound and touch [2].

2.4.2 Other justifications of using neuroscience

Another reason why neuroscience literature is relevant to game research is because understanding the brain predicts behavior, even when the main findings come from animals. A quality that we can infer about the mammal brain is that all mammal brains are more alike than they are different. Of course, there are differences, especially with higher order functions such as the functions performed in the frontal lobe [39], but the subcortical regions (i.e. everything besides the neocortex) share great similarities. For example, Patricia Churchland explains that Prairie Voles have more oxytocine and vasopresin than montane voles. As a result, prairie voles are monogamous, whereas montaine voles are not. Interestingly the structural and chemical anatomy (e.g. lots of oxytocine and vasopresin) seems to repeat itself in other species as well [16]. Because of this, a lot of neuroscience research is being generalized to humans, since falsification is unlikely [39].

Since the early 2000s this argument can be taken further. It is possible to predict behavior by understanding the brain, because it influences behavior. A very clear example of this is the study of [75]. They developed a brain computer interface to condition the brains of rats directly. Operant conditioning occured by stimulating a left or right whisker, which served as a cue to the rat to turn left or right. When a rat did this its medial forebrain bundle (MFB) was stimulated with a slight shock. Note, the MFB connects the ventral tegmental area to the nucleus accumbens, which all reside in the mesolimbic pathway. So in theory the rat has a choice to respond or not respond to the signal send to their whiskers. But they always move – and consequently receive an electric shock on their MFB [3].

Besides these materialistic, generalizable and behaviorist outlook there is also an advantage to studying the brain. Compared to other fields that involve the study of humans it's the most reductionistic one. Being able to link neural processes to behavior means that there is a possibility the behavior could be linked to chemistry and physics at some point. As a result, research directions could go into building artificial intelligence. Something no other study of human behavior is capable of, except for cognitive science.

2.4.3 Conclusion

So while it is indeed quite hard to argue that the human mind is purely materialistic without making some untested assumptions, this is not the case for the impact of the brain on human behavior. And do game-designers really need to know *exactly* what goes on in another human's mind? It would certainly be nice to know, but is another human mind understandable at all? We will not go into detail, but it is a slippery slope indeed. In conclusion, neuroscience allows us to understand human behavior. It has a very strong relationship with the mind itself and it can reasonably be assumed that it has a profound impact on mind and behavior. Hence the use of neuroscience as a tool for adding knowledge to psychology and illuminating psychological concepts, even from a very conservative standpoint, is justified.

2.5 MDA: a framework about game-design and analysis

The MDA framework (MDA stands for Mechanics, Dynamics and Aesthetics) conceived by Hunicke, LeBlanc and Zubek [33] offers the perspective of which element of the game-design process is being analyzed. The framework aids in the understanding of game-design and game analysis. While the MDA framework is being used less explicitly in the sections, its assumptions and vocabulary are being used nonetheless. At the end of this subsection an overview will be provided as to how each section relates to it.

2.5.1 Justification of choosing the MDA model

Deciding upon a game-design and analysis framework is difficult. Game-design in general has been dubbed as a problem which has "multiple plausible solutions as well as multiple subjective interpretations of such solutions" [59]. Indeed, game-design is a so-called wicked problem. This means that it is up to our subjective interpretation of which game-design and game analysis framework has the most utility since wicked problems are less suitable for scientific analysis compared to the problems defined in natural sciences or engineering.

The reason why the MDA framework has been chosen is because it is a parsimonious framework. Furthermore, the authors of the paper have won game-design awards a few years after publishing their paper and the MDA framework contributed to the guidance of how they would design these games. Most importantly, it helps to contextualize this paper in terms of game analysis, while having a relative straightforward way in how to convert these ideas to game-design since the same framework is being used. For example, it is easier to understand that this paper focuses heavily on game dynamics (Section 3 to 7) as opposed to game mechanics (Section 8) or game aesthetics (Section 3 and 4).

2.5.2 MDA: explanation of the general concept and the unambiguous parts

The framework has been slightly adapted since the original paper [33] did seem to contradict itself slightly on an important definition of a term. Hence the unambiguous ideas from the paper [33] will be explained first. In our opinion these are: the concept in general, the definition of mechanics and the definition of dynamics. Most of this information is available in the paper of Hunicke et al. unless stated otherwise [33].

The general idea of MDA is that a game designer creates a game by providing the mechanics of a game (e.g. the code and assets) and a consumer has an emotionally gratifying experience in playing the game (e.g. the game is fun or very sad, yet emotionally gratifying). This consumer experience could be seen as the aesthetics of a game. In between these two views there are the dynamics of the game. Dynamics can be viewed as the interaction of the player while the game is running (e.g. the causes and effects of what happens when a

[2] See https://www.youtube.com/watch?v=AY4ajbu_G3k

[3] There are some video recordings of this research. See https://www.youtube.com/watch?v=G-jTkqHSWlg

game is played). The intuitive idea is that these three views are causally connected as such:

(1) Mechanics $\xrightarrow{\text{Causes}}$ Dynamics $\xrightarrow{\text{Causes}}$ Aesthetics

(2) Mechanics $\xleftarrow{\text{Caused by}}$ Dynamics $\xleftarrow{\text{Caused by}}$ Aesthetics

(1) Is the view point of the designer for which mechanics are the most tangible and the aesthetic experience of a consumer the most unknown, it is hard to look in the mind of someone else. (2) Is the view point of the consumer for which the aesthetics are the most real and mechanics, created by a game development team, the most unknown. This means that the dynamics are partially known by each [33]. LeBlanc claimed that other disciplines (e.g. math and psychology), analyses of other games and our own experiences all have a direct partial insight into modelling game dynamics [42].

Now that the general idea is explained lets define what mechanics are. Examples will be included from another essay that LeBlanc wrote. The examples illustrate certain (perhaps unexpected) boundaries or inclusions of the definitions [43].

Mechanics are "the particular components of the game, at the level of data representation and algorithms" [33]. Examples given by LeBlanc are: program code, all of its equipment (e.g. the gaming device including controllers), gravity, energy and the limits of the human mind and body. The latter examples are mechanics in real life games (e.g. basketball) [43].

Dynamics are "the run-time behavior of the mechanics acting on player inputs and each others' outputs over time" [33]. Examples given by LeBlanc are: actual events, actual phenomena within the game, tactical game concepts (e.g. discovered check in Chess) and structural game concepts (e.g. the opening in Chess). He adds that game dynamics emerge from the game mechanics [43].

2.5.3 Limitations: ambiguity about aesthetics

In principle, the framework is now explained. However, the formal definition of the aesthetics and its examples seem to be distinct ideas – which defeats the purpose of having examples. In order to understand this ambiguity, a lot of additional material such as other papers, videos from the authors, games created by the authors – which are designed and analyzed by the MDA framework – and industry papers have been consulted. Hence even if the reader is familiar with the MDA framework, the idea of aesthetics has been slightly changed. Originally, it is defined as follows:

Aesthetics are "the desirable emotional responses evoked in the player, when she interacts with the game system." While this is a clear definition, the non-comprehensive taxonomy of aesthetics that serve as labels and examples are not emotional responses at all. The aesthetic labels are: sensation, fantasy, narrative, challenge, fellowship, discovery, expression and submission (the latter meaning game as pastime) [33]. Examples that LeBlanc give as aesthetics are: "a game that can challenge our intellect. ... It can stimulate our imagination." He furthermore adds "how the game behaves determines how it makes the player feel. Understanding how specific game dynamics evoke specific emotional responses is one of the greatest challenges of game design" [43].

It is not hard to intuit how the taxonomy is associated with desirable emotional responses. Yet, the label fantasy, for example, does not seem to be a desirable emotional response since fantasy is not an emotion and fantasizing is an activity. This contradiction between the labels and the definition is the source of the confusion. It is understandable why a player could crave to experience fantasy within a game and this is partially reflected in the definition. Following the definition, it seems that the labels reflect how players want to experience their desirable emotional responses. But is this really the case? Or is it the case that players want to experience fantasy because they want to escape real life and happen to experience emotions as a side effect of playing the game? Certain theories in social sciences hint to the latter.

Connecting the concept of aesthetics to existing literature in social science. For unknown reasons Hunicke et al. did not connect their paper to existing literature. Perhaps this is because the framework has been too industry driven or perhaps the most influential ideas that seem to be about aesthetics did not exist yet since they were not linked to gaming before. Two of these ideas will be discussed. The first idea proposed by Sherry, Lucas, Greenberg and Lachlan is the six gaming gratifications [73] – defined as a belief that a certain media behavior has a given desirable outcome [12, 60]. The second idea is the self-determination theory applied to gaming specifically [66]. Both papers have been published in 2006 as opposed to the MDA framework, published in 2004 [33].

The six gratifications for gaming and the self-determination theory (SDT) are about *need satisfaction*. Where the SDT are about basic psychological needs [66], the six gaming gratifications are a combination of: human basic needs (note: not grounded in SDT but theoretically it could have been), sex and gender norms [73]. It seems that the ideas about aesthetics could be academically linked to both research programs. No paper has been found on combinations between SDT and gaming gratifications. It might be interesting to see if there is a highly explanatory model that has the gaming gratifications replaced as aesthetics and SDT as one of the underlying factors behind the gratifications. SDT needs to be taken into account because of its superior explanatory power (in most situations around 50% of the variance [66, 76]) and because it has been demonstrated that gaming gratifications do not always have strong explanatory power [63, 68]. Note that the sometimes weaker explanatory power of gaming gratifications is due to the methodological issues or differences found in these studies. For example, [68] measured that their construct of competence – SDT has its own variation of this construct – almost did not explain any variance.

