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„A Simulation Study on the Impact of Dark Patterns in Mobile Games on User Interaction“

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Abstract

With the explosive growth of the mobile gaming industry, dark patterns—manipulative design techniques that exploit psychological and behavioral tendencies—have become increasingly prevalent. These patterns, which can pressure players into spending more time or money than they intend, are deeply embedded in many mobile games, raising ethical concerns about user manipulation. This thesis presents a simulation study that explores the implementation and impact of dark patterns in mobile game design, analyzing how these deceptive practices affect player behavior, engagement, and spending. By developing a custom mobile game with two versions—one featuring dark patterns and the other without—this research examines real-world player responses over a 30-day period. The results reveal a significant increase in player engagement, app usage frequency, and in-game purchases among users exposed to dark patterns. Players often reported feelings of frustration, loss of control, and a sense of being manipulated, particularly in response to techniques like "pay-to-win" mechanics, daily rewards, and appointment-based play. Interestingly, while dark patterns effectively boosted short-term metrics such as retention and revenue, they also led to diminished long-term user satisfaction and trust. These findings underscore the ethical challenges mobile game developers face, suggesting that the pursuit of immediate profits through dark patterns may ultimately alienate players and harm a game's reputation. This research contributes to the growing discussion around the ethics of game design, highlighting the need for industry regulation and consumer awareness to address the negative effects of dark patterns.

Kurzfassung

Mit dem rasanten Wachstum der Mobile-Gaming-Branche sind sogenannte "Dark Patterns"—manipulative Designtechniken, die psychologische und verhaltensbezogene Tendenzen ausnutzen—immer häufiger geworden. Diese Muster, die Spieler dazu verleiten können, mehr Zeit oder Geld zu investieren als beabsichtigt, sind in vielen mobilen Spielen tief verankert und werfen ethische Fragen hinsichtlich der Nutzerbeeinflussung auf. Diese Arbeit präsentiert eine Simulationsstudie, die die Implementierung und Auswirkungen von Dark Patterns im Mobile Game Design untersucht und analysiert, wie diese täuschenden Praktiken das Spielerverhalten, das Engagement und die Ausgaben beeinflussen. Durch die Entwicklung eines mobile Games mit zwei Versionen—eine mit Dark Patterns und eine ohne—werden reale Spielerreaktionen über einen Zeitraum von 30 Tagen untersucht. Die Ergebnisse zeigen einen signifikanten Anstieg des Spielerengagements, der Nutzungsfrequenz und der In-Game-Käufe bei Nutzern, die Dark Patterns ausgesetzt waren. Spieler berichteten häufig von Frustration, Kontrollverlust und dem Gefühl, manipuliert zu werden, insbesondere bei Techniken wie "Pay-to-Win"-Mechaniken, täglichen Belohnungen und zeitgebundenem Spielen. Interessanterweise führten Dark Patterns zwar zu kurzfristigen Erfolgen wie erhöhter Bindung und Umsatz, jedoch auch zu einer verminderten langfristigen Zufriedenheit und Vertrauen der Nutzer. Diese Erkenntnisse unterstreichen die ethischen Herausforderungen, denen sich Mobile-Game-Entwickler gegenübersehen, und legen nahe, dass die Verfolgung kurzfristiger Gewinne durch Dark Patterns letztlich Spieler entfremden und dem Ruf eines Spiels schaden kann. Diese Forschung trägt zur wachsenden Diskussion über die Ethik des Game Designs bei und betont die Notwendigkeit von Branchenregulierung und Verbraucherbewusstsein, um die negativen Auswirkungen von Dark Patterns zu adressieren.

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1 Introduction

The mobile gaming industry has experienced significant growth, establishing itself as a major segment within the global gaming market. In 2023, the global mobile games market generated approximately $76.7 billion in revenue, marking a stabilization after previous declines and maintaining a 22% increase over pre-pandemic levels [Gam23]. The design and development of a game are critical factors in creating a successful mobile game that can distinguish itself in the competitive landscape of app stores such as Google Play and the Apple App Store.

In the Apple App Store, approximately 1,350 new apps are released daily, contributing to a total of over 2.16 million apps available as of 2023 [42m23b]. Similarly, around 1,100 new apps are added to the Google Play Store daily, leading to a total of over 3.3 million apps [42m23a]. The competition is fierce, and only those games with exceptional design and user engagement strategies can hope to stand out. In the first quarter of 2024, users downloaded approximately 25.6 billion apps from Google Play [Sta24b]. Among these downloads, mobile games accounted for a significant portion, underscoring the substantial role of gaming in mobile app usage. Additionally, gaming apps remain the most popular category in the App Store, comprising over 13% of all active apps [Sta23b]. In 2023, consumers spent a total of $89.6 billion on the Apple App Store, with gaming apps accounting for the largest share [oA23].

In the Apple App Store, only 5% of all apps are paid, while the remaining 95% are free. Similarly, in the Google Play Store, only 3% of all apps are paid, with the remaining 97% being free [oA23, Sta23a]. This distribution underscores the necessity for free apps, especially games, to have exceptional design to stand out amidst the millions of other apps in these stores. The predominance of free apps means that monetization strategies such as in-app purchases (IAPs) and advertisements are critical for the financial success of these apps.

A 2016 study conducted by Greg Sterling revealed that only 5% of users engage in in-app purchases (IAP). A significant portion of these purchases is made by "big spenders" or "whales." These big spenders constitute 70% of in-app purchases, despite representing only about 10% of all paying users [Zip23]. Consequently, game designers often employ Dark Patterns to incentivize these big whales to spend even more money. Dark Patterns are design elements that intentionally trick users into performing actions they did not intend to take, often for the benefit of the app's revenue [SA21].

Game design frequently emphasizes 'player-centered design' or 'play-centric design' a concept described by Adams Ernest in "Fundamentals of Game Design" as the obligation of the designer to create a game that entertains the player [Ada14]. This principle suggests that the primary goal of game design should be to provide enjoyment and satisfaction to the player. However, the interests of game developers often diverge from those of their

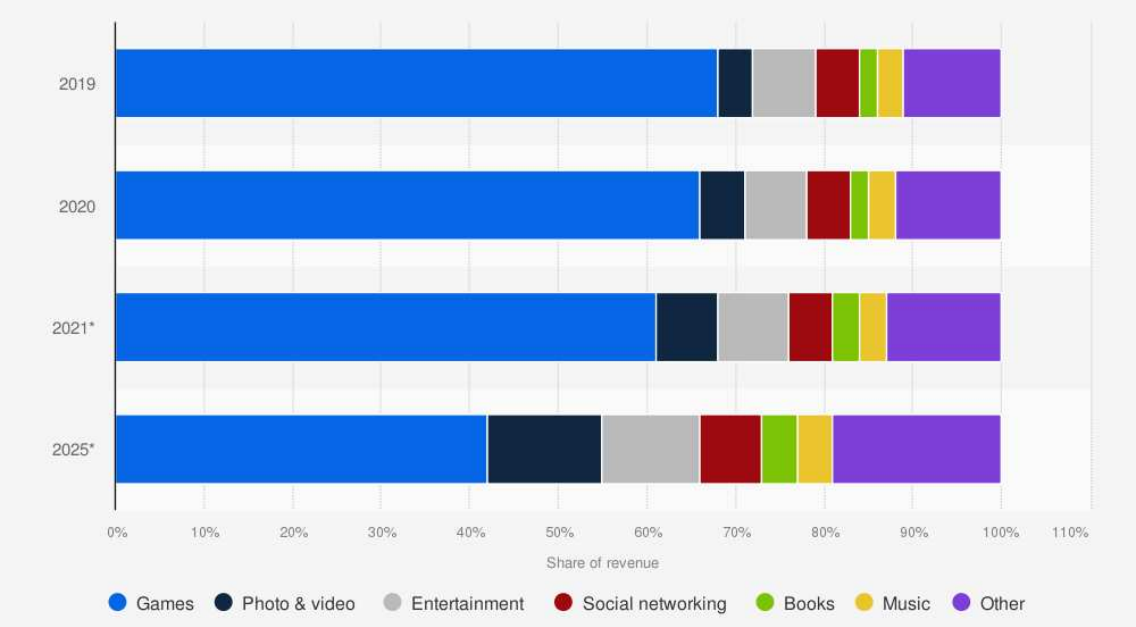


Figure 1.1: Gaming apps dominate consumer spending, accounting for 66% of revenue in 2020 [Sta24a].

player base, particularly when financial incentives are involved [ZBL13a]. While the ideal is to prioritize player enjoyment, the reality is that many developers are also focused on maximizing revenue, which can lead to the incorporation of manipulative design elements.

Researchers within the CHI research community have investigated critical aspects of UX (User Experience) and UI (User Interface) design across various websites and games, leading to the identification of Dark Patterns. Dark Patterns are manipulative design techniques used by developers to trick users into performing actions they did not intend [DGBF+20]. These patterns can include elements like confusing navigation, misleading labels, and deceptive imagery that guide users toward decisions that benefit the app's revenue model. An analysis by Linda Di Geronimo et al. examined 240 mobile apps and conducted an online experiment with 589 users. Their findings indicated that 95% of the apps contained at least one form of a Dark Pattern, with the most popular applications averaging seven different types of deceptive interfaces. Initially, most users were unable to recognize Dark Patterns. However, after being informed about the malicious designs, they became more adept at identifying them [GBF+20].

This raises the critical question of whether modern mobile games are designed primarily to maximize revenue by encouraging users to spend as much time and money as possible, or if they are designed to be genuinely enjoyable without a sole focus on profitability.

This dichotomy between player enjoyment and developer profit is at the heart of the discussion on Dark Patterns in game design. It challenges the ethical considerations of game design and the responsibility developers have towards their players.

1.1 Motivation

The widespread use of smartphones enables people globally to engage with mobile applications and games extensively. The accessibility and convenience of mobile gaming mean that it has become a ubiquitous part of daily life for many individuals. Many users perceive no harm when downloading free apps or games, assuming that if an app is free, there are no hidden costs. However, designers frequently employ Dark Patterns to manipulate players into spending money or time, often in ways that are not immediately obvious to the user. It is crucial to demonstrate that even free-to-play (FTP) games can incur hidden costs for players. These costs include direct spending, time investment, viewing ads, or social pressure to play continuously.

Chapter 2 will explore four main ways players pay for FTP games. These include direct financial transactions through in-app purchases, the time spent engaging with the app, exposure to advertisements, and the psychological impact of social connectivity pressures. Educating players on distinguishing between genuinely enjoyable gameplay and games designed to extract money is essential. By understanding these tactics, players can make more informed decisions about how they spend their time and money.

Informed players, especially big spenders, need to understand that companies will continue to develop games that exploit them financially by incorporating numerous Dark Patterns without being too obvious. The concept of "whales," or big spenders, is particularly important as these players often provide a significant portion of a game's revenue. By targeting these players with sophisticated and often covert manipulative strategies, developers can significantly increase their profits. This practice raises ethical concerns about the responsibility of game developers to their player base and the potential for exploitative practices in game design [SA21].

Understanding these dynamics is not only important for players but also for researchers and policymakers who are interested in the ethical implications of game design. By highlighting the prevalence and impact of Dark Patterns, this research aims to contribute to a more transparent and ethical game development industry. This understanding can lead to better regulation and guidelines that protect consumers from manipulative practices while still allowing for innovation and creativity in game design.

2 Dark Patterns in Game Design

The term "Dark Patterns" first emerged in 2010, when Harry Brignull, who holds a PhD in Cognitive Science, created the website `www.darkpatterns.org`, which is now available at `www.deceptive.design` [Dec]. Brignull defines Dark Patterns as "tricks used in websites and apps that make you do things that you didn't mean to, like buying or signing up for something," emphasizing their manipulative nature.

In the paper "What Makes a Dark Pattern... Dark?" by Mathur et al., the authors identified a total of 19 Dark Patterns, which can be categorized into four facets. These facets describe different aspects of Dark Patterns and their impact on users [MKM21]:

1. The user interface: This facet refers to user interface designs that trick or mislead users. Mathur et al. and Gray et al. describe Dark Pattern designs as "coercing, steering, or deceiving," and possessing "obnoxious, coercive, or deceitful" properties [MKM21, GCL20].

2. The mechanism of effect for influencing users: There are 13 distinct ways of influencing users through the user interface, such as subverting user intent or preferences, undermining user authority, tricking, attacking, exploiting, or manipulating users [CS10].