With regards to game-design, the literature shows that the aesthetics of MDA can be reasoned about in an academic fashion in terms of gratifications (hedonic and non-hedonic needs) and basic psychological needs. LeBlanc seems to reason along these lines albeit he never mentioned anything about the literature of SDT and gaming gratifications [42, 43, 44]. Unfortunately, not all authors of the MDA paper think about aesthetics along these lines, which might be the cause of the confusion. They tend to think more about it in terms of desirable *emotional* responses (see the definition of aesthetics). Robin Hunicke is a great example of this line of thought. For example, her aesthetic goal as executive producer on the game Journey was "feeling alone together" [32], which can be viewed as a desirable response and a novel experience. Other researchers have slight distinct ideas about what aesthetics are as well. Some equate aesthetics explicitly to gratifications [12] (e.g. labels could be fantasy and challenge), or implicitly to gratifications while using the original definition (i.e. "desirable emotional response") [34, 80, 78]; others equate it to desirable emotional responses directly (e.g. labels could be love and hope) while inter-sprinkling it with gratifications [38].

To alleviate these differences we decided to do what the Hunicke et al. did implicitly in their paper. We broaden the concept of what aesthetics are. Unfortunately, defining this broader concept explicitly proved to be too difficult. Instead we will characterize it as: anything that sounds like a desirable emotional response, basic psychological need or gratification. It can all be classified as an aesthetic goal.

For this paper it means that the perspectives will be combined allowing more room for aesthetic labels. For example, gratification-like words can be used such as: fantasy, challenge or violence. Words with emotional meanings such as: joy, frustrating or sadness can be used. Value loaded terms such as: engagement, having a feeling of x or aversion can also be used. The intent is to describe the cognitive and affective experience of the game with an implicit assumption that there are players out there who would want this experience.

The disadvantage of this characterization is that all aesthetic labels subtly emphasise different aspects of the player experience. Gratification-like words puts more emphasis on what people would want in a game (both cognitive and affective). Emotional words put a self-explanatory emphasis on the affective experience. Value loaded terms are a more idiosyncratic collection of words and describe the cognitive, affective or both experiences when playing a game.

In return for this disadvantage we get a better view of the nuances about aesthetics. Furthermore, this broad characterization still guides for good game-design. There is a slight amount of evidence that all views of aesthetics that have been discussed are successful end goals in designing games. For example, [78] showed that having aesthetic goals labeled as gratifications yielded to a higher intention to use and higher intention to recommend. [14] identified the four best smoking cessation apps out of roughly 300 apps by only using SDT; one of the four apps, iCoach, claims a success rate of 36% after using it for 3 months [4]. The least amount of academic evidence is for equating it directly to desirable emotional responses but Robin Hunicke did this when she created Journey which was winning all kinds of awards [32].

[4]iCoach website

2.6 Overview of the MDA framework and the sections

The connection between the MDA framework and the sections can be seen in figure 5. We start by defining frustration and engagement, which have dynamic as well as aesthetics elements. The next section which is about the types of frustration shows a balance between dynamics and aesthetics as well. In both of these sections, the dynamics explain as to how frustration arise and the aesthetic describes how frustration itself – be it positive or negative – is experienced. We are mostly interested in how an engaging-frustrating gameplay experience could occur within a game, hence the dynamics are the most prominent part of this paper. Section 5 focuses on the dynamics in a neurobiological sense. Section 6 showcases the dynamics of analog and digital slot machines games. Section 7 is a case study of an engaging-frustrating casual game and its dynamics. Section 8 is the only section that conveys how mechanics can influence dynamics.

With respect to game analysis, it is clear that we start from a mix between aesthetics and dynamics. Then we move on to understand more about the dynamics of how an engaging-frustrating experience occurs. We end with how this could potentially be created by a game developer by discussing the mechanics.

3. DEFINING ENGAGEMENT AND FRUSTRATION

For the present exploration we first provide a working definition on engagement (3.1) and frustration (3.2). Subsequently, we give a precise characterisation on what constitutes an engaging frustrating casual game (3.3).

3.1 Engagement

There appears to be no general consensus on what constitutes an engaging game experience. This is, for example, visible in a literature review about engagement [9]. Some researchers relate the term to intrinsic motivation and flow [77], without giving a formal definition. Other researchers have conducted factor analyses to distinguish high engagement from addiction, and find very subtle, almost indistinguishable differences [70]. Indeed, numerous researchers do not clarify their use of the term at all; it seems to be assumed that the reader knows what engagement means. Furthermore, it is arguable that engagement is the strongest predictor of the usage of digital games. According to Lee and LaRose deficient self-regulation – measured with items as "I feel my game playing is out of control" – was a better predictor for digital game usage than flow.

For the purpose of this paper, engagement is considered to be the first level of immersion as defined by Brown and Cairns [10]. By inferring a theory from qualitative data (i.e. grounded theory) they found that immersion – otherwise known as involvement – has three levels: engagement, engrossment and total immersion. In the first level, the player exhibits a need to invest *time* and *effort* in the game, while having *a willingness to concentrate*.

This need does not arise when the genre is experienced as aversive from the player's perspective or when controls are unintuitive. In other words, "an engaged gamer is inter-

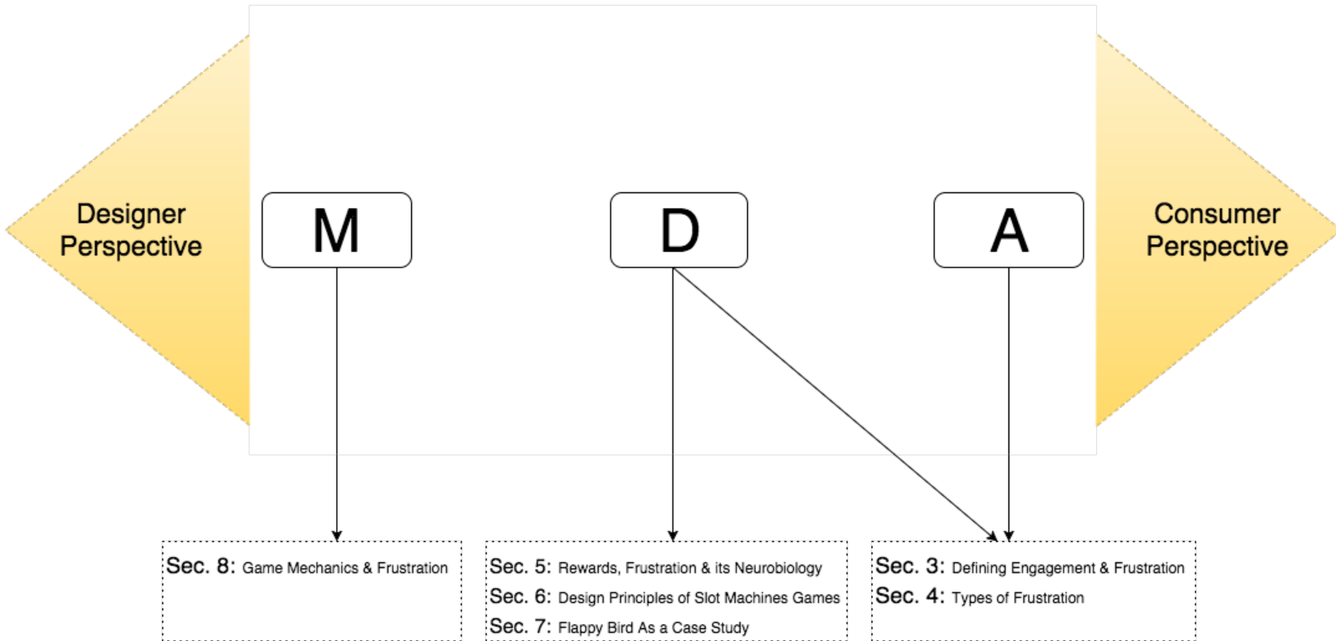


Figure 5: Schema of how the MDA framework relates to the sections of this paper.

ested in the game and wants to keep playing. What this experience lacks is the emotional level of attachment that is seen in later levels of immersion" [10]. For more complex games high immersion might be necessary (e.g., games with a strong narrative component), which is typically not the case for simple casual games (e.g., Flappy Bird). For full descriptions of the second and third level, we refer to Brown and Cairns [10].

3.2 Frustration

As written before, in psychology frustration is well-known in terms of the frustration-aggression hypothesis [57, 11, 53, 39]. For example, according to [57] frustration occurs when an effort of goal-attainment is thwarted; it induces an aggressive drive that motivates someone to injure the object or person being the obstacle to the goal. According to this hypothesis, frustration causes aggression.

A common definition of frustration in the context of gaming is given by Gilleade and Dix as "that which arises when the progress a user is making towards achieving a given goal is impeded." [25] While the definitions are very similar, Gilleade and Dix do not mention frustration causes aggression. This definition of Gilleade and Dix is empirically supported by Chumbley and Griffiths [15] who found that players who experienced more failure in the game Micromachines felt more frustrated. In other words: within a game, frustration is the feeling that occurs after a perceived failure. As an aside, they also found frustration has no association with willingness to play, frustrated players are just as willing to play Micromachines as non-frustrated players.

There is one more nuance. But in the context of gaming, the empirical foundation of this nuance might be a bit too speculative. According to marketing researcher Gelbrich who studied frustration in hotel customers after service failures, frustration mostly tends to occur when situational factors can be blamed [24]. Anger, for example, tends to occur mostly when another person can be blamed – which, according to Gelbrich, is a distinct third category from the other two categories situational factors and oneself. While this clearly explains why players can be frustrated by: glitches, lag or other bugs, it is harder to understand *if* and *why* failure in a game could be perceived as a situational factor.

According to the study of Juul [35], players prefer to feel responsible for their failures, but compared to successes they tend to attribute failures more to external circumstances (i.e. situational factors). Players who feel responsible for their failures tend to rate a game higher than players who believe they failed due to external circumstances [35]. A recent qualitative master thesis (September, 2015) argued that a frustrated player blaming herself adds to a positive experience within the game. In his master thesis, Nylund interviewed 9 people from the game industry (6 game-designers) who all argued from their experience that this is the case [58].