3. The role of the user interface designer: Some designers exploit their domain-specific knowledge to deploy Dark Patterns to achieve their goals. As early as 1998, Brian J Fogg noted that some designers use "persuasive technologies" as a mechanism to influence users without their knowledge [GKB+18, Fog99].

4. Benefits and harms resulting from a user interface design: This facet focuses on the intended outcomes of Dark Patterns, where designers aim to benefit the online service or harm users to achieve profit [CS10, MAF+19c].

2.1 Categories of Dark Patterns in Design

Zagal et al. defined that there are three major categories of Dark Patterns in the design of games. Those three categories can be divided into either two or three subcategories. They analyzed design strategies by professional designers, observations by game researchers, and player and game critics' reactions. The three major categories are Temporal Dark Patterns, Monetary Dark Patterns, and Social Capital-Based Dark Patterns. There is also a fourth category which can be called Psychological Dark Patterns, which is also stated on the website `www.darkpattern.games`. [DPG, ZBL13a]

2.1.1 Temporal Dark Patterns

This category of Dark Patterns "cheats" players of the game out of their time. Players who play mobile games that contain temporal Dark Patterns will experience that progress in the game takes more or less time than they expected. There are a few guidelines that players can follow to check if the game they play contains temporal Dark Patterns. The first thing is, that they can check if the feeling of playing the game and completing certain steps in the game takes about as much time as they expect, or if it takes significantly longer or shorter. Another factor could be to ask themselves if they feel like they "wasted their time" by playing the game, or if they at least had fun while playing. [Boj08, Dard]

Grinding

When talking about temporal Dark Patterns, performing repetitive and tedious tasks is called grinding. Grinding is omnipresent in most social media games like Candy Crush Saga or FarmVille, as well as in massively multiplayer online role-playing games like Guild Wars 2 or World of Warcraft. Grinding is the act of a game prioritizing the time a player invests in a game over the skill of the player. Grinding makes the player spend more time in a game, where the sole purpose is to extend the time a player spends in the game, rather than the player experiencing new parts of the game. [APS08, Dard]

Playing by Appointment

Another Dark Pattern that can be considered a temporal Dark Pattern is "playing by appointment". Games that use playing-by-appointment Dark Patterns sometimes force players to orient their activities in the real world according to a schedule set by the game if they want to achieve progress. An example is FarmVille, where crops need a certain amount of time in order to be harvested, but if a player waits too long they start to wither and the player is not able to harvest the crop anymore. So if a player wants to harvest ripe crops, they have to adjust their real-life schedule according to the game, if not they will start to lose the money they invested in the crops and it will be very hard for a player to progress in the game. [LWFW12, Dard]

2.1.2 Monetary Dark Patterns

Monetary Dark Patterns can make players spend insanely huge amounts of money in the game, in order for the player to make progress in the game at a faster pace or generally at all. Sometimes players do not even want to spend any money, but at a certain point, games may become insanely difficult or tedious if they do not invest real money in the game. There are again a few questions a player can ask themselves to check if the game contains monetary Dark Patterns. For example, if the player thinks after spending the money in the game if they regret their decision, or if, after some time, the player does not know how much they actually spent in the game. Another indicator of monetary Dark Patterns could be that the player does not actually know what they will get in return

for their spent money or that they do not know how much money they have to spend in order to achieve the goal they expected to get with their investment. [ZBL13a, Dara]

Pay to Skip

A very common monetary Dark Pattern is the so-called Pay to Skip pattern. This pattern is actually already quite old, it was implemented in early video game arcade machines, where the player could decide to continue playing from the point they lost by inserting more money. Nowadays though most of the time, pay to skip simply means paying for a super weapon that easily lets you beat the level or a very hard boss the player is currently stuck at. The pay-to-skip pattern often appears together with grinding, by making something like a rare item in a game achievable by playing a very long time, sometimes a few hundred hours, or by simply buying the item with real-world money, in order to skip the progress of grinding for that item. [ZBL13a, Dara]

Pre-Delivered Content

Nowadays a lot of games are released in a state which could be considered as not 100% finished. That state used to be known as "Early Access Game", where players spent money on a game, and in so doing, they hoped for the developers to finish the game and receive the game in a finished state a few months or years later, sometimes though developers were not able to achieve that goal and the money which was invested in the game by a player would not be returned. But since players knew that they invested in an "Early Access Game" it may be considered a risk the player was willing to take. [LBH18] But in recent years even big publishers like EA, Capcom, or Activision-Blizzard started to release games that were not completely finished, or not even complete in content, even though those games were full price. An example would be Street Fighter X Tekken, where the game costs $30 in the US, but the game did not contain all of the characters playable, even though the characters were already on the disk. They charged an extra $20 for the other 12 characters that were locked in the character select menu. This type of Dark Pattern is called "Pre-Delivered Content". [Ope, Dara]

Monetized Rivalries

The last major Monetary Dark Pattern is the so-called Monetized Rivalries pattern. This Dark Pattern is more broadly known as "Pay to Win". It especially looks at people who want to be as competitive as possible. So in order to climb leaderboards or achieve certain achievements, they are encouraged to pay for in-game items that help them claim their goal of being one of the best in the game. A very well-known example is FIFA, with the game mode FIFA Ultimate Team, where players can create their own dream team from scratch, by buying players from the market or opening so-called booster packs where random players are inside. Booster Packs can be bought with in-game money, which the player receives while playing the game, or with real money, which speeds up the process of getting a better team significantly and allows the player to play more competitive games

against other players with a similar good team and a high rank. As you can see in Figure 2.1 Ultimate Team revenue significantly increases revenue year by year for Electronic Arts. [Siu21, FIFa, FIFb, ZBL13a, Dara]

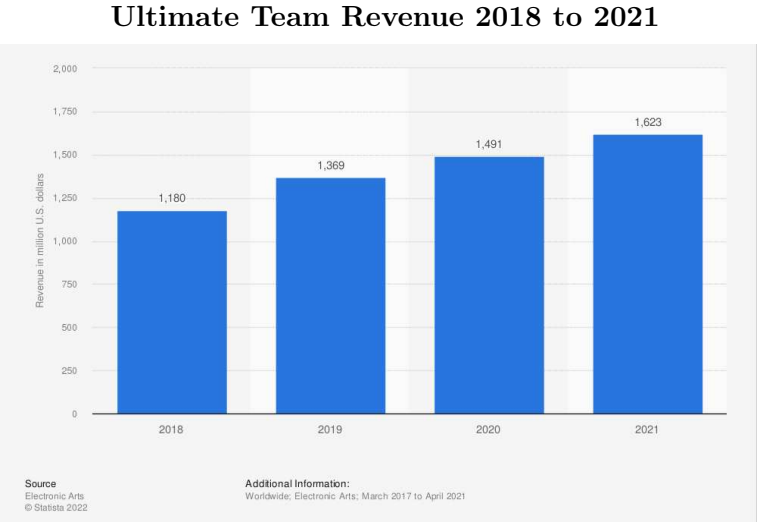


Figure 2.1: Net revenue generated by Electronic Arts from extra content sales for Ultimate Team mode from 2018 to 2021 (in million U.S. dollars) [ele]

2.1.3 Social Dark Patterns

Since playing games can be said to be a social activity, there is also the risk of a player losing their social standing and their social relationships. For example, a player's respect or friendship can be lost by either playing or not playing the same game as their friends do. A player may feel pressured to play a game because otherwise, he may lose connection with his group of friends, and thus lose the respect of the group because they are not part of a main social activity in their group. [Darc]

Social Pyramid Schemes

Pyramid schemes or multilevel marketing schemes are business models that offer people who invest in their product, in their idea, or in the person, high levels of returns. By convincing more and more people to invest, they "are compensated not just for the sales they personally generate but for the sales generated by the people they recruit". Most of the time, those schemes are either unethical or illegal, but not all of them are [Mun04]. Games that implement the social pyramid Dark Patterns scheme, encourage players to invite their friends and in return receive in-game bonuses for the game. An example of that would be Facebook games like Dungeon Overlord, Candy Crush Saga, FarmVille, Cooking Mama, or City of Wonder, where players can invite their friends and in return, they can send them very important gifts. In the game Dungeon Overlord for example

they can send gifts like a horse or plutonium, which is very important for the progress in the game. Players that send the gift do not possess the actual item they send, so it makes sense to daily send an item to your friends and encourage them to send them one back to you. Items like a horse or plutonium are very hard and time-consuming to acquire, so it makes sense for players to invite friends and encourage them to join the game, who can then send them their daily gift for free. [Con11] At points it is almost impossible to progress in the game without paying with real money for an item in the game because it would take days or weeks to pay for it with in-game money. Or the simpler way would be to invite friends that simply can send you said item as a gift every day. So the actual Dark Pattern is not the ability of the player to invite friends to the game, but rather the obligation that they have to invite them and convince them to keep playing in order to progress which makes them feel like they are trapped inside a pyramid scheme. [Lis10, ZBL13a, Darc]

Impersonation

Sometimes players receive notifications from other players, mostly inside their friend list, where the other player sent them a gift. For example in FarmVille, where it says: "Howdy Farmer, Sarah sent you: 2 Eggs. Help out Sarah & give them a gift back."[How] Even though Sarah actually never sent the gift in the first place. The game impersonates the players' friends as a Tutorial about how to receive Gifts from your friends. Another problem is the so-called "Friend Spam" where the game asks for your Twitter or Facebook credentials and posts without the players' knowledge, to the other social media platform. Players may lose friends through the action of the game that posts, since they may feel like they are being flooded by Notifications that they are not interested in, thus why they remove their friends from their friend list on Facebook or stop following them on Twitter. [Far, ZBL13a, Darc]

Psychological Dark Patterns

The last Dark Pattern is the Psychological Dark pattern, which is very similar to the Social Dark Pattern. The psychological Dark Pattern makes the player believe that by playing the game, it becomes more valuable to themselves. So when the player has achieved a lot of rare items, it can become very difficult for them to throw the game away, or not play the game anymore, since they feel like they will lose a part of their achievement. Players are also more likely to come back to a game, where they only completed a goal partially and not completely since they want to make constant progress in the game. Game developers often try to make players think they are more skilled than they actually are, to make them continue their game. Brains also respond more positively to variable rewards than to consistent ones. Most of the time rewards in games are given after completing a certain task and vary from new items and skins to in-game currency and experience points for leveling up your character. Examples of psychological Dark Patterns are: [Darb]

- **Invested / Endowed Value**
  A game where you already have spent a lot of time and money, is very hard to throw away
- **Badges / Endowed Progress**
  Players do not want to stop playing when they are close to achieving a goal.
- **Complete the Collection**
  Some players love to complete games, and get all the achievements and items in a game.
- **Illusion of Control**
  The game makes the players believe they are stronger and more skilled than they actually are.
- **Variable rewards**
  Human brains enjoy rewards, especially rewards that are unpredictable and unexpected.
- **Aesthetic Manipulations**
  Games often play with the players' desires, by using trick questions and playing with the emotions of the player.
- **Optimism and Frequency Biases**
  Players tend to overestimate parts of the game because they memorize it that it occurs quite often.[Darb]

2.2 Categorization of Dark Patterns Using Taxonomies

In the literature, several taxonomies have been developed to categorize Dark Patterns in digital interfaces. One of the most widely cited taxonomies is from Mathur et al. [MAF+19b], which organizes Dark Patterns based on their coercive nature. Their work divides Dark Patterns into categories such as "asymmetric information," where key details are hidden from the user, and "obstruction," where users are forced through unnecessary steps to reach their desired outcome.

For mobile games, these taxonomies can be expanded by adding subcategories that focus specifically on player behavior and monetization strategies. For example, Dark Patterns that exploit psychological biases, such as the endowment effect or loss aversion, are particularly effective in games. These patterns manipulate the player's emotional attachment to virtual items, making them more likely to spend real money to avoid losing their progress [ZBL13b].

In this thesis, we use a customized taxonomy to categorize the Dark Patterns found in mobile games, particularly those related to time manipulation, monetary investment, and social pressures. This taxonomy allows for a more granular analysis of how different patterns affect user behavior and engagement, providing a comprehensive framework for understanding their role in game design.

3 Related Work

There are already several papers discussing Dark Patterns. For example, Mathur et al.'s study titled "Dark Patterns at Scale" involved analyzing around 53,000 product pages from about 11,000 popular shopping websites. They discovered 1,818 instances of Dark Patterns, with at least one pattern found on 1,254 websites—meaning over 11% of these sites contained Dark Patterns. More popular websites also featured Dark Patterns more frequently, with 234 patterns identified across 183 sites classified as deceptive behaviors.[MAF+19b]

Mathur et al. created a taxonomy for Dark Pattern characteristics consisting of the following dimensions:

- **Asymmetric:** Is the user interface fairly distributed, with all choices presented equally?
- **Covert:** Does the website make the user buy something without full awareness by making options more appealing?
- **Deceptive:** Are there misleading statements or omissions, such as countdown timers that refresh upon page reload?
- **Hides Information:** Does the site conceal critical details, like additional costs, until the final checkout step?
- **Restrictive:** Does the interface limit user choices, for instance, by allowing sign-up only through social media?