Compared to the earlier definition from Gilleade and Dix, the nuance is the attribution of frustration. This can be towards oneself ('good' frustration according to [58]) and towards the situation ('bad' frustration, according to [24]). In this paper, the definition of Gilleade and Dix will be used, because it has more empirical support compared to the proposed nuance. The proposed nuance will be used as well, but when it is used it will be explicitly mentioned since the empirical foundation is more speculative and adds extra assumptions.

Now that frustration is defined, we want to caution that it does not imply that it could be characterized as a negative emotion and nothing else. We will show this view to be incorrect in more detail (in Section 4).

3.3 Engaging frustrating casual games

While casual games defy a standard definition because of the diverse nature of the games [64], they can be understood as games that require simple rules, and do not require a long-term commitment or special skills to play.

As such, engaging frustrating casual games can be understood as games that: (1) are categorised as casual games (i.e. very easy to play, hard to master and supports short gameplay sessions – see [40] for a discussion on the term), are generally experienced as being simultaneously (2) engaging, and (3) frustrating. A prototypical example of a game that fits this definition is FLAPPY BIRD.[5]

3.4 Conclusion

While the characterization of an engaging frustrating casual game may seem redundant, we will point out – building upon psychological literature – that the specific interplay between engagement and frustration is not well understood, particularly in the context of different types of frustration (discussed next). Furthermore, by defining and characterizing the most important elements of this exploration (i.e. frustration, engagement and casual games) we hope to avoid confusion that some papers might give with implicitly assuming a definition or characterization.

4. TYPES OF FRUSTRATION

Qualitative studies show that frustration does not have to be negative *per se* [23]. It may always be a negative feeling to a particular individual or it may always lead to aggression when one is overly frustrated. However, that does not mean that the consequences are always negative. Hence, we explore different types of frustration that people may experience. Particularly, we explore positive frustration (4.1) as resulting from (a) hierarchical goals, (b) presenting goals from a different perspective, (c) narrative frustration, (d) holdouts, (e) near-misses, and briefly explore negative frustration (4.2).

4.1 Positive Frustration

Frustration has been observed to be beneficial for the persons who are experiencing it. This effect can occur in different manners. In some cases, the feeling is endured while positive gains are made elsewhere. In other cases, a frustrating event completely disappears, despite it being there moments ago. It can also be a necessary requirement in order to amplify the satisfaction that will be obtained after overcoming it. In one particular case, the experience of an activity being simultaneously engaging yet frustrating has been observed and does not seem to hinder engagement at all. All of these examples are seen to be positive frustration.

4.1.1 Hierarchical goals

This type of frustration entails that the progress of a less meaningful goal is impeded while the progress of a more meaningful goal is not. Since a more meaningful goal subsumes a less meaningful goal, a hierarchy exists. Hence we call it hierarchical goals. One researcher has found some evidence that the importance of a real-life (not game related) goal to a person and the intensity of the feeling frustrated are related [41].

In [23] it is stated why frustration is a meaningful introspective experience. “Indeed, a successful workshop leaves people frustrated because of the recognition of how much effort is called for individually and communally in order eventually to be able to do authentic spiritual discernment. This is a good frustration, however, because it moves persons and communities to undertake the labour of true spiritual renewal in order one day to be able to do communal discernment” [23].

Another similar example is presented in [72] where students learned software engineering principles via a simulation. “Although incorporated into a series of larger group projects, Polack-Wahl [62] also utilised students roleplaying as the clients in systems development. This experience enabled the students to gain a valuable first-hand insight into the viewpoint of clients, and in particular their frustration when systems developers did not listen to their requirements.”

4.1.2 Presenting goals from a different perspective

When a goal is presented in a different perspective (e.g., presenting dying repeatedly as part of training a specific skill, and not so much as the result of being a bad game player), the frustration of a player might be re-framed. For example, the authors in [26] created a game that normally would frustrate any player. It aims to teach fledgling game-design students which bad practices exists in game accessibility. The authors did this by creating a normal game and after its development there was a second development phase where they broke all the game accessibility requirements. The students responded that they believed the game was a lot of fun to play. Most of them stated, however, that this was only the case because they knew that the bad practices were meant to teach them something about game accessibility.

4.1.3 Narrative frustration

Frustration may also be (purposely) embedded in narrative frameworks. For instance, in The Art of Game Design, Schell explains the hero’s journey, which could be viewed as a structure or framework in order to create a good story. The hero’s journey was first discovered as a pattern. The pattern itself is seen in almost every mythological story [69].

In the hero’s journey there are twelve distinct phases. The seventh phase is one of frustration. In this phase the hero endures setbacks directly or indirectly from the main antagonist in the story. This is argued to be necessary in order to make the story more meaningful. Without setbacks, a story is believed to be less meaningful, because the one reading the story is less invested in the character. Since humans have a natural tendency for loss aversion [37], more meaning is created by giving the reader the feeling of potentially losing someone.

4.1.4 Holdouts

A mixed form of frustration (partially positive and negative) are holdouts. When a player is frustrated with a game but

[5] We refer the reader that is unfamiliar with this game to the following gameplay video: https://www.youtube.com/watch?v=UloBiVGtAP4

is willing to wait until she has seen a certain segment, then she is holding out. In the prototypical example the player is curious enough to see a certain special segment or turning point in the game. If that segment or turning point is fun in the experience of the player, then she will continue playing. Otherwise she will quite the game [13].

4.1.5 Near-misses

Another type of frustration which could be viewed as positive is the near-miss. A near-miss occurs when a player almost reaches a certain goal but ultimately fails. A classic example is a gambler getting two bars in the first and second slot but no bar in the third slot. This leads to frustration, and an almost compulsive like behavior to continue playing [17, 4].

The idea of a near-miss shares similarities with the psychology of shaping (an operant conditioning technique where a partially correct behavior is rewarded [57]). In the experience of the player, near-misses could be perceived as an indicator for skill-development. Just missing a target is a lot better than completely missing a target. [17] presents a somewhat similar idea. As will be presented in the remainder of the paper, explaining a game in terms of variable rewards and near-misses, might be a substantial part of the answer to the question of why casual games could be experienced as frustrating and engaging.

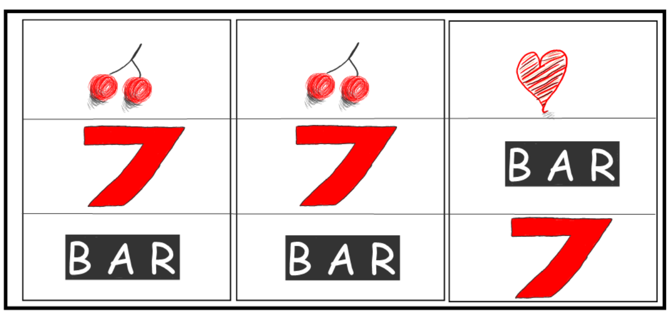


Figure 6: Example of 3 near-misses on a slot machine (the sevens, the bars and the cherries). The biggest near-miss are the sevens since it 'slid through' on the right slot.

4.2 Negative Frustration

Concisely speaking, negative frustration has the consequence of the player quitting or developing a tendency towards quitting the game. This is what most psychologists and game-designers assume frustration (as a general concept) does. Examples are: unexpected bad controller design, lag, or so-called campers that repeatedly kill a re-spawning player within seconds.

Scholarly textbooks in the field of psychology generally depict negative frustration in relation to the frustration-aggression hypothesis. However, negative frustration itself remains largely ill-defined. Yet, working definitions generally place negative frustration in the following framing: "whenever a person's effort to reach a goal is blocked, an aggressive drive is induced that motivates behavior intended to injure the obstacle" [57].

4.3 Conclusion

We have presented a non-comprehensive list of distinctive frustrating experiences that could be beneficial to game design. More specifically, these are: hierarchical goals, presenting goals from a different perspective (i.e. reframing), narrative frustration, holdouts and near-misses. These types of frustration are deemed beneficial, because each of these frustrating experiences has a beneficial component to it as explained in the paragraphs. Negative frustration emphasizes bad user interfaces and acting out one's aggression.

In other sections hierarchical goals and holdouts will be somewhat explored. Presenting goals from a different perspective will be explored in-depth by understanding well-studied biases in psychology and near-misses will be explored by understanding its neurobiology and by understanding the practicality of it in slot machines and games. Narrative frustration will not be explored, since a narrative is not a necessary requirement for an engaging-frustrating casual game as defined in this paper. Negative frustration will also not be explored because we are showing that frustration does not only have to have negative consequences with regards to gameplay itself.

5. REWARDS, FRUSTRATION, AND ITS NEUROBIOLOGY

Here, we go deeper into relevant psychological theories on rewards, frustration, and its neurobiology. Particularly, we discuss operant conditioning (5.1), near-misses (5.2), liking and wanting (5.3), and the neurobiology of frustration (5.4). We will highlight the relevance of each theory to the gaming domain in the text.

5.1 Operant conditioning

The relevance of operant conditioning (i.e., a method of learning that occurs through rewards and punishments for behavior) in the gaming context may be evident: much if not all of the learning processes that take place within game environments may be regarded as operant conditioning (albeit in distinct layers).

Indeed, it can be said that B.F. Skinner and other behaviorists have done ground-breaking work on reinforcement learning. They showed that variable-ratio and variable-interval schedules produce new habits that are more resistant to extinction compared to the fixed-ratio and fixed-interval schedules [57]. This means that when rewards are given in a variable amount of time or after a variable amount of tries, the (newly) learned habitual response will stay active. Bateman and Nacke [4], have surveyed that this is associated with the nucleus accumbens in the brain. Whenever a reward is received, dopamine is released in the nucleus accumbens [4].[6]

The nucleus accumbens is popularized as a part of the pleasure center of the brain, and situates itself in the limbic system. The limbic system used to be known to be the emotional center of the brain. However, more recent research in neuroscience revealed that the neocortex and reptilian com-

[6]While outside of the scope of the present paper, it is interesting to note that the release of dopamine in the nucleus accumbens is not directly linked to hedonic impact (liking) [8], but is suggested to be directly linked to *wanting* [67]; via the meso-limbic pathway.

plex also have influence on the emotional experience of an individual. Still, the substructures of the limbic system are the most related to emotional experiences [39, 4].