Using these characteristics, Mathur et al. demonstrated that Dark Patterns are commonly embedded in primary interaction paths on websites, often sharing similar attributes. Their detection approach relied on automating these interaction paths and grouping textual elements for analysts to review (see Figure 3.1).

First, they created a Corpus with different criteria to evaluate lists of popular shopping websites from the Alexa Top Sites API [Ale]. Then they used WebShrinker to classify the list of websites to only return shopping websites. They also used Selenium and the Polyglot Python library to filter out non-English websites.

After the corpus was created they built a Selenium-based web crawler which was able to distinguish URLs for products and non-product. They trained a Logistic Regression classifier on a dataset of labeled URLs (product/non-product), which they trained manually, using the SGDClassifier from sci-kit-learn. They extracted several relevant features from the URLs, like length, number of slashes, and if the URL contained the words product or category. They added their classifier to their original web crawler. The crawler

then visited the most likely URLs that were product URLs. URLs that were most likely product URLs had an 'Add to Cart' Button on the website. This way they were able to use the crawler on all of the 19,000 shopping websites, where they gathered 53,180 product pages from 11,286 shopping websites.

Then they started to simulate the product purchase flows by creating a checkout crawler on OpenWPM. They trained the crawler to find the 'Add to cart' buttons, 'View cart' buttons, and 'Checkout' buttons. They split the 53,000 product URLs into two equal lists, which the crawler approximately took 90 hours to complete.

The checkout crawler then divided the pages into meaningful segments in order to assist with the discovery of Dark Patterns. They developed a segmentation algorithm for visible HTML elements, where they stored for each segment the element type, text, dimensions, and coordinates, as well as its text style and background color. Altogether the crawls resulted in around 13 million segments.

They used hierarchical clustering to discover Dark Patterns from the data set of segments. For data pre-processing they removed duplicates, like the hundreds of 'Add to Cart' segments across all websites. This way they managed to reduce the list of segments by 90%.

Text segments were transformed into Bag of Words (BoW) representations, and put in a BoW matrix (M_{ij}). They filtered out punctuation and stop words from the list and only kept tokens that appeared in at least 100 segments. Then they used Principal Component Analysis (PCA) on the BoW matrix, where they retained 3 components. That was more than 95% of the variance. Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDB-SCAN) algorithm was then implemented to extract clusters.

The clusters were passed through twice. In the first pass, one researcher scanned the clusters and the goal was to find segments that might reveal themselves as Dark Patterns. They checked for specific types of user interfaces, website characteristics, and product options. With this first pass, they managed to go from 10,277 clusters to 1,768. In the second pass, they extracted all the websites that could be assigned to these segments for further investigation. Two researchers examined 200 of the 1,768 clusters and recorded all the Dark Patterns they could find. They computed Cohen's kappa between all the segments they found, with a resulting score of 0.74.

As a final detection of Dark Patterns, they reused the checkout crawler to monitor websites that contain Dark Patterns of interest every four hours for a period of weeks, for example, websites that contain countdown timers, in order to check if they renew or if they really end when the timer is over and the discount vanishes or not.

As already mentioned they discovered 1,818 instances of Dark Patterns from 1,254 websites. While this is not a complete representation of all the Dark Patterns on all the websites they visited, since the crawler only explored product pages, cart pages, and checkout pages of websites and it only analyzed text-based user interfaces, it shows that there are a lot of Dark Patterns on most of the popular English speaking shopping websites in the world. [MAF+19b]

Building upon the identification of Dark Patterns in shopping websites, it's crucial to examine their implications within the mobile gaming industry. Aagaard et al.'s study,

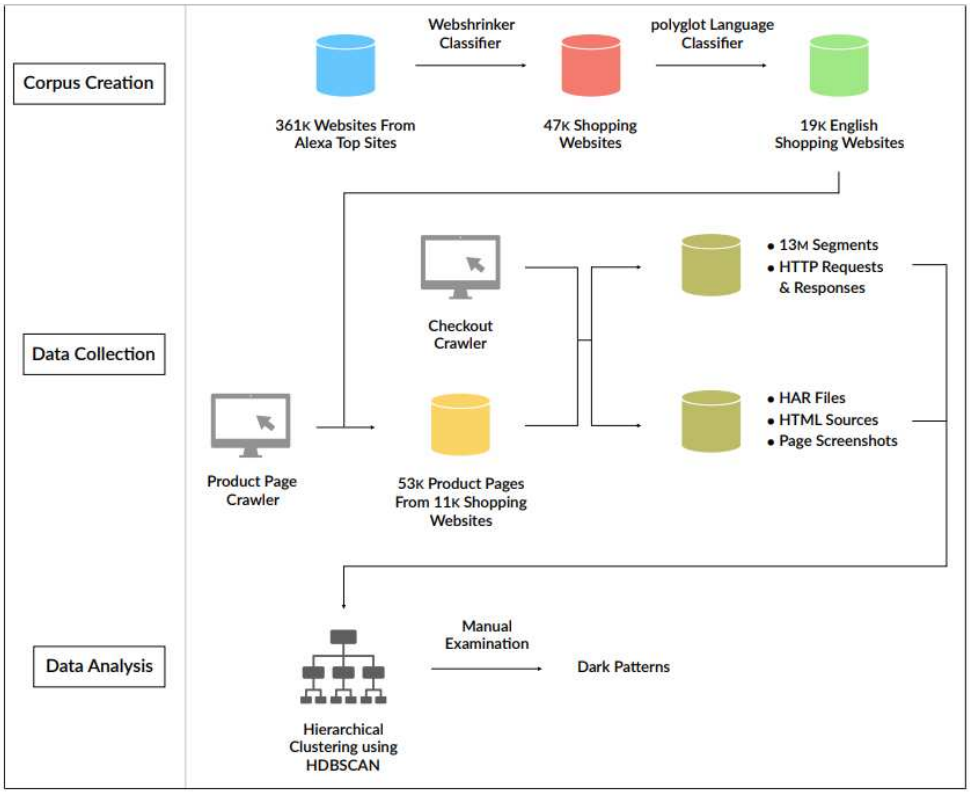


Figure 3.1: How Arnuseh Mathur et al. collected the data using crawling, and how they performed data analysis using clustering. [MAF+19b]

"Designing Healthy, Highly-Engaging Mobile Games," explores the challenges of creating games that are both engaging and promote well-being [DBNM21]. The study acknowledges the diverse interests of industry stakeholders, including developers, investors, and players, which can lead to conflicting objectives in game design. To address these challenges, the researchers conducted a multi-stage experiment involving interviews, brainstorming sessions, and co-design workshops with participants such as mobile game players, professional game designers, and business developers. This comprehensive approach aimed to develop strategies for designing games that are both healthy and highly engaging [AKBD22].

The question they researched in their paper was: 'Is it possible, and how might we, develop game experiences both 'healthy' and 'highly engaging?'. For this experiment they tried to develop an understanding of players' and game creators' experiences with Dark Patterns and how they can support and practice design to create healthier and more highly engaging mobile game experiences. They invited several participants (mobile game

players, professional game designers, game developers, and business developers) from all over the world between the ages of 22 to 40, with an average age of 30 to participate in 6 stages. In the first stage, they interviewed each person separately to find out common themes and they made them rank all different kinds of Dark Patterns and their impact (see figure 3.2). In the second stage, they used brainstorming and mind-mapping exercises where the participants had to find out ways to develop solutions on how to design healthy and highly engaging games. In the third step, four co-design workshops were held where the participants were split into pairs, where the findings of stage two were expanded and iterated upon together with stakeholders. In Stage Four the concepts were refined using the knowledge from the interactions from the workshop. In phase five there were again workshops where the iterative co-design, testing, and validation were held for the concepts. In the last phase, they developed a strategy to support communication and translation of outputs and how they can be used in practice in the real world. [AKBD22]

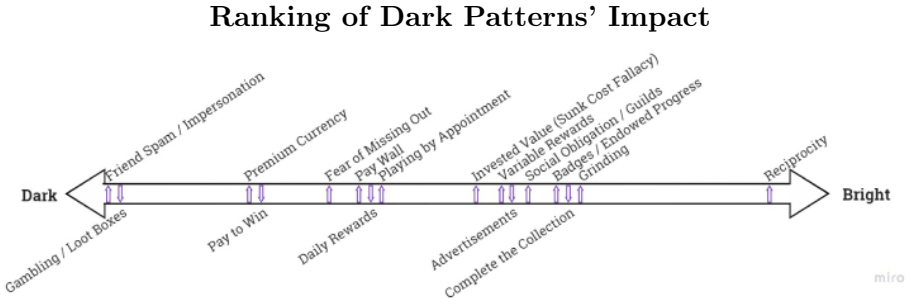


Figure 3.2: The figure illustrates a continuum of Dark Patterns in mobile games, ranked by their perceived impact from "dark" to "bright." This ranking, developed through participant evaluations in the study, categorizes design techniques based on their level of manipulation and ethical concerns[AKBD22].

The findings of this research made clear that the term Dark Patterns was unfamiliar with most of them, but they still were able to identify a lot of mechanics which are used by them during gameplay. Especially the popular ones like Pay to Win mechanics, Playing by Appointment, Daily Rewards, Artificial Deficit, Invested Value, and Loot Boxes. Many participants said that these mechanics can be frustrating and make them feel like they are being cheated. But also not all Dark Patterns are equally bad, some are only bad when they are combined with other mechanics. But all of them agreed that gambling mechanics like loot boxes and practices of impersonation were among the worst Dark Patterns they experienced. While they are the worst and they try to warn others away from them, many of them still engage with loot boxes in their favorite game. [AKBD22]

When it comes to the question of how Dark Patterns are created and who is responsible for them, the answers were quite similar. Especially from the Game creators' and the business developers' standpoint of view. Some of them mentioned that they simply stumbled upon these patterns while others said that these patterns are "intentional, immutable, and inescapable design choices driven by market forces beyond their control. We have ads every 30 seconds. That's a lot, right? We do it because that's what everyone

else does. I cannot afford to only show an ad every minute". They mentioned that they have to add patterns like this not motivated by greed, but because they want to keep working in the mobile game industry. One game designer said: "I'm going to do everything I can to make sure that you stay here and you click on [our game] again...I know that you don't care about this stuff I've made, you just try to distract yourself". [AKBD22]

On the other hand, when the question of responsibility came up, the stakeholders' responses varied quite a bit. One answer to the question of why Dark Patterns exist was for example that: "Dark Patterns exist because they work". They would only disappear or change if players would stop interacting with them. Business Developers said that In-Game-Purchases are not bad, they open up options to players, by making it possible to create deeper layers inside of the game. Only very few Game Creators felt they were responsible, and they used "very exploitative forms of game design". [AKBD22]

While Aagaard et al. focused on general mobile gaming experiences, Sousa et al.'s study, "The Dark Side of Fun: Understanding User Engagement and Needs in Early Childhood Mobile Gaming," [SO23] shifts attention to a more vulnerable demographic—young children. This research explores how Dark Patterns in mobile games designed for early childhood exploit psychological triggers to enhance engagement, raising ethical concerns about their impact on young minds. The study emphasizes that early childhood is a critical developmental period, and exposing children to manipulative design techniques can shape their gaming behaviors and expectations in harmful ways. Key findings include the use of game mechanics such as "daily rewards" and "variable rewards" to increase engagement, the inclusion of monetization schemes disguised as gameplay incentives, and the ethical implications of these practices. The authors advocate for stricter regulatory measures to prevent the use of Dark Patterns in games targeted at children, calling for more transparency in mobile game design and better parental control over in-game purchases and engagement mechanics.