5.2 Near-misses

When a near-miss has occurred, dopamine is released in related dopaminergic reward structures such as the mesolimbic pathway [17, 4]. Clarke *et al.* [17] suspect that the dopaminergic neurons fire at the time when a win is very likely to occur. So neuronal reward structures of the brain fire when a player wins, but are also likely to fire when a player *anticipates to win.*

More specifically, the study of [17] researched this effect with slot machines. Table 2 presents the brain structures associated with winning (as opposed to losing) and near-misses (as opposed to other full-misses). Indeed, there are strong indications that near-misses and wins are neurobiologically related [17].

The most likely explanation is that near-misses result in experiencing positive affect in anticipation of the reward; at the end of this process the player will not get it and negative affect is experienced. Another proposed explanation would be that near-misses are a form of illusion of control (explained in more detail in subsequent sections). In any case, the literature on near-misses supports the notion that rewards are experienced by their subjective interpretation and not by their objective value [17].

5.3 Liking and wanting

The wanting-and-liking theory states that liking and wanting have partially different neural correlates in the brain [39]. Their most pronounced difference is that they are governed by different neurotransmitters. The wanting pathway is akin to feeling and acting on desire or cravings. When an individual wants an object, dopamine is being released in the mesolimbic pathway (as stated with the near-misses). These neurotransmitters do not amplify pleasure, but do reinforce behavior [6].

As such, liking is behaviorally akin to enjoyment. When an individual likes an object, μ-opioids and endocannabinoids are being released in limbic forebrain structures, such as the nucleus accumbens. These neuromodulatory peptides and lipids act as neurotransmitters, and are natural versions of heroin and marijuana and amplify pleasure [6]. This does not occur when an individual solely wants something.

The wanting-and-liking theory explains the effect of how people could want something, but not like it. It is argued by researchers on this topic that this effect mainly happens on a sub-conscious level [7, 79]. A prototypical showcase of this theory would be to look at drug addicts. When people build tolerance for drugs they like the experience less than before, but their addictive behavior does not decrease, creating a mismatch in wanting and liking.

With regard to games, it gives an idea of why players could be engaged in games they perceive as frustrating. For example, players could be engaged, because they want to achieve their goal. At the same time, they might not like it. While some literature is cautious on whether or not reinforcement learning occurs when people show activation in their so-called liking hotspots (e.g., [6]), it is plausible that reinforcement learning does *not* occur, as Bateman and Nacke [4] found that reinforcement learning occurs with dopamine, a neurotransmitter that is not associated with liking.

As such, it is likely that near-misses are solely associated with parts of the wanting system, and not the liking system. While we did not find neuroscience literature on the subject, questionnaire ratings do indicate that participants felt more unpleasant when they experienced near-misses compared to experiencing full-misses, which are experienced as unpleasant in the first place (with no reward activation in the brain) [17].

5.4 The Neurobiology of Frustration

Concisely speaking, it is hypothesized that triumphing over hardship produces dopamine in the brain. This would imply that the moment a frustrated player achieves her goal, a dopamine release occurs in the brain. Such a release would further segment the behavioral pattern in the player [4]. For example, if a frustrated FLAPPY BIRD player changes the way she taps against the screen by tapping with the index finger instead of the thumb and (perhaps by chance) obtains a higher score, then the player is likely to play with her index finger for a while.

This finding, however, has to be met with some caution. The study of [50] did not find this association when players killed other players in a first-person shooter. They did see phasic activation patterns of striatal activity, but could not relate the activation patterns to a specific element of the game. However, they did find less striatal activation than usual when a player was killed, which means it is likely that less dopaminergic neurons fired. Furthermore, they found that the negative feeling of not obtaining a goal is being associated with the right temporal pole, and to a lesser extent the left temporal pole. Unfortunately, it is still relatively unknown what the temporal poles precisely do [50].

Here, the suggested implication to gaming is that the more unexpected a full-miss (generally leading to frustration due to goal blocking), the less activity there will be in the striatum. The less activity in the striatum, the less dopamine and/or opioids will be released. Naturally, the precise sensitivity to this phenomenon differs from person to person.

5.5 Conclusion

The basal ganglia has a role with all types of rewards processing discussed in this section. More specifically, it has a role with: operant conditioning (nucleus accumbens), near-misses (ventral striatum), winning (ventral striatum) and frustration (which has striatal activity). While it is not the only part, it is a large structure that seems to be the common denominator. On another note, the feeling of frustration has been associated with the temporal poles, a structure that is a bit of a mystery with regards to its function. Furthermore, the so-called liking hotspots are associated with the basal ganglia but not with dopamine. Yet, dopamine is associated with all forms of rewards processing as discussed in this section. This means that the liking and wanting pathway is not visible through fMRI.

Table 2: Brain areas of winning situations and near-miss situations

Win - all non-win	Near-miss - full-miss
Bilateral ventral striatum	Bilateral ventral striatum
Bilateral anterior insula	Right anterior insula
Rostral anterior cingulate cortex	Rostral anterior cingulate cortex*
Thalamus	-
Dopaminergic midbrain neurons	-

* In the near-miss condition it was only activated during a specific near-miss. The brain area activated when the relevant last winning symbol stopped briefly as a winning condition in the middle (e.g. three bananas in the middle), and then fully stopped at the place beneath it (e.g. two bananas and a cherry with the banana underneath the cherry).

The insights in neuroscience show that operant conditioning has a neurobiological basis (5.1), anticipation is an important element in game-design and has a neurobiological basis (5.2), that there is a distinction between (sub-conscious) wanting and liking (5.3) and there is less reward processing when someone is killed in a game (5.4).

6. DESIGN PRINCIPLES FROM SLOT MACHINE GAMES

Indeed, insights from the gambling domain are invaluable to the modern digital gaming context, in order to support the neurobiological perspective from a more pragmatic point of view. That is, before the digital games industry existed, designers of slot machines have developed their own best practices to keep players engaged. Some parts of gambling could indeed be experienced as quite frustrating. We highlight seven design principles from slot machines games below, and will utilise these principles in our analysis for the case study (discussed next).

6.1 The Seven Design Principles

Rewards are the first principle of keeping players engaged. It appears that next to real money pay-outs, sound is the biggest reward that keeps the player engaged [28]. Visual cues help as well. The second principle are *reinforcement schedules*. Slot machines almost exclusively use variable ratio reward schedules [28]. Third, the *frequency of near-misses* is artificially heightened. By artificially heightening the frequency, players will play more often [28]. Fourth, *losses are disguised as wins*. For example, if a player needs to pay two coins for a spin, and wins one coin back, then this is a loss of one coin disguised as a win. Physiologically players experience these types of losses as wins [28].

The next principle is a well studied cognitive bias called *illusion of control*. Gamblers experience this when they are given the power to hold a few slots. They have the feeling they control the game, which is mathematically not true, the probabilities remain the same [28]. The sixth principle is *bonus rounds*, which often occur entirely random in gambling games. Players rate these experiences as one of the most compelling elements of a gambling game [28]. The final principle is *competition*, even though players cannot really compete, the illusion of control bias lets them believe they can [28].

These seven principles could be applied to designing a casual game – and to a large extent already are. Furthermore, principle 1, 2, 3, 4 and 6 are also supported by the neurobiological theory explained in Section 5. This is because principle 1, 2, 4 and 6 can be considered to be related to operant conditioning. Principle 3, on the other hand, can be considered to be related to the neurobiology of near-misses.

Despite that principles 5 and 7 are not supported by neurobiological theory surveyed in this paper, they are supported to be motivating by the competence aspect and relatedness aspect of self-determination theory [65]. Indeed, one may claim that the illusion of control gives a feeling of competence, and that competition fulfils the need of relatedness. For further reading on the topic of self-determination theory, we refer the reader to Ryan and Deci [65].

6.2 Conclusion

While the design principles of slot machines come from a pragmatic background, it is supported by literature from neuroscience and psychology. The design principles focus on the perception of the player receiving rewards. They mostly do this by encouraging the player to feel she is in control and by giving the idea that the slot machine game is generous (e.g. bonus rounds and disguising losses as wins).

7. FLAPPY BIRD AS A CASE STUDY

Now that we have (1) an informal classification of distinguishing different types of frustration, (2) a neurobiological background, and (3) a more pragmatic background on design principles, we can apply these theories to an engaging frustrating game. For this case study, we investigate a prototypical example of an engaging frustrating game, namely FLAPPY BIRD (Figure 7).

A characteristic of FLAPPY BIRD is that it is easy to understand. So players do not need a tutorial, players only need to experiment the first few tries in order to understand the rules of the game. Research shows that there is no evidence that game tutorials give a more productive, effective or efficient learning experience in simple games; game tutorials only appeared to become relevant with complex games like FoldIt [13]. Hence, the lack of a game tutorial in FLAPPY BIRD may be considered to be a design feature.

7.1 Profiling the Players of Flappy Bird

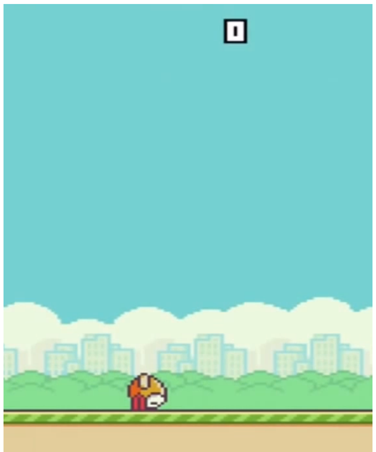


Figure 7: Flappy Bird. Some players die within milliseconds.

A study by Poels, IJsselsteijn, and de Kort showed that a substantial amount players play video games because they are bored. However, this is less the case for gamers that game more frequently [61]. With regards to Flappy Bird, it is likely that a considerable number of player engage with the game because they are bored.

Despite that players may start out being bored, it is suggested that casual gamers consider competence and autonomy to be the greatest need they want to have fulfilled [56]. Furthermore, it is suggested that casual gamers consider relatedness to be the need they want to have least fulfilled.