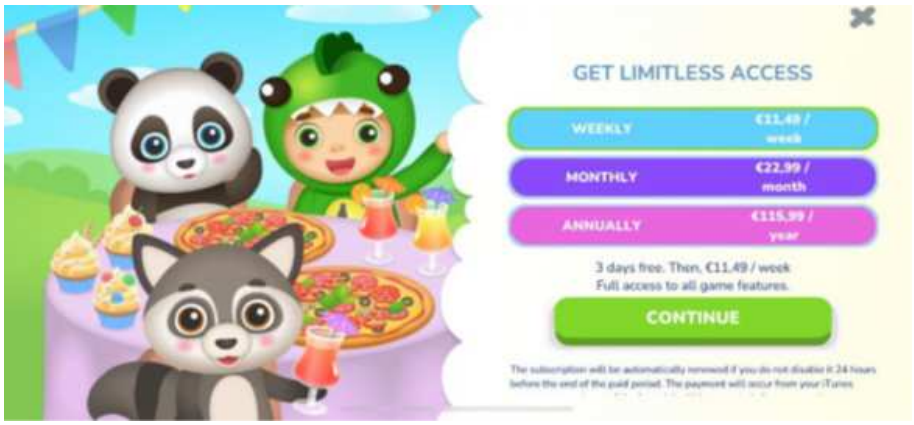
Engagement through Psychological Triggers: The use of game mechanics such as "daily rewards" and "variable rewards" effectively increases engagement in young players, fostering a habit-forming cycle. These mechanics create a false sense of urgency, encouraging children to log in frequently and participate in more sessions.

Monetization in Child-Centric Games: The paper reveals how mobile games for young children often include monetization schemes disguised as gameplay incentives, such as offering the ability to bypass difficult levels through in-app purchases. This blurs the line between entertainment and commercial exploitation, raising concerns about the influence of these tactics on young minds.

Ethical Implications and Regulation: The authors advocate for stricter regulatory measures to prevent the use of Dark Patterns in games targeted at children. They call for more transparency in mobile game design and better parental control over in-game purchases and engagement mechanics.

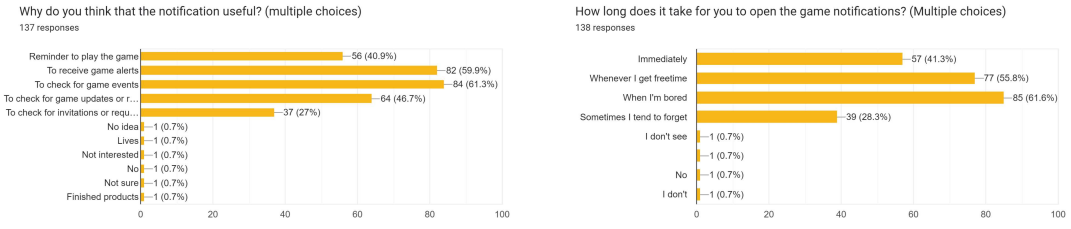
The study contributes to the broader discourse on Dark Patterns by demonstrating their impact not just on the general population but on vulnerable groups such as children. It underscores the need for ethical game design that prioritizes the well-being of users

Manipulation of Children in Mobile Games[SO23]



over profit.

Expanding on the exploration of Dark Patterns in mobile gaming, it's important to consider how specific design elements, such as push notifications, influence player behavior. Sali et al.'s study, "Understanding the Dark Patterns in Push Notifications in Games and Its Influence on User Behavior," examines how these notifications are used to manipulate players [SG]. The research highlights that push notifications often create a sense of urgency or exploit psychological triggers, leading to addictive behaviors and compulsive gameplay. The study surveyed 156 participants across various age groups and genders to examine differences in their reactions to game notifications. Key findings include significant differences across demographics in the likelihood of turning on notifications, waiting for notifications, and finding them useful. Younger users and males were found to be more responsive to game notifications, often exhibiting compulsive behaviors when interacting with them. This research underscores the need for greater awareness of these Dark Patterns and emphasizes the importance of developing healthier notification habits to mitigate their negative effects.



Dark Patterns in push notifications[SG]

In Chart 3, titled "Why do you think that the notification is useful?", the data shows that a majority of participants found game notifications helpful for in-game management. Specifically, 61.3% used notifications to track game events, while 59.9% relied on them for game alerts, and 46.7% used them to check updates or rewards. A smaller proportion

(27%) found them useful for tracking invitations or requests, illustrating the wide range of purposes game notifications serve in engaging players and facilitating game progression.

Chart 3, "How long does it take for you to open the game notifications?", reveals that 61.6% of respondents opened notifications when they were bored, making this the most frequent trigger for interaction. Another 55.8% opened notifications during free time, and 41.3% did so immediately. The data suggests that boredom and spare time are key drivers in how players engage with notifications, though 28.3% occasionally forgot to open them, hinting at variable habits in response to these prompts.

Sali concludes that while notifications are integral to keeping users engaged in games, they also contribute to problematic gaming behaviors, including addiction and social isolation. This paper adds to the growing literature on how digital interfaces, particularly in mobile gaming, employ Dark Patterns to shape user behavior in ways that benefit developers at the expense of players' well-being.

Building upon the examination of Dark Patterns in mobile gaming, it's essential to consider how artificial intelligence (AI) influences user experience design. AI has become a key tool in creating dynamic user experiences in mobile games. Developers use AI algorithms to personalize in-game experiences, tailoring content, challenges, and offers to individual users. In the context of Dark Patterns, AI can fine-tune manipulative design strategies, making them more effective by adapting to a player's behavior and preferences. For instance, reinforcement learning algorithms can create adaptive difficulty systems that adjust the game's challenge level in real-time, maintaining player engagement. Additionally, AI powers predictive models that forecast player behavior, allowing games to trigger specific Dark Patterns, such as limited-time offers or reward notifications, at optimal moments to encourage further engagement [SHM+16]. In this research, AI models were applied to categorize player interactions with the dark and non-dark versions of the game. These models enabled real-time adjustments to gameplay mechanics, allowing for an in-depth analysis of how different players responded to Dark Patterns over time. This AI-driven approach provided valuable insights into how Dark Patterns can be optimized to increase engagement and monetization while revealing the ethical challenges of using such techniques.

4 Experimental Setup and Game Design

This research employs a simulation study to analyze the impact of Dark Patterns on user interaction and engagement within a controlled environment. The core methodology involves developing a mobile game as a Progressive Web App (PWA), which serves as the platform for testing various design choices. While the PWA functions as the delivery method, the simulation study allows for a detailed examination of player responses to Dark Patterns across different demographics, providing insights into behavior influenced by these manipulative design elements.

The game was built using Flutter, an open-source UI Software Development Kit, specifically version 3.20.0-1.2.pre from the beta channel. Flutter was chosen for its fast prototyping capabilities and smooth cross-platform functionality.

Ensuring accessibility, the PWA was designed to run on iOS and Android devices supporting WebGL version 2.0 or higher, maximizing its reach to smartphone and tablet users. The game's interface, built using Flutter and Dart, greets players with an inviting menu system, facilitating easy navigation. Once in the game, players are met with a grid-based board with colorful tiles, each level offering new challenges and objectives (see Figure: 4).

With a variety of levels, players face diverse tasks, from clearing tiles to achieving specific scores, ensuring each session feels fresh and engaging. Adding to the excitement, players must strategize within constraints, such as limited moves, time limits, or unique objectives, injecting urgency and decision-making into gameplay.

Ultimately, the mobile game serves as a platform for exploring the intersection of design and user behavior, offering valuable insights into how different demographics interact with digital experiences. Through its design and gameplay, it provides a space to examine the impact of design choices as Dark Patterns on user engagement and satisfaction.

Key gameplay elements include:

- **Objectives:** Each level presents specific goals, such as clearing designated tiles, achieving a target score, or fulfilling other objectives. These goals are prominently displayed in the upper-right corner of the screen.
- **Moves/Time:** Players are limited by either a set number of moves or a time constraint, depending on the level's objective. The remaining time or moves are indicated in the upper-left corner.
- **Level Progression:** Completion of a level unlocks the next, offering progressively challenging gameplay. Each subsequent level introduces new obstacles and complexities.

The game provides a classic match-three game with diverse levels, strategic tile-swapping mechanics, and clear win conditions.

The game board consists of a grid populated by jellies of various colors and shapes, each uniquely identifiable. Players are tasked with the manipulation of two adjacent jellies to create a linear arrangement of a minimum of three identical jellies, either horizontally or vertically. The successful formation of such a sequence leads to the removal of the matched jellies from the grid, resulting in the descent of upper jellies to fill the resultant voids. This fundamental gameplay mechanic allows players to earn points. When a player successfully aligns four jellies, a unique jelly is produced, which has the ability to clear an entire row or column. Furthermore, arranging five jellies in a T or L shape generates another variant of special jelly, a so-called rainbow jelly, which can remove all jellies of a designated color from the grid. When you combine 2 rainbow jellies, the whole grid gets removed and refilled with new jellies, granting a lot of points.

Figure 4.1: The Gameboard

Each level is characterized by specific goals, which may involve reaching a designated score, gathering a certain quantity of jellies in particular colors, or eliminating obstacles. The current goal is clearly indicated in a box situated in the upper right corner of the screen. Progress within the level is denoted by stars located at the bottom of the screen, with the successful completion of the level objective upon earning a minimum of one star. However, players can obtain greater rewards by collecting additional stars. Some levels impose limitations, such as a restricted number of moves or a time limit to achieve the objectives, which is displayed in a box at the upper left corner of the screen.

To study the effects of Dark Patterns, the application was designed with two versions: a Dark Pattern version and a control version. The following section explains the application's architecture, the implemented Dark Patterns, and the user behavior metrics gathered for analysis.

4.1 System Architecture

The application's architecture is composed of several key components: a Flutter-based user interface, a business logic component, a persistence component, and a Firebase-hosted

database. These elements work to provide a seamless and responsive user experience.

The **Flutter UI** is constructed from widgets, which are the building blocks of the user interface. This structure allows for a dynamic and adaptive UI that reflects the current state and configuration of the application, managed by the underlying business logic. The use of Flutter widgets ensures a smooth and interactive user experience, with real-time updates and animations enhancing the application's responsiveness.

The **Business Logic** component is crucial for processing user input and orchestrating the application's behavior. It handles updates to the UI, manages persistent application data, and sends anonymized user behavior data to the remote Firebase Web server. This component ensures that the application operates efficiently and securely, processing inputs and outputs in real-time while maintaining the integrity and security of user data.

For **Persistence**, the application leverages the shared preferences plugin for simple data storage. This allows for the efficient saving and retrieval of small amounts of data, such as user settings and preferences, ensuring that these preferences are retained between sessions. This lightweight storage solution is ideal for maintaining user-specific configurations without the overhead of a more complex database system.

The **Unity Game Module** is integrated into the Flutter application using the Flutter Unity widget package. This allows for embedding a Unity game within the Flutter interface, leveraging Unity's powerful engine for game development. The game module includes 2D graphics, physics, and interactive elements created in Unity, providing an immersive gameplay experience. The integration is seamless, enabling smooth communication between Flutter and Unity components. This setup allows the Unity game to be controlled and displayed within the Flutter app, maintaining a consistent user experience across different sections of the application. The Unity game module is described more thoroughly in the next Unity Game Module Section 4.2.

The **Remote Server** is hosted on Firebase, providing robust backend support for the application. Firebase offers a suite of APIs and tools designed for secure and scalable application development. This backend solution facilitates GDPR-compliant data collection, ensuring that all user data is handled in accordance with stringent privacy standards. Firebase's real-time database capabilities allow for fast read and write access to user data, enabling the application to deliver a highly responsive experience.

Overall, the system architecture is designed to be efficient, secure, and scalable, leveraging modern technologies and best practices in mobile application development. This architecture not only supports current functionality but also provides a solid foundation for future enhancements and scalability.

4.2 Unity Game Module

The Unity Game Module was developed with Unity Version 2022.3.18f1. It contains four different scenes which represent the different objectives the game has. The four different scenes are called "Colors", "Moves", "Obstacles" and "Timer". Each scene contains the same 3 Objects.

The **Main Camera** serves as the viewpoint through which the player experiences the

environment by changing the Field of View depending on the screen size of the user's phone.

The **Background** contains a sprite renderer that displays the picture and scales it according to the screen size of the user's device.

The **Level** contains the actual game logic including the Game Grid4.2.2 and the GameUI4.2.3, also called HUD[1].

4.2.1 Level

The Level class in Unity is designed to manage the overall game flow and progression in the game. It acts as a bridge between the player's interactions with the game grid and the broader game mechanics, such as scoring and determining whether the player wins or loses a level. This class also integrates with the external Flutter system, enabling communication between the Unity game and the Flutter platform.

The class primarily focuses on setting up the level, handling game outcomes, and managing the score. During the setup phase, it initializes the game grid according to the specific configuration of the current level. This includes setting the grid's dimensions and defining the target scores required to achieve one, two, or three stars.

As the game progresses, the Level class tracks the player's score, updating it as pieces are cleared from the grid. It also monitors whether the player has won or lost the game by calling the appropriate methods when the game concludes. When a game is won or lost, the class waits for the grid to finish any ongoing actions, such as filling new pieces, before displaying the win or lose screen to the player.

The class further handles situations where no more valid moves are available on the grid, prompting a shuffle of the game pieces to ensure continuous gameplay.

4.2.2 Game Grid

The GameGrid class in Unity is responsible for managing the core mechanics of the game, where the player interacts with the game pieces. It defines the structure and behavior of the game board, handling everything from initializing the grid and placing game pieces, to processing user input and orchestrating the game's logic, such as detecting matches and handling piece movement.

At its core, the class dynamically creates a grid based on the dimensions specified for each level. Each cell in the grid is filled with game pieces or obstacles, and the game board is continuously updated to ensure smooth gameplay. A key feature of the class is its use of coroutines to manage time-based operations, such as filling the board with new pieces, waiting for player actions, and checking for available moves. This asynchronous behavior ensures the game runs smoothly, with real-time animations and responses to player input.

The camera's view is automatically adjusted to fit the size of the grid, maintaining an optimal display regardless of screen size or orientation. This allows for a consistent visual experience across different devices.

[1] Heads-up-Display

During gameplay, the class monitors player interactions, allowing them to swap adjacent game pieces. When a valid move is made, the game checks if any matching combinations of three or more pieces have been created, triggering the removal of those pieces and potentially spawning special pieces like row or column clears. The board is then refilled, and the process repeats, ensuring a continuous cycle of gameplay.

Additionally, the class handles special mechanics like power-ups and obstacles. Power-ups can be generated based on player actions or as part of the game's initial setup. These can be used strategically by the player to clear pieces or perform other game-altering effects.

4.2.3 HUD

The HUD class in Unity is designed to serve as the primary interface that displays essential game information to the player. It presents details such as the current score, the number of remaining moves or time, and the objectives needed to complete a level. Additionally, it visually tracks the player's progress by showing star indicators based on the score, reflecting whether they have achieved one, two, or three stars for their performance.

At the start of the game, the HUD initializes various visual elements, such as activating the appropriate star indicators. As the game progresses and the player's score changes, the HUD updates to reflect the new score. It also monitors whether the player has crossed certain score thresholds, unlocking additional stars to reward their progress. In some configurations, this progress is communicated to the external flutter system, indicating that the player has reached a new milestone.

Besides score tracking, the HUD is responsible for displaying the remaining resources for the level, such as moves, time, or obstacles. It provides dynamic updates as the game advances, ensuring that the player always knows how many moves or how much time they have left to achieve their objectives. The HUD adapts to different level types by modifying its interface to suit the specific challenges of each game mode, whether it is a time-based, move-based, or obstacle-clearing level.

When the game concludes, whether through a win or loss, the HUD displays an end-of-game screen. In a victory scenario, the screen shows the final score, the number of stars earned, and sends the player's progress to the external flutter system. If the player loses, the interface communicates the outcome appropriately. This provides the player with immediate feedback and closure, while also tracking their performance for future reference.

4.3 Implemented Dark Game Design Patterns

To thoroughly analyze the impact of dark game design patterns on player behavior, we incorporated several such patterns into our game application. These patterns were categorized into three main types: temporal, psychological, and monetary. Each category represents distinct ways that game mechanics can subtly influence player engagement, time investment, or spending habits, often to the player's detriment.

4.3.1 Temporal Dark Game Design Patterns

Temporal Dark Patterns are designed to extend the player's time spent in the game, often by artificially prolonging gameplay sessions or creating a sense of urgency that compels players to return frequently.

One example of this is the **Grinding** mechanic, where players are required to accumulate experience points (XP) to progress. By introducing randomized XP rewards for each level, players are encouraged to replay levels multiple times, thereby extending the overall playtime. This repetitive gameplay loop can create the illusion of progress, while in reality, it serves to keep players engaged for longer periods without necessarily offering substantial rewards.

Another temporal pattern employed is **Playing by Appointment**, where players are pressured to engage with the game at specific intervals. Daily notifications remind players to log in and play, fostering a routine and making the game a habitual part of their day. As shown in Figure 4.2, these notifications are designed to prompt players at the same time each day, subtly encouraging a sense of obligation to maintain their daily participation.

Additionally, **Daily Rewards** offer increasingly valuable incentives for players who log in consecutively over multiple days. This strategy taps into the psychological desire for consistency and progression, where players feel compelled to maintain their streak in order to receive larger rewards. As depicted in Figure 4.3.1, players are rewarded with items such as free power-ups or in-game currency, reinforcing the habit of daily engagement and making it more difficult for them to stop playing.

Figure 4.2: Daily Notifications

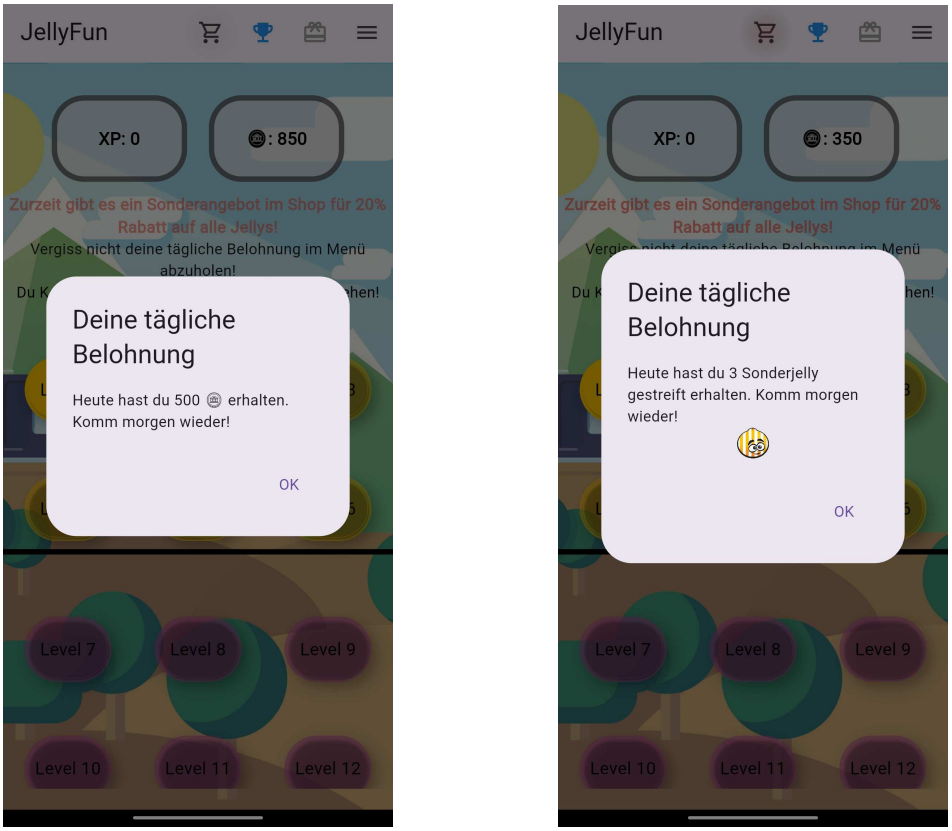


Figure 4.3: Playing daily gives the user an advantage by rewarding them with free power-ups

4.3.2 Psychological Dark Game Design Patterns

Psychological Dark Patterns are more nuanced, manipulating the player's emotions and cognitive biases to maintain engagement and encourage deeper involvement in the game.

The **Complete the Collection** pattern exploits players' natural desire to collect and complete sets. In our game, players are presented with a series of levels, each visually distinct and grouped by color, which urges them to unlock and complete all available levels. This is vividly illustrated on the main menu screen (Figure4.4), where the presentation of different colors and incomplete sets creates a psychological pressure on the player to finish the collection. Initially, only one level is accessible, with additional levels requiring either progression through the game or in-game purchases, heightening the sense of exclusivity and achievement.

Another prominent psychological tactic is the **Invested/Endowed Value effect**, which operates on the principle that players become more emotionally attached to their progress as they invest more time and effort into the game. The more levels they unlock and the further they advance, the more valuable the game feels to them, even if the actual value is only perceived. This sense of ownership encourages players to continue playing

and spending money to safeguard their investments.

We also employed **Variable Rewards**, where players receive random rewards, such as XP or in-game currency, after completing levels. This technique taps into the well-known psychological principle of intermittent reinforcement, where unpredictable rewards create heightened anticipation and engagement. As seen in Figure 4.5, the fortune wheel randomly dispenses rewards, making players eager to see what they will receive next, further fueling their desire to continue playing.

Lastly, **Deceptive Competition** manipulates players by creating the illusion of a competitive environment, often featuring a seemingly unbeatable opponent. The player is driven to surpass the opponent's high score, but once they do, the game quickly restores the opponent's superior position, compelling the player to try again. This manufactured rivalry is demonstrated in the high-score screen (Figure 4.6), where the player might briefly feel victorious only to be overtaken again, perpetuating the cycle of striving for dominance and continued engagement.

Figure 4.4: The main menu screen of the game, displaying different colors for each level group urging the user to complete the collection

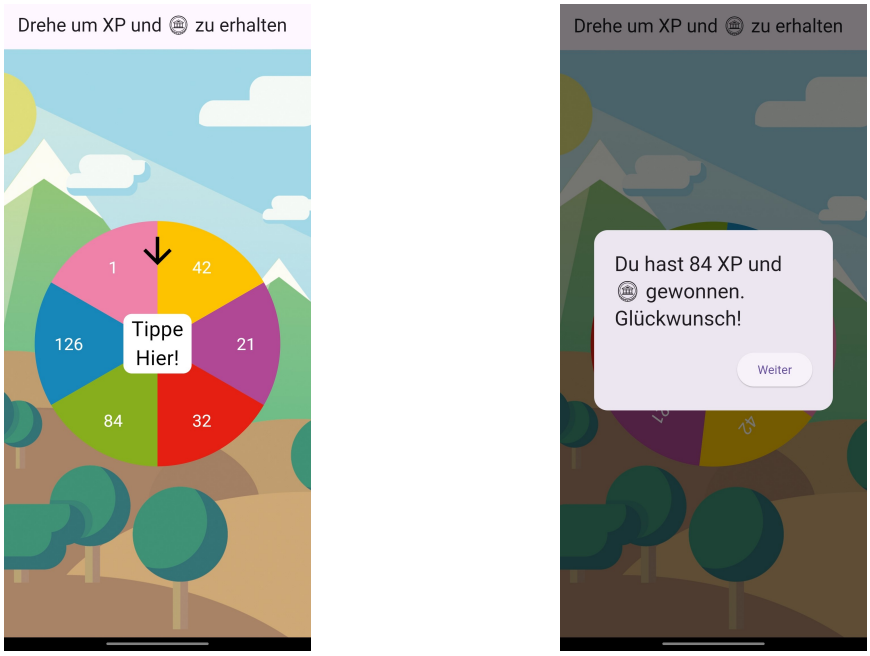


Figure 4.5: The variable rewards fortune wheel offers different rewards for each level

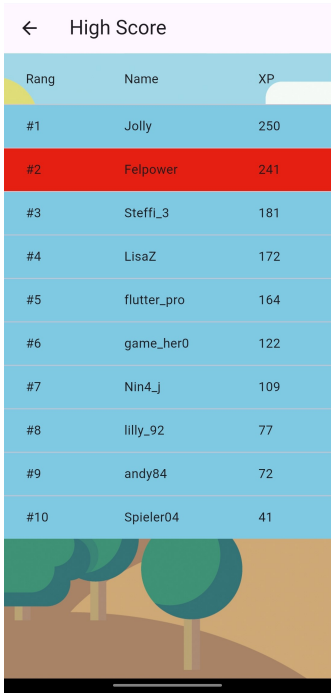


Figure 4.6: This screen displays a fake high score, where the user may overtake the player in the first spot but only for a few minutes before he gets overtaken again

4.3.3 Monetary Dark Game Design Patterns

Monetary Dark Patterns are specifically designed to encourage in-game purchases, often creating a situation where spending money feels like the only viable path to success.

One of the most prominent examples of this is the **Pay to Win** model, where players can spend in-game currency (often purchased with real money) to gain advantages such as power-ups or the ability to skip difficult levels. This system not only allows players to bypass challenging sections of the game but also creates an artificial sense of achievement through financial investment rather than skill or strategy. As demonstrated by the shop screen (Figure 4.3.3) and the option to purchase level skips (Figure 4.3.3), players can acquire items that make progression easier, subtly encouraging them to spend money to gain an edge in the game.