Why Flappy Bird became viral is not well understood. Research findings show that reading negative reviews 15 minutes before playing a game will not physiologically affect a gaming experience [13]. So it could be that the game got popular via word of mouth (among other means), and even when people would review it in a negative fashion, players might still be drawn to try it out.

7.2 Potential Cognitive Biases for Flappy Bird

There are a few cognitive biases that we need to consider. When a player plays Flappy Bird these biases may occur. First, the effect of a player being overconfident (7.2.1) may be introducing a bias (i.e., the overconfidence effect; a well-established bias that nevertheless has recently been subject to academic debate). Second, the illusion of control might occur (7.2.2), and third, so may a fundamental attribution error (7.2.3).

The generalizability of effects remains an issue to consider. That is, there are cultures where cognitive biases and even brain activations differ substantially compared to people born and raised in a western culture [30]. This finding hints to the idea that a designer is only able to design for an experience for a particular prototypical player [29].

That said, while these biases may occur when people play Flappy Bird, it is not certain if they do occur. The idea of the following paragraphs is to present some possible ways in which players could be tricked into believing, for example, that the game is more easy than it really is.

7.2.1 Overconfidence

Overconfidence is defined in three ways. The relevant definition for us is that people tend to overestimate their skill-level compared to their real performance. In the comprehensive literature review of Moore and Healy [52], the pitfalls in the current research of overconfidence are presented.

The background of this theory is that humans estimate their skill-level via an irrational Bayesian probabilistic process. Moore and Healy conducted an experiment with a trivia game about facts of the United States. They showed that when a game is experienced as hard, people tend to overestimate their skill level, and believe they performed worse than other people. So for example, if a player gets a hard question, then, on average, she might estimate her probability of answering it correct to be 10%, in reality she would answer it 5% correct of the time, and would guess her peers would have answered it 12% correct of the time [52]. In Flappy Bird, this effect could also occur, which would mean that players would consistently overestimate their future performance. For viewers that prefer to view these type of stories in a tabular form, see table 3.

Table 3: Examples of people their estimation on easy and difficult questions, according to the findings of [52].

Difficulty question	Estimation	Peers	Reality
Hard	10%	12%	5%
Easy	10%	8%	15%

7.2.2 Illusion of control

While it is hard to argue that the illusion of control provides a cognitive bias in Flappy Bird (i.e., the tendency for people to overestimate their ability to control events), we posit that it is an applicable bias. Particularly, in this context of illusion of control, the *hot-hand fallacy* could be applicable.

The hot-hand fallacy is informally defined as believing that people are better in scoring points when they are on a winning streak, while successful outcomes are in fact based on randomness or luck (statistically speaking). The hot-hand fallacy occurs when people believe that a certain winning streak has a causal effect on later outcomes, and has been demonstrated with gambling and basketball throws. Indeed, game players generally do not score more or less points after a hot streak of successful actions. With Flappy Bird, this fallacy could occur when players have a certain number of good runs in a row, which would excite the player as a result [18]. Inversely, the hot-hand fallacy may apply with a notable streak of near-misses.

7.2.3 Fundamental attribution error

The fundamental attribution error occurs when the characteristics of an event are too much attributed to the person or the environment [53]. An example is blaming a newly hired CEO for causing a company to fail, when the company had terrible financial forecasts to begin with.

There are cultural differences. In one study Japanese and American participants were shown a cartoon character with a sad or happy face while there were four cartoon characters who had the same facial expression or the opposite facial expression. On average, Japanese people claimed that the main cartoon character was influenced by the other characters to agree or disagree with their emotions (attributing the emotion to the environment). American participants claimed, on average, that the person had a sad or happy face, because of the character his own will, thus attributing the emotion to the main character, not the environment [49].

If these finding are generalizable to Flappy Bird, then this could mean that compared to people from an eastern culture, people from a western culture would blame their own skill more than the game and vice versa. So with regards to this bias, people from a western culture are more inclined to believe that the outcome of any game is in their control. This may have an impact on their intrinsic motivation to continue to play more.

7.3 Reinforcing Effects in Flappy Bird

The following analysis is based on actual Flappy Bird gameplay sessions by us, and Youtube recordings of gameplay session by third parties. Two assumptions are being made: there is no social activity during gameplay and there is no social activity after gameplay. If the reader is not familiar with operant conditioning, then we would recommend any introductory psychology textbook, such as [57].

7.3.1 Positive reinforcement

In the game Flappy Bird, there are multiple ways of positive reinforcement. First, there is a *fixed-ratio of reinforcement* with scoring a point. This occurs via visual and audible events. Every time the bird passes through the empty space between the pipes the score increases with one point (visual) while a small high-pitched sound plays (audible).

A *variable ratio reward* occurs with regards to getting a high-score. From the described theory in this paper, the frustrating but still reinforcing part occurs with a *near-miss*. When the player is getting a higher high-score it is reinforcing and likely to be arousing. It is unlikely the player will get into a so-called flow state [20] – which we assume the reader to be familiar with – when she is obtaining a higher score, because of the difficulty of the game leading to high arousal [54]. This reinforcement scheme occurs solely via visual means. The medal, high-score and even the small star at the beginning when a medal is obtained in the previous try all play a role in this reinforcement scheme. Most of these visual cues are very salient, except for the star, which is subtly visible at the beginning of the next try.

7.3.2 Negative reinforcement

When passing through the empty space between the pipes, the bird does not die. So not having the frustration yet is a reward in itself. It is a form of *negative reinforcement*, because although the punishing sounds are anticipated, they do not occur.

7.3.3 Negative punishment

When the bird dies, the player has *no more control* over the player character (the bird). Control over the bird could arguably be seen as something positive. Hence it is negative punishment if this positive element is taken away.

7.3.4 Positive punishment

The bird dies every try. While every death could be seen as a punishment, not all deaths are equal. When the bird dies before a near-miss occurs, the punishment is at its greatest.

The *punishment* happens mostly *via audible means*. First there is a punch sound, which is louder than most other sounds in the game. This sound is quickly followed by a small, softer and more melodic sound. Visually the bird falls to the ground.

It is suspected by us that the frustration is the highest at the moment when the punch sound occurs, and lowers with the smaller and softer sound. So in Flappy Bird it is clear that the game *is strictly speaking not simultaneously engaging and frustrating*, but alternating in engagement and frustration. However, since the frustration happens in small durations spaced with quite some time in between, it might be experienced as simultaneously engaging and frustrating by the player when he talks about the game.

7.4 Other Effects in Flappy Bird

We briefly discuss three other effects that may account for the investigated engaging / frustrating effects, namely intrinsic motivation (7.4.1), variety (7.4.2) and types of positive frustration (7.4.3).

7.4.1 Intrinsic motivation

In the gaming domain, the relationship between extrinsic and intrinsic motivation is difficult at best. Indeed, the overall effect of offering a reward (e.g., points) for a previously unrewarded activity is a shift to extrinsic motivation and the undermining of pre-existing intrinsic motivation (i.e., the overjustification effect). We refer the reader to Akin-Little [2] for a deeper investigation on this effect.

In the case of Flappy Bird, the most salient external reward is the high-score. This high-score is likely related to social comparison and perceived status. One would assume that in Flappy Bird most gamers will probably not take high-scores too seriously (except for a small group of gamers). So even if the over-justification effect would decrease intrinsic motivation, it would not happen much. Furthermore, an inverse of the effect is also possible. This occurs when an individual receives a reward that is too little to justify the work done. As a result the individual attributes his actions to intrinsic motivation [53].

So we believe that the extrinsic motivation adds to the intrinsic motivation experienced in the game, because our assumption is that the rewards do not justify the time invested in the game. It is a game in which competence (how good a player performs) increases very slow. Moreover, because the game mechanics have easy to understand causal relationships, autonomy (events are caused by a gamer her own actions) is present as well. Even relatedness (connection with others) might be present to some extent, via social cognitive processing that occurs within the player by seeing, e.g., a favourite character (which does exist in RPG games [46]). So casual gamers that keep playing the game might experience a slow but steady increase in their intrinsic motivation.

7.4.2 Variety

In one version of the game, the color of the birds change. The background changes as well. And in all versions, levels are randomly generated. These elements introduce variety in the game and cause a slower habituation to the game, compared to if these elements would not vary. This means that the desensitization of dopamine will happen at a slower rate [11], which in turn suggests that the player will stay more aware during the game.

7.4.3 Types of positive frustration

One type of positive frustration is directly apparent, the near-miss. For instance, when the player has the same amount of points compared to the high-score, but alas, the bird dies and the next round begins with zero points. According to the investigated theories on near-misses, game players will want to play the game, despite their negative feeling of it. A holdout could also occur. An example is that a player who has a high-score of 47 really wants a high-score of 50. Or maybe she wants to beat the high-score of her friend and do everything it takes.

Finally, when a game such as Flappy Bird is framed from a different perspective (e.g., mindfulness training), the potentially frustrating in-game experiences could be perceived as being part of the mindfulness training itself.

7.5 Conclusion

The biggest considerations as to what makes Flappy Bird an engaging yet frustrating game are operant conditioning and cognitive biases. To a lesser degree: intrinsic motivation, variety and the types of positive frustration have been examined as well. These elements are hypothetically why Flappy Bird is a frustrating-engaging game. Almost all of these elements can be grouped under two major groups. They either can be classified as an element related to rewards or they are a cognitive bias. For example: holdouts (4.1.4 and 7.4.3), near-misses (4.1.5, 5.2, 6 and 7.4.3), operant conditioning (5.1, 6 and 7.3), the liking and wanting pathway (5.3), the neurobiology of frustration (5.4) are all theories or ideas related to rewards. Most other concepts or theories belong or are related to cognitive biases. Examples are: hierarchical goals (4.1.1), presenting goals from a different perspective (4.1.2, 6 and 7.4.3), overconfidence (7.2.1), illusion of control (7.2.2 and 6), fundamental attribution error (7.2.3). Intrinsic motivation (7.1 and 7.4.1), variety (7.4.2) and narrative frustration (4.1.3) are the odd ones out – albeit intrinsic motivation may be associated with *intrinsic* rewards.