This system also serves as a safe, simulated environment for studying spending behaviors, as players are tempted to engage in microtransactions to enhance their gameplay experience. By analyzing how players respond to these purchase options, we can gain insight into the effectiveness of monetary Dark Patterns in driving in-game purchases and maintaining player retention.

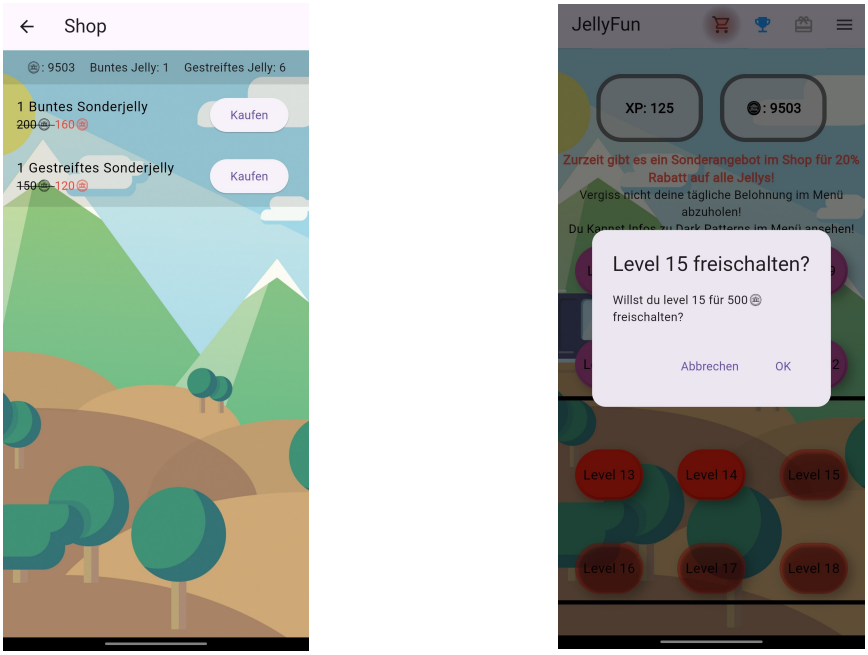


Figure 4.7: The shop offers the user the ability to buy power-ups to achieve a victory easier and the buy level options, allow the user to skip a level they can not beat

4.4 User Group Recruitment and Study Procedure

Participants were recruited through targeted online campaigns on platforms such as Facebook, Instagram, and YouTube. These campaigns directed potential participants to a dedicated website where they could find installation instructions and a link to download the mobile game as a progressive web app compatible with their mobile devices.

Upon launching the application for the first time, users were presented with an introduction explaining the purpose of the study. Participation was voluntary, and explicit consent for data collection was required before proceeding. This consent was collected digitally within the app. After consent was granted, participants provided basic demographic information and shared insights into their gaming habits through an initial survey.

The game included a tutorial to familiarize participants with the mechanics and features of the app. Depending on the experimental group they were randomly assigned to, participants received tailored instructions that reflected the condition of the study: no Dark Patterns, multiple Dark Patterns, or a single Dark Pattern such as Fear of Missing Out or Variable Rewards.

For the 30-day duration of the study, participants interacted with the game as they wished. The app tracked their usage, recording metrics such as play frequency and in-app behaviors. On the final day of the study, participants received a notification inviting them to complete a concluding survey. This survey captured feedback on their experiences during the study, focusing on the effects of any manipulative design elements they may have encountered.

The responses collected during this period provided the foundation for analyzing user behavior and engagement across the different experimental conditions.

4.5 User Data

To evaluate the influence of dark game design patterns on user behavior, a system was developed to collect and report various anonymized data points to a remote Firebase Realtime Database (RTDB). This section will examine the specific aspects of user behavior that were tracked, emphasizing their importance in assessing the effects of dark game design patterns on gameplay.

For each user, an entry is created in the RTDB when the application is launched for the first time. This ensures that user activity is tracked from the outset, allowing us to monitor their engagement with the game. Importantly, there are two distinct versions of the application. One version incorporates dark game design patterns (e.g., variable rewards, notifications, etc.), while the other does not. Users are randomly assigned to one of these versions upon first launch, making the randomization process essential for comparing behavior across different user groups. This randomization is logged in the RTDB via an integer value, alongside the user's unique identifier (UUID), indicating whether the user is exposed to Dark Patterns.

User Interaction and Usage Time Monitoring

One of the primary metrics collected is user interaction time. The script records the time when the application is opened and closed, allowing for an accurate calculation of the total usage duration and the frequency with which the game is played. This data helps us analyze if users in the Dark Pattern group tend to engage for longer periods or more frequently compared to the group without Dark Patterns.

Beyond general usage, the script captures more granular activity by recording timestamps of level starts. For each session, whenever a user starts a new level, a timestamp and the corresponding level number are logged in the RTDB. This data is essential to evaluating how frequently users advance through the game and whether Dark Patterns impact their progression speed or willingness to start new levels.

Notifications and Behavioral Impact

A key feature of the Dark Patterns version is the use of local notifications to re-engage users. For those in the Dark Pattern group, the script monitors when the application is opened as a direct result of interacting with a notification (i.e., when a user taps on the notification). This is crucial for evaluating the effectiveness of these notifications—whether they successfully prompt users to re-enter the game. By comparing users who open the app independently versus those who are triggered by notifications, we can assess the manipulation power of such design strategies.

4.5.1 Notification Service

The notification service is designed to engage users by sending push notifications based on their behavior and interaction with the game. This system monitors key metrics like the time since the user first started the app, their engagement with specific game elements (e.g., finishing levels), and whether they have completed a post-game survey. By integrating Firebase Cloud Messaging (FCM), the service dynamically selects users to receive notifications based on these conditions.

The service extracts user data from the Firebase Realtime Database (RTDB), where each user's activity is logged. The system filters users who have interacted with Dark Patterns and monitors if they have completed the end-game survey. If users are eligible based on their in-game activity or survey status, a personalized push notification is sent, encouraging them to continue playing or participate in the survey.

The notifications sent are tailored to different user groups, ensuring that players exposed to Dark Patterns receive distinct messages compared to those who are not. The system also tracks when a notification is sent and logs it in the Firebase database to avoid redundant messages and provide an overview of the system's interactions with each user.

A critical feature of this service is its ability to send reminders to users who have not completed the end-game survey after 30 days of play. These reminders are crucial for collecting post-game feedback and evaluating the impact of Dark Patterns on user behavior.

The notification system is executed daily through a scheduled GitHub workflow using cron jobs. The workflow runs at specific times every day, ensuring that users are re-engaged regularly. The automation is handled through GitHub Actions, which triggers the Python script that sends the notifications.

The notification service runs on an Ubuntu environment within GitHub Actions, installing the required Python dependencies before executing the script that manages the notification dispatch. This seamless integration of scheduled jobs ensures that the notification service operates automatically, delivering timely reminders and keeping users engaged without manual intervention.

4.5.2 Data Extraction and Analysis of Dark Game Design Patterns

In order to analyze the behavioral impact of dark game design patterns on players, a Python script was developed to extract, process, and analyze user interaction data from the Firebase Realtime Database (RTDB). The data provided insights into user engagement, session times, level completion, and interactions triggered by various in-game elements, specifically focusing on how users responded to Dark Patterns.

The code was implemented with the following key objectives:

Data Extraction from Firebase RTDB

The script connects to Firebase using a service account credentials file, pulling user activity data directly from the database.

Data Parsing and Normalization

Once the data is retrieved, it undergoes a series of transformations to extract relevant fields, such as session start times, level completions, purchases, and interactions with game features like notifications and daily rewards. The script ensures that timestamps and events are consistently formatted to allow chronological analysis of user behavior.

Analysis of Dark Game Design Patterns

A central focus of this script is categorizing user behavior based on four predefined dark game design patterns:

- Off (No Dark Patterns)
- On (Standard Dark Patterns)
- FOMO (Fear of Missing Out)
- VAR (Variable Rewards)

By categorizing users into these patterns, the script enables a comparative analysis of how different manipulative design techniques influence in-game behavior, such as playtime,

purchasing power-ups, or engaging with push notifications. This categorization is crucial to understanding the effectiveness of these Dark Patterns in driving user engagement.

Behavioral Metrics and Engagement Tracking

The script tracks key user actions:

- **App and level activity:** Including the time spent within the game and levels started, finished, or won.
- **Purchases:** Monitoring in-game purchases, including power-ups or level skips, which can be triggered by monetary Dark Patterns.
- **Push Notifications** Tracking when users interact with notifications and whether they lead to higher engagement or in-game purchases.
- **Rewards:** Analyzing the impact of daily rewards on user retention and engagement.

By associating these actions with Dark Patterns, the analysis highlights how design choices can either prolong playtime, encourage spending, or prompt users to return to the game.

Session Analysis and Player Dropout

The code also tracks individual gaming sessions and identifies players who drop out early, stop playing after a few days, or do not engage beyond the initial levels. This information helps quantify the retention rate and dropout causes, particularly in the context of the implemented Dark Patterns. It also determines the average session length and the number of sessions per user, helping establish patterns of usage.

Survey Data and Demographic Analysis

If players complete surveys (e.g., demographic questions or end-of-game feedback), the script processes these responses, incorporating them into the overall dataset. This demographic data (age, gender, education, etc.) is cross-referenced with gameplay behavior, revealing potential correlations between player demographics and their susceptibility to Dark Patterns.

Statistical Output

At the conclusion of data processing, the script compiles an array of statistics:

- **Total users, active users, and dropouts:** Segmented by Dark Pattern category.
- **Levels started, completed, and won** To gauge overall engagement.
- **Playtime and session lengths:** Including the average time spent per level and per session.

- **Monetary behavior:** Including the number of levels and items bought under different pattern categories.
- **Push notifications and engagement:** Examining whether notifications lead to increased playtime or spending.
- **Demographic correlations:** Analyzing how different demographics are affected by Dark Patterns in gameplay.

These statistics provide a detailed breakdown of how various Dark Patterns influence player behavior, including retention, spending, and session duration. The outputs are saved as an Excel file, which serves as the basis for further analysis and visualization in the research.

Visualization and Presentation

The processed data, along with key statistics, is exported into a structured Excel file. This allows for easy visualization and further analysis.

5 Quantitative Overview of User Behavior and Dark Patterns

This study aims to explore the influence of Dark Patterns on user behavior within the context of a mobile game application. Initially, a preliminary study was conducted to test the feasibility of the main study, confirming that the design and methodology were effective. Building on this, a more extensive empirical evaluation was carried out to thoroughly investigate these effects. This chapter provides an overview of the evaluation's design, structure, participants, and the obtained results from both studies.

5.1 Design and Structure

Participants downloaded the mobile game application as a Progressive Web App from a GitHub Pages hosted website. Two versions of the application were distributed: one with Dark Patterns and one without. Our evaluation focused on discerning differences in user behavior based on the presence of these Dark Patterns.

5.1.1 Evaluation Indicators

We initially evaluated many indicators over two months to gauge user behavior:

Days Played in Total: Total number of days users engaged with the application.
Users that Played Daily: Number of users engaging with the application daily.
Total App Starts: Total number of times the application was launched.
Average Playtime per level: Average duration of each level played.
Total Levels Started: Total number of levels initiated by users.
Total Levels Finished: Total number of levels successfully completed by users.
Total Levels Won: Total number of level victories achieved by users.
Max Level: The highest level reached by any user.
Average Levels: The average amount of levels played per user.
Average Level Per Session: The average amount of levels played per user per session.
Total Levels Bought: Total number of levels purchased by users.
Total Items Bought: Total number of items acquired by users.
Total Daily Rewards Collected: Total number of daily rewards collected by users.
Total Highscores Checked: Total number of highscores checked by users.
Total Push Notifications Clicked: Number of push notifications clicked by users.
DarkPatterns Off: Number of users who experienced the application without Dark Patterns.

DarkPatterns On: Number of users who encountered the version incorporating Dark Patterns.
Start Survey Done: Number of users who completed the initial survey.
Average Age: The average age of users.
Gender: The gender of the user.
Education: The education level of the user.
Occupation: The current occupation of the user.
Frequency of Playing: How often each user plays mobile games on an average day.
Hours Playing: Average number of hours played per day per user.
Money spent: Average amount of money spent per month per user.
End Survey Done: Number of users who completed the concluding survey.
Played Till End: Number of players that played till the end of their 30-day period.
Reason Cancelled: The reason each user stopped playing the game.
Influenced: Number of users that felt influenced by Dark Patterns.
Influenced Time: The feeling that Dark Patterns influenced time spent in the game.
Influenced Frequency: The feeling that Dark Patterns influenced the number of times the game was opened per day.
Pattern Influence: Which Dark Patterns they thought they received.
Push Received: The number of users that think they received push notifications.

Dark gaming design patterns primarily seek to increase how often and how long users engage with the game, making the time spent on the application a critical measure of user behavior. Over a period of 30 days, each user could play the game without any restrictions. After this period, user behavior across the two versions of the mobile game was compared using the specific metrics listed above (see 5.1.1).

An important factor analyzed was the impact of notifications on the user, by counting the number of users who clicked on notifications and the number of app starts for users receiving notifications.

5.2 User Demographics and Engagement Preliminary Study

A total of 89 users installed the preliminary study application, of which 48 did not use the application for more than one day. Among the remaining users, 20 experienced the version without Dark Patterns, and 21 encountered the version with Dark Patterns. Below, we provide a detailed analysis of user engagement and behavior for both versions.

5.2.1 Users Without Dark Patterns (DarkPatterns Off)

The version without Dark Patterns had a total of 54 users, out of which 34 dropped out, leaving 20 active users. These users started a total of 809 levels and finished 659 of them. They also bought eleven levels and three items. The average age of these users was 33.65 years. The highest level reached was 86, and the longest streak of continuous play was four. The gender distribution included 32 males, 20 females, and one non-binary person. Two users had completed compulsory education (lower secondary school), eight had completed

an apprenticeship, five had completed vocational school (commercial school), 17 had completed the Matura/Abitur (secondary school leaving certificate), and 21 had completed university or a university of applied sciences. The occupational breakdown showed that 30 users were students, one was an employee (apprentice, worker, employee, contract employee, civil servant), three were self-employed (self-employed, freelance contractor, contract worker), 13 were job-seeking, on parental leave, and six were retirees. The total hours spent playing by this group was 206.5 hours. Out of these users, ten participated in the end survey. The application was started a total of 470 times by these users, with an average of 5.36 levels played per session and an average of 40.45 levels completed overall. From the twenty users, the statistics state that the average amount of hours spent playing mobile games per user per month was 3.82 hours and the average amount of money spent was 0.82 euros.

Out of the twenty users who participated in the starting survey, only ten users took part in the end survey. The most common reason for cancellation was that the users forgot about the application, which was a problem for three users. Two users had the problem that they did not have enough time to play the game, one user stated that they disliked the Design/Graphics of the game, and another user said that the game was too difficult. Four users thought that they experienced Dark Patterns even though there were none implemented in this version without Dark Patterns. Two of them answered that the Dark Patterns made them play longer and two of them answered that the Dark Patterns made them play shorter. For the number of times that the users opened the app, one responded that the Dark Patterns did not influence how often they opened the app. Two said they started the app more rarely and one user said that they opened the app more often. After giving the users the option to state which Dark Patterns they realized, two mentioned they did not realize any Dark Patterns, one thought they had daily rewards, one had variable rewards, one had a high score, one had push notifications, one thought that the levels were in blocks, and one user even believed all the mentioned Dark Patterns were present.

5.2.2 Users With Dark Patterns (DarkPatterns On)

For the version with Dark Patterns, there were 35 total users, with fourteen dropouts, resulting in 21 active users. These users started a total of 1793 levels and finished 1400 of them. Additionally, they bought 291 levels and 25 items. The average age of users in this group was 29.43 years. The maximum level reached was 501, and the longest streak was three. Gender distribution included 18 males and 17 females, with no non-binary person reported. Regarding education levels, there were no users with only primary or lower secondary education. Seven users had completed vocational training. None had attended specialized vocational schools or commercial schools. Eleven users had finished upper secondary education (equivalent to a high school diploma), while seventeen had attained a university degree or a degree from a University of Applied Sciences. As for occupational status, the data showed that 23 users were students or pupils. One user was employed in a non-self-employed capacity (including apprentices, workers, employees, contractual staff, and civil servants). Eleven users were actively seeking employment or

on parental leave. There were no users who were self-employed (including freelancers and contractors) or retired. The total hours spent playing by this group was 114 hours. Eleven users participated in the end survey. The application was started a total of 1612 times by these users, with an average of 5.19 levels played per session and an average of 85.38 levels completed overall. A total of 1621 notifications have been sent to the users with Dark Patterns out of those 1621 only 70 notifications were pushed, which indicates that either a lot of people have deactivated the push notifications or that most of the users ignored the notification they received.

Out of the 21 users who participated in the starting survey, eleven took part in the end survey. Out of these eleven people, six played until the end. Among the reasons for cancellation, three users cited forgetting about the application, three users mentioned not having enough time to play, one user found the game too boring, and another one user disliked the design or graphics of the game. An observation was that only five users felt they were influenced by Dark Patterns. Of these, two users reported that Dark Patterns increased the time they spent playing, while three users said that the Dark Patterns did not influence playtime.

Regarding the frequency of app usage, one user indicated that Dark Patterns did not affect how often they opened the app, while four users reported that they opened the app more frequently. When asked about specific Dark Patterns they noticed, users identified various patterns: one user noticed daily rewards, four users noticed that they had variable rewards after they finished a level, and one thought the levels were organized in blocks. Interestingly, only one user mentioned that all the mentioned Dark Patterns were present in the version with Dark Patterns. Additionally, three users reported receiving push notifications, which could have influenced their engagement with the game.

In summary, the responses highlight the influence that Dark Patterns can have on user behavior, affecting both the duration and frequency of gameplay, as well as perceptions of the game's design.

5.3 Main Study

5.3.1 User Demographics and Engagement Main Study

For the main study, the statistics reveal several key insights into user behavior and engagement. As of June 9th, 2024, a total of 2,283 users downloaded the application, of which 302 completed the start survey successfully. This resulted in a total of 1,956 users who downloaded the application but never finished the survey at the start of the application. Out of the 302 users who completed the survey, 165 users dropped out. A user counts as a dropout if they played only for one day. The application was started a total of 21,434 times, with an average playtime per level of 96.3 seconds. Users started 15,236 levels, finished 11,157 levels, and won 9,793 levels. Four users were able to finish all 501 levels in the game. Additionally, users bought 1,006 levels and 219 items, collected 307 daily rewards, checked 358 high scores, and clicked on 100 push notifications out of 309 sent. A total of 75 users completed the end survey. The average age of users was

38.43 years, with a gender distribution of 114 males, 184 females, and four non-binary individuals. Due to the size of the study, it was decided to split the users into four groups: the two groups with Dark Patterns off and Dark Patterns on remained the same, but two new groups were introduced. The first group was the so-called Fear of Missing Out group, where the only Dark Pattern activated was the daily rewards. In this group, users could get a gift every 24 hours to see if daily rewards created a sense of urgency for players to collect their gift daily. The second group was the VAR group, where the only activated Dark Pattern was the variable rewards after each level that the user won.

5.3.2 Users without Dark Patterns (DarkPatterns Off)

The version without Dark Patterns for the main study had a total of 79 users, with 37 dropping out, leaving 42 active users. These users initiated a total of 3,240 levels and completed 2,559 of them. They also purchased 21 levels and seven items. The average age of these users was 35.87 years. The highest level reached was 252, although none of the users managed to reach the maximum level. The longest streak of continuous play recorded was three days. In terms of gender distribution, there were 20 males, 56 females, and one non-binary person. Regarding educational background, four users had completed compulsory education (lower secondary school), 14 had completed an apprenticeship, eight had attended vocational school (commercial school), 21 had completed the Matura/Abitur (secondary school leaving certificate), and 30 had completed university or a university of applied sciences. Occupationally, 62 were employees (apprentice, worker, employee, contract employee, civil servant), three were self-employed (self-employed, freelance contractor, contract worker), seven users were students, and five were job-seeking or on parental leave. No retirees were recorded in this group.

The hours spent per user playing games in this group amounted to 1.26 hours per user per month, with the average amount of money spent per month per user being 1.2 euros. The application was launched a total of 4,424 times by these users, with an average of 2.04 levels played per session and an average of 77.14 levels completed overall. Of the 42 active users, 19 participated in the end survey. The most common reasons for cancellation included that the game was too boring (six users), lack of time to play (six users), and forgetting about the application (nine users).

Six users reported feeling influenced by Dark Patterns. Among them, two believed these patterns made them play longer, and another two felt they played for a shorter duration. Regarding app usage frequency, four users said the Dark Patterns did not affect how often they opened the app, while one user reported opening the app less frequently, and another reported opening it more often. When asked to identify specific Dark Patterns, three users mentioned daily rewards, one user thought they noticed variable rewards, another one reported high scores, one mentioned push notifications, and three users believed they encountered that levels were arranged in blocks. There was also one user who reported receiving push notifications.

5.3.3 Users with Dark Patterns (DarkPatterns ON)

The version with Dark Patterns for the main study had a total of 85 users, with 43 dropping out, leaving 42 active users. These participants initiated 4,384 levels and successfully completed 3,289. Additionally, they purchased 566 levels and 119 items. The average age within this group was 37.58 years. The highest level attained was 501, with four users reaching this milestone of finishing all 501 levels of the game. The longest recorded streak of continuous play was four days.

Gender distribution showed 32 males, 50 females, and one non-binary individual. In terms of educational background, four users completed compulsory education (lower secondary school), 12 completed an apprenticeship, six attended vocational school (commercial school), 19 achieved the Matura/Abitur (secondary school leaving certificate), and 42 completed university or a university of applied sciences. Regarding occupations, 68 were employees (including apprentices, workers, employees, contract employees, and civil servants), four were self-employed (self-employed, freelance contractors, contract workers), five were students, and four were job-seeking or on parental leave.

On average, users spent 1.45 hours per month playing games, with the monthly expenditure averaging 5.11 euros per user. The application was launched 6,835 times by these users, averaging 2.29 levels played per session and an average of 104.38 levels completed overall. Of the 42 active users, 22 participated in the end survey.

The reasons for discontinuing play varied, with three users finding the games' graphics were not appealing enough, one that the game was too boring, three lacking time, and two forgetting about the application. Notably, ten users felt influenced by Dark Patterns: six believed these patterns increased their playtime, while four felt their playtime was reduced. Regarding app usage frequency, eight users reported that Dark Patterns led them to open the app more often, while two users noticed no difference.

When identifying specific Dark Patterns, seven users mentioned daily rewards, six observed variable rewards, four noted the high score, six cited push notifications, and three believed the levels were arranged in blocks. No user mentioned that they experienced all of the Dark Patterns.

5.3.4 Users with Fear of Missing out Dark Patterns (DarkPatterns FOMO)

The version of the study incorporating Dark Patterns focused on Fear of Missing Out (FOMO) engaged a total of 78 users. Of these, 43 users dropped out, resulting in 35 active participants. These active users initiated 4,350 levels and successfully completed 2,926 levels. Additionally, they made some purchases, with 416 levels and 93 items bought. The average age of the users was 39.15 years. The highest level achieved was 500, although no users managed to attain the maximum level. The longest continuous play streak recorded was four days.

The gender distribution among these users was fairly balanced, with 37 males, 38 females, and one non-binary individual. In terms of educational attainment, four users had completed compulsory education (lower secondary school), 15 had completed an apprenticeship, five had attended vocational school (commercial school), 25 had achieved

the Matura/Abitur (secondary school leaving certificate), and 26 had completed higher education at a university or university of applied sciences. Regarding their occupations, 59 users were employed in various roles including apprentices, workers, employees, contract employees, and civil servants. Additionally, seven users were self-employed, six were students, and four were either job-seeking or on parental leave.

On average, users spent 1.11 hours per month playing games, and their monthly expenditure averaged 1.94 euros per user. The application saw a total of 5,591 launches, with users playing an average of 2.34 levels per session and completing an average of 124.29 levels overall. Out of the 35 active users, 19 took part in the end survey.

When examining the reasons for discontinuation, the responses varied: one user found the game too difficult, two users felt bored, eight users cited a lack of time, and two users simply forgot about the application. Interestingly, ten users reported feeling influenced by Dark Patterns. Of these, six believed these patterns extended their playtime, while three felt their playtime was reduced. In terms of app usage frequency, five users indicated that Dark Patterns prompted them to open the app more frequently, two users saw no change, and three reported less frequent openings.