Hence a useful overarching framework is to view frustration from the perspectives of rewards (extrinsic and intrinsic) and cognitive biases. It is also worth noting that according to the MDA model these concepts and theories say something about the dynamics of the game. What we have argued until now is that these dynamics may – or in some cases might – produce a game aesthetic for what we call the engaging-frustrating experience.

Up until now, we explored the relationship between how game dynamics produce a certain game aesthetic. The frustrating-engaging gameplay experience is the game aesthetic of this paper. Sometimes game mechanics have been discussed in previous sections by coincidence, but in most cases game dynamics have been discussed. For example, the whole operant conditioning paradigm is a game dynamic. Anything that involves introducing a cognitive bias is a game dynamic as well. In some cases, game mechanics have been discussed but have been looked at as game dynamics. For example, when the artificial heightening of near-misses has been presented in the slot machine section (a game mechanic), the most important question that has been answered is the effect that this has on the player (a game dynamic). In short, we did not present enough on how game mechanics lead to game dynamics in the first place. The next section will.

8. GAME MECHANICS & FRUSTRATION

This section will present ideas on how game mechanics lead to game dynamics. To make this section more concrete, three game mechanics will be showcased on how this could occur. These are: randomness, movement and time. All of these mechanics could contribute to an experience that is both engaging yet frustrating. We hope this section to be an example for one of the many ways how game designers could think about creating a frustrating-engaging game, when they start from the perspective of game mechanics.

The distinction with the previous sections is that the unit of analysis has changed to the mechanics of a game instead of the dynamics. Consequently, not all concepts and theories from previous sections are equally helpful since game mechanics are on the intersection of design and (social) science. Hence not all theories and concepts will be discussed or need to be discussed in this section.

8.1 Justification for analyzing randomness, movement and time

In this analysis, we assume that the mechanics and dynamics are motivated by the challenge aesthetic. Players who, for example, mainly prefer a good narrative or prefer to play games that have a lot of discovery mechanics will not be interested in a frustrating-engaging casual game. In other words, a player must be triggered by the challenge aesthetic in the first place since the frustration occurs because the game is too challenging (e.g. a player dies many times). Another assumption is that the games themselves are viewed as challenging by players, players who happen to be very good are more likely to get into a flow state.

The assumptions about fixing the aesthetic to challenge, simplifies the analysis with regards to understanding how aesthetics could be related to frustration and engagement. For this analysis, the experienced frustration and engagement is related to how the player is experiencing the difficulty level (i.e. challenge) within the game. Indeed, the perceived challenge within a game has strong connections to both engagement and frustration, whereas this is a lot harder to understand for an aesthetic like fantasy or narrative. We tried to do an analysis without these assumptions and found out that frustrating the fantasy aesthetic, for example, leads to different game genres and also leads to definition problems with regards to what frustration is.

Since there is no need to set assumptions with regards to the dynamics, we will move on to the justification for choosing the mechanics: randomness, movement and time. The main idea is that the game mechanics relate to a pragmatic section of this paper. For example, randomness has been chosen because it is a game mechanic that is used a lot in slot machine games. The game mechanic will therefore relate to Section 6. Movement has been chosen because it is one of the defining game mechanics in FLAPPY BIRD and will therefore relate to Section 7. Time has been chosen, because it is a game mechanic that is not present in slot machines or FLAPPY BIRD and relates to the future work subsection (Section 10.2). The time mechanic is not present within many slot machine games and FLAPPY BIRD, the mechanic does not have an implicit body of knowledge in this paper, like the other two mechanics have. Hence the analysis about the time game mechanic may yield interesting insights for future work.

8.2 Analysis

Robin Hunicke analyzed how a first person shooter related to the aesthetic experience of dynamic difficulty adjustment [31]. In her analysis of game mechanics there are: enemies, obstacles, items and a player that is able to move around. From her analysis we noticed a few important details that we need to consider in this analysis as well. First of all, it is easier to imagine how these game mechanics interact with each other when the context of a game is known. Furthermore, in our interpretation she implicitly showed that there are different types of dynamics. There is the previous hinted dynamic of a player searching for items, obstacles and enemies. There also is the dynamic of a rising challenge through, for example, a rising difficulty and scarcer rewards. The first dynamic happens within levels and the second dynamic also occurs between levels. Finally, the analysis itself had no references to other papers – other sections of the paper did. This means that the nature of these analyses are more rational, design-centric as opposed to empirical and science-centric by nature. For example, there are no scientific papers about specific game mechanics and how they relate to dynamics conductive for a frustrating-engaging experience.

Synthesizing science with design is difficult. But we need to make an attempt for this particular analysis due to the lack of empirical evidence. Most, if not all, empirical evidence presented in this paper is about the relationship between game dynamics and a frustrating-engaging experience, which we will use. However, we will use a more rational approach (e.g. 'common sense') when it comes to the relationship between game mechanics and game dynamics. Nigel Cross wrote more about the distinction between science and design and stated that design is pragmatic which means that any solution to a given problem that fits within the constraints is good. Science, on the other hand, is about understanding the truth and prefers an optimal solution for a given problem if there is one [19].

The general layout of each analysis is that it starts with stating the assumptions about the player and stating the context of the game. Then we move on to analyzing the game mechanics and how they relate to the game dynamics. Finally, we show how the game dynamics contribute to a frustrating-engaging experience and how they sometimes counteract each other. We end with what players might say. By doing the analysis in this manner, the implications of the three game mechanics are more fully explored.

8.2.1 Randomness

Lets start with randomness as a game mechanic. This game mechanic will be viewed in the context of a slot machine game. As stated before, one assumption is that the game is viewed as a challenging game by the player. It may be the case that a player fully understands that he cannot win and therefore feels there is no challenge to be had from a slot machine game. In such a case, the intended experience would most likely not occur. We have to assume that this understanding is not very salient in the player experience.

In essence, randomness in slot machine games lead to one engaging game dynamic, which is that the player hopes to win a lot of money by mere chance. A frustrating game dynamic that randomness leads to is that the game is inherently too hard since slot machine games need to make money in most contexts. A second order dynamic may be that the player will notice this after a while and will feel hopeless due to a lack of control and too frustrated because of it. As discussed in Section 3.2, this may result in a player quitting the game. Hence the final dynamic is too undesirable.

As discussed in section 6, slot machine designers have many design principles to mitigate the undesirable effect of the final dynamic. The principles of slot machine games are: rewards, reinforcement schedules, a higher frequency of near-misses, disguising losses as wins, illusion of control, bonus rounds and competition. Some principles give the feeling that the player is in control (i.e. more near-misses, disguising losses as wins, illusion of control and competition) and mitigate the dynamic of hopelessness and losing control. Other principles are based on psychological theories about rewards and encouraging the player to want it (i.e. rewards, reinforcement schedules and bonus rounds), which amplify the engaging dynamic.

Hence there are two game dynamics slot machine designers focus on: tricking the player that she is in control and encouraging her to want rewards. This combination of being in control and wanting rewards from a game leads to an engaging experience. The frustrating experience is present because the game is too hard on average, which means that the player will anticipate rewards while the rewards are not being given. Nevertheless, since the player feels she's in control and wants the rewards she will continue to play.

As an aside, what is more difficult to determine is if the player will describe this game as fun or as frustrating since there are arguments for both sides. One possible explanation is that the player finds the slot machine game frustrating but is too compelled to play more rounds. Another explanation is that the player does find it fun because the frustrating experience might be reframed and the engaging experiences might be exaggerated due to cognitive dissonance (i.e. holding a believe that contradicts existing beliefs, potentially causing a reframe [53]).

8.2.2 Movement

Movement as a game mechanic will be viewed in the context of Flappy Bird. Some players may view this game as too difficult and blame it on bad UI design for example. If this is the case, then such a player will most likely quit the game. If they blame their faults on themselves however, then they probably will continue to play [58] (we refer back to 3.2). Hence we must assume that a player blames the death of the bird on their skills, not the UI of the game.

The difference between Flappy Bird and slot machines is how the most distinctive mechanic contributes to the dynamics. With slot machines almost everything is being done to migitate the aversive feelings that randomness can evoke (e.g. disguising losses as wins). Flappy Bird, on the other hand, uses the movement mechanic to create an asymmetrical way of flying upwards compared to flying downwards. Furthermore, the manner in going up (push a button) and going down (do nothing) are asymmetrical as well. The following paragraph will show how this creates more difficult gameplay.

As can be seen from the images, one tap means the bird is going up at a constant speed. Combine this with a constant speed of going right and the combination is a constant speed going up and right. This is especially visible when a player would tap really rapidly on the screen. There is some kind of gravity mechanic that slows the speed down which allows the bird to fall. When the bird falls, it accelerates up to a limited point. Furthermore, the peak speed of falling down is higher than the speed when it is tapped and going up. In other words, there is a difference in peak speed with regards of going up and down. In normal casual games, players are accustomed to symmetric controls with regards to movement and speed. In short, the manner how movement is implemented in Flappy Bird allows for the game to become extremely difficult.

A lot of potential dynamics have been discussed in Section 7 about Flappy Bird. Potential cognitive biases such as overconfidence, illusion of control and the fundamental attribution error may play a role. What is more likely to play a role are the reinforcing effects in Flappy Bird. Other effects such as overjustification and some sense of competence, autonomy and perhaps even relatedness may be present along with types of positive frustration. These dynamics suggest the game has unpredictable multiple reward schedules while the player has some feeling of control as long as the bird lives, making the game seem easier than it is, which leave for an engaging-frustrating experience.

Interestingly, there are three types of comments on Flappy Bird. These comments are seen all over the web (e.g. Twitter or YouTube). The game is seen as: fun, frustrating and the player wants to quit but the player cannot stop playing. We believe that the main two variables explaining these three comments are the skill level of the player (e.g., good players get into a flow state) and the attribution of the player's frustration. For example, a player who believes she is good but isn't will attribute her frustration as her own

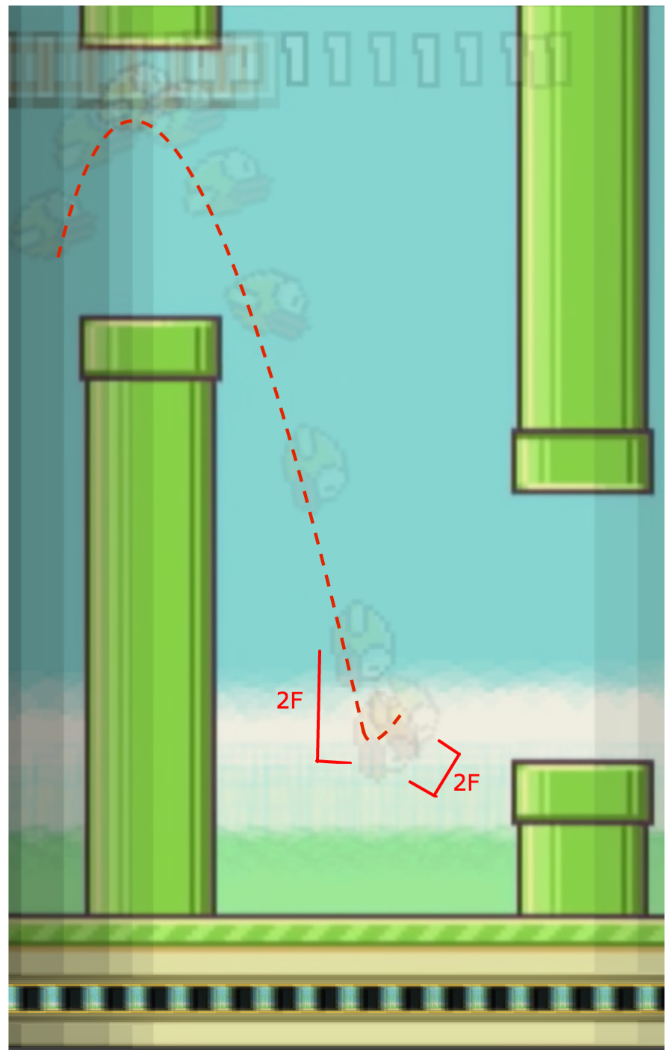


Figure 8: Movement mechanics of Flappy Bird: one upward motion and downward motion. Every fourth frame (4F) of a video has been taken, except for the last 2 sprites (2F) [7].

mistake and will either say she loves the game – if she does not realize her own frustration – or claim she is frustrated about it but cannot stop playing.

8.2.3 *Time*

Time as a game mechanic will be in the context of SUPER MARIO BROS. This popular game is assumed to be an engaging game. Manipulating the time mechanic within the game will be an analysis of how the game can be engaging yet frustrating. Players will likely quit the game if they feel the game cannot be beat. Otherwise, they will be engaged and frustrated.

In order to make SUPER MARIO BROS. more frustrating by manipulating the time mechanic, time-pressure needs to be created. By creating time pressure the difficulty will rise and the amount of subsequent failure will rise as well. Just like Flappy Bird (and unlike slot machines), no active effort will be made to let the player feel in control. We assume that the game itself, and the default biases that also may be in play with Flappy Bird are in effect.

The time-pressure mechanic can be quickly created as follows take the end time of professional speedrunners and add 10 seconds to the time. This does mean the frustrating-engaging experience is slightly unbalanced since adding 10 seconds is a best guess of what casual players can achieve after many tries [8].

Compared to the previous games, there is less operant conditioning. There too many possible explanations of why this is the case. For example, the game is much older and the digital game-design profession was much younger. Nevertheless, a reward schedule could be seen in terms of progress. For example, a player can die just before she finishes the level, which is a near-miss. Passing an obstacle that has not been passed before is another example. In the other games a lot more is going on with regards to operant conditioning. This might mean that the game will eventually be too frustrating since cognitive biases eventually vanish when a player gets repeatedly stuck in the same level. If this is not the case, then the experience will be a frustrating-engaging one.

If the time-pressure mechanic happens to deliver the so-called frustrating-engaging experience, then reactions from players may be similar to the reactions about FLAPPY BIRD. If this is not the case, then reactions will be negative – the type of reactions that game-designers wish to avoid.

8.2.4 *Conclusion*

The analysis of the three game mechanics shows that there are many similarities with regards to how casual games can have an engaging-frustrating experience. The analysis clearly shows that game mechanics can be very different, but this is much less the case for game dynamics. They share the following characteristics:

- difficult or even impossible to beat,
- players feel some form of control or at least anticipate it in subsequent rounds,
- variable reward schedules emerge or are explicitly coded in the game and players anticipate the rewards.

The difference is mainly on how the mechanics achieve this. Furthermore, in some games, the biases emerge without the game designer intending it (e.g. SUPER MARIO BROS. and FLAPPY BIRD), whereas with slot machines they are actively controlled and explicit design principles exist. However, with all three games, the difficulty of the game has been intentionally designed. Finally, all games have a high variability for when players succeed and when they fail. A player might, for example, surpass his high-score three times within a row, only to die prematurely for fifty times afterwards.

9. CONCLUSIONS

This article provided an exploration on how casual games such as FLAPPY BIRD can be engaging while simultaneously being frustrating. From numerous psychological studies we attempted to distill generic insights for the casual gaming domain with regard to the interplay of engagement and frustration. The exploration focused on the following perspectives:

- defining frustration, engagement and casual games,
- informally classifying types of (positive) frustration that could occur in any experience,
- understanding the neurobiology of rewards in the casual gaming context,
- understanding the design principles from slot machine machines – in the context of addiction – and linking the design principles to casual games,
- analyzing a frustrating-engaging game through the lens of neurobiology, while trying to explain the dynamics of the game through additional literature from related domains.
- analyzing the mechanics of the same game and slot machines and adapting the mechanics of an engaging game in order to make it engaging-frustrating.

By defining and classifying types of frustration in Section 3 and 4 we have shown that frustration is more than a mere negative experience that should be avoided. We have argued that while the experience may always feel unpleasant, this does not translate to the idea that behavioral outcomes are always negative. It furthermore does not mean that the experience of frustration should always be avoided. On the contrary, in some cases frustration is needed since it is believed that frustration motivates people to reach their goals [23]. We explored these ideas more in-depth from the perspectives of neuroscience (Section 5), game studies (Section 6, 7 and 8) and psychology (Section 6 and 7).

Derived from the presented perspectives and the investigated psychological theories, we suggest that a potent explanation for some games being perceived as simultaneously engaging and frustrating, is a *(purposely?) dissociated neural activation of the liking- and wanting-pathways.* That is,

[7] Created with QuickTime from Apple and the image editing tool www.pixlr.com by overlaying each image with each other and changing the opacity so that all birds are a bit visible.

[8] The first four levels are edited with time-pressure in the following Java file: http://bit.ly/1nX0bMR. Attribution goes to the creators of the game (Nintendo)

the current state of psychological literature suggests that in engaging frustrating casual games, the neurobiological conditions may be created in which, informally speaking, the dopaminergic wanting-pathways are being stimulated (e.g., via operant conditioning and the effects of near misses), while the liking-pathways are not being stimulated (see Section 5).

In addition, from Section 6 and 7, it is surmised that conditioning is enforced via several cognitive biases that trick a player into expecting euphoria (liking-pathway), when instead frustration is yielded – with conditioning being iterated to a point that the player is motivated to interact with the game on a foremost instinctual level. Since Section 5 explains that the pathways are distinct, we posit that these stimulations of the wanting-pathway may lead to players interacting with the game not only without actually liking it, but also without knowing why they are interacting with the game. Indeed, this calls for drawing another parallel between drug addiction, and play behavior in which liking may be barely exhibited (cf. [27, 71, 74]).

Section 8 showcased three examples of how one could design an engaging-frustrating game by looking at game mechanics first. It was shown that game mechanics can contribute differently to dynamics that are involved in creating a frustrating-engaging experience. In some cases, the situation or culture plays a distinct role in the dynamics (e.g. fundamental attribution error) – also discussed in Section 7. So for game designers fruitful questions are: what dynamics do I need for a frustrating-engaging experience and how will the situation, our culture and the mechanics of my game contribute to these dynamics? In the analysis of Section 8, it has been expected that the dynamics of a frustrating-engaging experience – with regards to the challenge aesthetic – in a casual game are fixed. The dynamics of such games are: (1) very difficult or impossible to beat, (2) players need to feel or anticipate agency and control (e.g., the game seems easy and it heightens near-misses), (3) schedules that give rewards at variable intervals or ratios at a high variability (e.g. score 15 points on round 1 and die immediately on the second round) and (4) the player wanting (perhaps even craving) rewards.

10. DISCUSSION

The discussion section presents implications, the limitations of this paper and future work. Most implications of this paper are also applicable to other fields since an engaging yet frustrating experience sheds light on many aspects of an emotional experience that is not exclusive to digital games. Then, limitations will be presented. Finally, we will end with expectations, hypotheses and more general notions with regards to future work.

10.1 Implications

Due to the nature of the topic, the implications are broad. We first start with discussing the variables of interest. This hints at future research and sometimes highlights some aspects of this topic that might be understated in the main text. Implications for education are discussed next. The final two sections are implications with regards to serious games and frustration as an emotional experience.

10.1.1 Variables of interest

The conclusions of this paper hint at the idea that there are two classes of interesting dependent variables when it comes to player experience. The first class is illustrated by variables such as: enjoyment, flow and engagement. The second class is illustrated by variables such as: willingness to play, digital game usage or amount of hours played. The wanting-and-liking theory, the aesthetic experience of frustrating-engagement itself and the ideas about near-misses suggest that these two classes of variables are not always related to each other, just like they are not related with each other in the context of addiction.

Another implication is that anticipation should be more incorporated into current models of game-design and player experience modeling. While anticipation has not been explicitly discussed it has been a part of the discussion in some sections of this paper. For example, perhaps players who anticipate flow or who anticipate a game to be challenging – while in reality it is too difficult – may not experience flow but they may continue to play. Anticipation can also be linked to cognitive biases, which it already has in terms of the overconfidence bias (i.e., anticipation of skill-level and difficulty of an estimation problem) [52].

Operant conditioning and cognitive biases are other classes of interesting independent variables of interest. Operant conditioning and cognitive biases may have an effect on willingness to play, digital game usage or amount of hours played. It would be interesting to see to what extent they have an effect on enjoyment. Cognitive biases likely do have an effect on enjoyment, since there probably is a cognitive bias that influences affect or mood directly. Does operant conditioning have a positive association with affect or mood as well?

Finally, the biggest elephant in the room is the relationship between frustration and attribution. As stated in 3.2, the evidence is small. However, it is only small because it has not been studied and replicated enough. If it turns out that frustration only leads to quitting a game when the attribution of the feeling is to the environment, then player experience modellers have an interesting addition to their existing models. Imagine an AI system being able to distinguish when a player feels a fault is his or her own compared to the fault of the game environment. It would broaden the research agenda of dynamic difficulty adjustment.

10.1.2 Education

Despite that this paper has been written within a game context, there might be important implications with regards to education. While there is low support in psychology about the attribution of frustration, empirical support from slot machine design shows that the illusion of control is necessary for engagement. Hence it may be the case that the attribution of frustration in education is an important question to ask. Perhaps if children feel in control, then it may not be a problem at all that learning itself could be a frustrating experience. However, if children feel frustrated due to the situation they are in, then learning becomes a terrible experience indeed.

This is not only an implication of feeling frustrated while attributing it to the environment. It is mainly the implication of attribution itself. For example, it is possible to learn feeling helpless (aptly called learned helplessness). In such a case, the source of the problem will also be attributed to the environment [1].

10.1.3 Serious games

The ideas presented in this paper suggest that there are moments within an educational game that the aversive consequences of goal-blocking can be avoided. Moreover, in some cases it can even be a beneficial experience. The conclusions seem to suggest that a player needs to feel some form of progression. The progression can be small; it can feel random even, but it has to be present. In that sense, a frustrating-engaging game does not block a goal indefinitely. Eventually, a player is able to progress further. One could even ask the question if a game could be terribly designed, as long as the players attributes the sources of negative affect to himself and wants to continue playing due to operant conditioning or some other motivating factor. As discussed in Section 4.1.2, this has been the case for [26].

The flexibility of that it probably does not really matter what form of progression is implemented is not shared when it comes to the design of user interfaces. Serious games that stall, hang, have difficult menu's, have a toxic player base – among other things – will deter players from playing. We would recommend that when serious games are implemented, more attention is drawn to this aspect of game-programming than the actual game itself. Not many players would like to play a serious game that crashes every 6 hours.

10.1.4 Frustration as an emotion

It is well-known that frustration is not a basic emotion [22]. However, this does not mean the experience has to be ignored. It also does not have to mean that all research should be focused on the frustration-aggression hypothesis. Unfortunately, the field of psychology has a tendency to focus on the negative experiences and not positive ones. We would like to ask emotion researchers to look at frustration as an emotion and the consequences of the experience (positive and negative).

10.2 Future research

Future research that seems immediately obvious is testing the claims that have been made in this paper. Yet, a perhaps less visible area of research is to investigate the effects of frustration with regards to other aesthetic experiences. In Section 4, narrative frustration has been presented as a positive form of frustration. Perhaps there are also beneficial aspects with frustration with regards to: immersion, fellowship, discovery and expression? In drama, there is a specific style that might be seen as frustrating immersion which has been pioneered by playwright Bertolt Brecht decades ago.

Another path of research is to investigate what the effects of cognitive biases are on commercial or serious digital games. The field of cognitive psychology is big and there are many biases that could be investigated. While Wikipedia articles are not peer-reviewed, the article on cognitive biases does give an idea on how big the list is[9] (note: many biases overlap or are related). It also may help cognitive psychologists to gather participants with less effort, since playing games is viewed as a fun activity.

The tweaked Mario game could also be tested. While it has been a prominent part of Section 8, it has not been empirically tesed to what extent it constitutes an engaging-frustrating experience. Two good comparison groups may be one playing FLAPPY BIRD and one playing TETRIS. Manipulation checks need to be taken into account such as to what extent are all 3 games engaging.

The game FLAPPY BIRD itself or SWING COPTERS could also be tested under an fMRI. While it is hard to see if the liking or wanting pathway would activate (fMRI does not measure neurotransmitters), hypothesizing and measuring striatal activity alone would be interesting. Perhaps an analogous 'game' could be made for mice. Such a game would incorporate principles from operant conditioning and cognitive biases that are generalizable to animals (many are not but emotional biases may be). Then, an indication of activated wanting and liking pathway could be measured.

For more specific future work, we propose a modest parsimonious hypothetical model in figure 9. The hypotheses of the model are motivated by the discussed literature of this paper. From the sections discussing the neurobiology and slot machine design, we have reason to believe that operant conditioning is positively associated with amount of hours played per week on digital games. We furthermore believe that the cognitive bias illusion of control has a moderated association on the previous relationship with regards to slot machine games. This is because it has been shown in that section that the design principles are to deliberately trick players into believing they are in control. While there could be many causal mechanisms behind it as discussed in this paper, it would be interesting to see if this model would not be falsified to begin with. It may also be interesting to test this model with the game FLAPPY BIRD. Manipulation checks such as players liking games with a challenge need to be done beforehand.

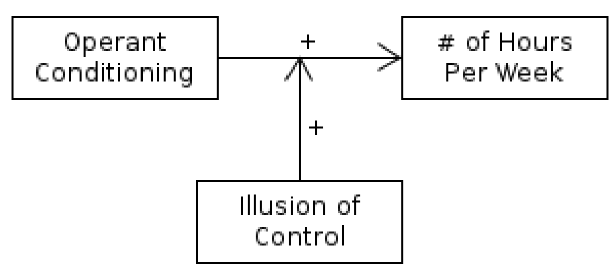


Figure 9: Interaction model between operant conditioning and illusion of control with the amount of hours played on a slot machine game.

[9]Link to the article: https://en.wikipedia.org/wiki/List_of_cognitive_biases

One area that would be less fruitful is to try to predict to what extent intrinsic motivation determines how many hours per week someone plays a digital game. In their study about self-determination theory, Ryan, Rigby and Przybylski found that self-determination theory did not have great explanatory power with regards to how long a game was played [66]. Hence intrinsic motivation was not accounted for in the model of figure 9.

Finally, we propose a sketch of another psychological study. In this study the results discussed in Section 3.2 need to be replicated for games. More specifically, it needs to be known if a player will quit a game if the attribution of the frustration is attributed to the game and continues playing if she attributes it to herself. For such an experiment, a game needs to be quite difficult to extremely difficult in order to make it frustrating. Another dynamic is that a player should feel a small sense of progression since this is likely to occur in natural settings as well, even with purely frustrating games. This sense of progression preferably occurs subconsciously, which might be possible since it is a phenomenon in strategic decision-making [5]. In the conclusion of Section 8, this form of progression has been made more specific as variable reward schedules. A concrete example is that Flappy Bird or Swing Copters 2 could have a modified collision box in one condition and a pixel perfect collision box with the sprite of the character in another condition. Frustration and attribution would need to be measured by surveys. A useful survey for measuring attribution between a participant or the situation the participant is in is the Revised Causal Dimension Scale [51]. It has not been possible to find a useful survey for measuring frustration, which means that it has to be constructed. The surveyed literature in this paper that did use surveys for frustration used only one or two items, and have not been validated with other surveys (i.e., no convergent or discriminant validity). It may be helpful to construct it in terms of goal-blocking (e.g., “I died often in the game”) and in terms of the feeling of frustration (e.g., “I felt frustrated while playing the game”).

10.3 Limitations

Perhaps the biggest limitation is that this paper does not have an experiment to back up the claims. It is not a systemic literature review either, although we did our best to incorporate every paper that would be relevant on the topic. With regards to content, we emphasized frustration over engagement despite both being equally important with regards to the experience. We did this because there is more literature available and more research has been done on engagement. We wanted to show the potential positive benefits from having a (partially) frustrating experience. Nevertheless, it is still a limitation since it biases the argument that we have made. Furthermore, the frustrating-engaging experience is implicitly derived, or at least has a close connection with, the challenge aesthetic. This is partially the case, because research on games tend to gravitate towards the challenge aesthetic (e.g., flow theory). It is one of the reasons why we did not look at other aesthetics enough.

One limitation are the definitions in Section 3. The advantage of definitions is that it has been explicit from the start what we mean with certain terms. It may be the case, however, that the reader still believes the terms are vague. It may also be the case that the our definitions renders this paper incomparable to other research since they use the terms differently. With regards to the term frustration what could be a bit confusing is that the process of how frustration occurs has been defined, but the feeling of frustration has not been defined.

A methodological limitation is that it seems rather ad-hoc. It may be logical to first define terms, then seek counter examples with regards to the current theories but the sections after that and why they are chosen might look too random to be in a paper. In a sense, the idea is to start with fundamental research disciplines (neuroscience) while going through applied research settings and ending in a very practical setting (game mechanics). This is definitely not the best approach to take and an improved approach to answer similar questions are probably known to some game scholars.

The final limitation is our scientific background. During the peer-review process we have been called an expert on neuroscience (the email about this quote cannot be disclosed). This is simply false and it was never the intention of us to propagate this idea. While we did take a few courses on the topic, it does not make us an expert compared to a neuroscience PhD student in the same field, for example. Instead this review is more in the same vein as the review on the neurobiology of play, which was a review where 2 computer scientists reviewed the neuroscience about joy and claimed in particular that they are not neuroscientists [4].

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