When asked to identify specific Dark Patterns, the responses included eight users who mentioned daily rewards, two who noticed variable rewards, one who noted high scores, and two who cited push notifications. Additionally, two users reported receiving push notifications, which could have influenced their engagement with the game.

5.3.5 Users with Variable Rewards Dark Patterns (DarkPatterns VAR)

In the study examining the impact of Variable Reward (VAR) Dark Patterns, 67 participants initially joined, but 42 dropped out, leaving 25 active users. These users began a total of 3,262 levels and completed 2,383. Despite this engagement, only three levels were purchased, and no additional items were bought. The average age of the participants was 41.7 years. The highest level reached by any user was 189, and no one achieved the maximum level. The longest streak of continuous play recorded was three days.

The demographic breakdown showed a gender distribution of 25 males, 40 females, and one non-binary person. Regarding educational background, the users were diverse: one had completed compulsory education, 13 had finished an apprenticeship, ten had attended vocational school, 13 had the Matura/Abitur, and 29 had completed higher education at a university or a university of applied sciences. The occupational data revealed that 50 users were employees (apprentices, workers, employees, contract employees, civil servants), four were self-employed, four were students, and five were either job-seeking or on parental leave.

Participants in this group spent an average of 1.08 hours per month playing the game and spent an average of 0.43 euros per month. The application was launched 4,584 times by these users, with an average of 3.12 levels played per session and 130.48 levels completed overall. Out of the 25 active users, 15 took part in the end survey.

The reasons for discontinuation varied among the participants: three users reported boredom, one mentioned a lack of time, and one cited forgetfulness as their reason for stopping. Interestingly, nine users felt influenced by Dark Patterns; among them, five

believed these patterns extended their playtime, while three felt it reduced their playtime. In terms of app usage frequency, four users indicated that Dark Patterns led them to open the app more often, three reported opening it less frequently, and two saw no change.

Participants were asked to identify specific Dark Patterns they noticed: five mentioned variable rewards, two identified daily rewards, and three pointed to high scores. Only one user reported receiving push notifications, potentially affecting their game engagement.

DarkPatterns	**Off**	**On**	**FOMO**	**VAR**
Total Users	79	85	78	67
Total Dropouts	37	43	43	42
Active Users	42	42	35	25
Total Levels Started	3240	4384	4350	3262
Total Levels Finished	2559	3289	2926	2383
Total Levels Bought	21	**566**	416	**3**
Total Items Bought	7	**119**	93	**0**
Average Age	35.87	37.58	39.15	41.7
Max Level	252	501	500	189
Users Max Level	0	**4**	0	0
Longest Streak	3	4	4	3
Total Notifications Sent	0	**2827**	0	0
Total Notifications Pushed	0	**68**	0	0
Hours Playing	1.26	1.45	1.11	1.08
Money Spent (euros)	1.2	**5.11**	1.94	**0.43**
End Survey Count	19	22	19	15
Played till End	6	14	9	11
Influenced	6	10	10	9
Push Received	1	7	2	1
Total App Starts	4424	6835	5591	4584
Average Level Per Session	2.04	2.29	2.34	3.12
Average Levels	77.14	104.38	124.29	130.48
Gender Distribution	**Count**			
Male (0)	20	32	37	25
Female (1)	56	50	38	40
Non-binary (2)	1	1	1	1
Education	**Count**			
Compulsory (0)	4	4	4	1
Apprenticeship (1)	14	12	15	13
Vocational (2)	8	6	5	10
Matura/Abitur (3)	21	19	25	13
University (4)	30	42	26	29
Occupation	**Count**			
Employee (0)	62	68	59	50
Self-employed (1)	3	4	7	4
Student (2)	5	2	4	3
Job-seeking/Parental leave (3)	7	5	6	4
Retired (4)	0	4	0	5

Table 5.1: Comparison of Dark Patterns Statistics

6 Comparative Analysis of User Behavior and Dark Patterns

This chapter provides an in-depth analysis of how different Dark Patterns affect user behavior in a mobile game. It evaluates four user groups: one with no Dark Patterns (DarkPatterns Off), one with all patterns enabled (DarkPatterns On), one influenced by Fear of Missing Out (DarkPatterns FOMO), and another affected by Variable Rewards (DarkPatterns VAR). By comparing these groups, we explore the impact of each Dark Pattern on user engagement, retention, and interaction with the game.

6.1 Data Analysis Approach

Due to the relatively small sample sizes within the individual experimental groups, conducting inferential statistical tests was deemed inappropriate. The statistical power of such tests would have been too low to produce reliable results, increasing the likelihood of Type II errors. Therefore, descriptive statistics were used to summarize user behavior and engagement metrics. This approach allows for the exploration of observed trends and addresses the research questions without making unsupported generalizations.

While the descriptive analysis provides insights into user engagement and interaction with the game, the findings are not generalizable to a broader population. Future studies with larger participant pools would enable robust inferential analyses to validate these trends.

6.2 Engagement Metrics Comparison

6.2.1 Total Levels Started and Finished

The number of levels started and finished is a key indicator of user engagement. The DarkPatterns On group had the highest engagement, with users starting 4,384 levels and finishing 3,289. This contrasts with the DarkPatterns VAR group, where users started 3,262 levels and completed 2,383. The DarkPatterns Off and FOMO groups had intermediate levels of engagement, suggesting that the presence and type of Dark Patterns significantly influence user interaction.

The higher completion rate in the DarkPatterns On group may indicate that these users were more motivated or compelled to finish the levels they started. This trend could be linked to the presence of manipulative design elements that encourage prolonged gameplay by leveraging psychological triggers such as urgency, reward anticipation, or sunk cost [KDG10, KDG11].

6.2.2 Levels and Items Purchased

Monetization is a critical aspect of mobile games, and Dark Patterns can significantly influence user spending. The DarkPatterns On group exhibited the highest number of purchases, with 566 levels and 119 items bought. This is in stark contrast to the DarkPatterns VAR group, where only 3 levels were purchased, and no items were bought.

This stark difference highlights the effectiveness of certain Dark Patterns in encouraging users to spend money within the game. The FOMO group's purchases were also relatively high, with 416 levels and 93 items bought, indicating that the fear of missing out can be a powerful motivator for in-game purchases. On the other hand, the difference in purchase behavior between the OFF/VAR and ON/FOMO groups may be attributed to the fact that participants in the ON and FOMO groups were exposed to a Dark Pattern that increased the frequency of opening the in-game menu. As a result, these participants were more frequently presented with the store and, thus, with the opportunity to make purchases. Additionally, since there was no significant difference in purchases between the ON and FOMO groups, it can be inferred that the number of money users typically spend on mobile games did not play a crucial role in their purchasing behavior within the game. [RB19]

6.2.3 Average Age and Demographics

The average age of users varied across the groups, with the DarkPatterns VAR group having the highest average age at 41.7 years and the DarkPatterns On group having the lowest at 37.58 years. This age difference could suggest that older users are less susceptible to certain Dark Patterns, as seen in the lower engagement and purchase rates in the VAR group.

Gender distribution was relatively balanced across all groups, with a slight female majority. The educational background showed a higher concentration of university graduates in all groups, particularly in the DarkPatterns On group, where 42 users had completed higher education. So that means that gender does not appear to play a major role in the purchasing patterns in this context. If it had, one might have expected the FOMO group to show distinct behavior from the others, as the gender distribution in this group was noticeably different compared to the rest. However, one cannot rule out the possibility that part of the variation between the ON group and the others is related to the age of the participants. In the ON group, there was a notably higher proportion of individuals aged 26–35, along with a significantly lower representation of those over 45, compared to the other groups. This distinct age distribution could explain some of the differences observed, as the age breakdown in the FOMO and VAR groups was quite similar to each other. [LWJ09, PSKK22]

6.2.4 App Usage Frequency and Playtime

The frequency of app usage and playtime provides insights into how often and how long users interact with the game. The DarkPatterns On group had the highest total app

starts (6,835) and the most frequent session lengths, with an average of 2.29 levels per session. This suggests that the Dark Patterns used in this version effectively kept users returning to the game more frequently.

In contrast, the DarkPatterns VAR group had the lowest total app starts (4,584) but the highest average levels per session (3.12). This indicates that while fewer users started the app, those who did were more engaged during each session. This could suggest that variable rewards are effective in maintaining engagement once users are active in the game.

6.2.5 Survey Participation and User Feedback

Survey participation rates and user feedback provide qualitative insights into user satisfaction and the perceived influence of Dark Patterns. The DarkPatterns On group had the highest-end survey participation (22 users), indicating a higher level of user involvement. Common reasons for discontinuation across all groups included boredom, lack of time, and forgetting about the application.

Interestingly, more users in the DarkPatterns On group reported feeling influenced by Dark Patterns (ten users) compared to the other groups. This suggests a higher awareness and potential dissatisfaction with these manipulative design elements. The feedback indicates that while Dark Patterns can drive engagement, they may also lead to negative user experiences and perceptions.

6.3 Impact of Specific Dark Patterns

6.3.1 Fear of Missing Out (FOMO)

The FOMO group demonstrated significant engagement, with users starting 4,350 levels and completing 2926. The fear of missing out on daily rewards appears to be an effective strategy for increasing user interaction. Users in this group also made a substantial number of purchases (416 levels and 93 items), indicating that FOMO can drive both engagement and monetization.

However, user feedback revealed that the Dark Patterns also led to feelings of being manipulated, with several users noting increased playtime due to the perceived pressure to not miss out on rewards. This aligns with existing research that suggests FOMO can be a powerful but ethically questionable motivator [RSEM20, REH22, FDS21].

6.3.2 Variable Rewards (VAR)

The VAR group had the lowest total engagement metrics but the highest average levels per session, suggesting that variable rewards are effective in maintaining engagement once users are active. This pattern aligns with the psychological principle of intermittent reinforcement, which can be highly addictive [Ski53].

Despite lower overall engagement, the users who remained active were highly engaged, starting and completing more levels per session compared to other groups. This indicates

that while variable rewards may not attract as many users, they can significantly enhance the experience for those who do engage.

6.4 Ethical Considerations and Long-Term Implications

6.4.1 User Satisfaction and Trust

While Dark Patterns effectively increase engagement and monetization, they raise significant ethical concerns. Users in the DarkPatterns On group reported higher awareness of these manipulative techniques, which could lead to long-term user dissatisfaction and trust issues. Prior research has highlighted the negative implications of Dark Patterns on user autonomy and well-being [GKB+18, Bri15]. The perception of being manipulated can erode trust, leading to a negative user experience and potential loss of user loyalty.

6.4.2 User Engagement & Monetization

Research has shown that specific Dark Patterns, like those involving Fear of Missing Out (FOMO) and Variable Rewards (VAR), can drive both user engagement and spending within mobile games. Dark patterns exploit psychological triggers like intermittent reinforcement to keep users playing and spending money, similar to mechanisms seen in gambling. This is particularly effective in free-to-play models, where in-game purchases become central to game progression and user satisfaction.[LS21, PZ22]

6.4.3 Implications for Game Design

The findings suggest a need for ethical considerations in game design. While Dark Patterns can drive short-term engagement and revenue, they may undermine long-term user satisfaction and retention. Game designers should balance the use of engaging elements with transparent and ethical design practices to foster positive user experiences and sustainable user relationships. There is growing concern over the ethical implications of Dark Patterns. Manipulative techniques, such as misleading advertising or aggressive monetization strategies, have been criticized for distorting consumer decision-making. These tactics not only increase short-term profits but also risk long-term trust and user satisfaction, as players may feel coerced or misled into making purchases.[PZ22, LHK23]

6.4.4 Regulatory and Policy Implications

The widespread use of Dark Patterns has attracted the attention of regulators and policymakers. Recent discussions emphasize the need for guidelines and regulations to protect users from manipulative design practices [MAF+19a]. Implementing regulatory frameworks can ensure that game developers adhere to ethical standards, promoting fair and transparent interactions with users.

6.4.5 Future Research Directions

Future research should explore the long-term effects of Dark Patterns on user behavior and satisfaction. Studies could investigate the impact of regulatory interventions and the effectiveness of ethical design practices in maintaining user engagement without compromising user trust. Additionally, the research could examine the psychological mechanisms underlying user responses to Dark Patterns, providing deeper insights into designing user-centered and ethical digital experiences.

6.5 Dark Patterns in Broader Digital Ecosystems

The usage of Dark Patterns is not restricted to mobile games alone; these manipulative design elements are also prevalent in other digital environments, such as social media platforms and e-commerce websites. The e-commerce sector, in particular, has a long history of using manipulative design practices to influence user behavior. Dark patterns such as hidden fees, limited-time offers, and deceptive interfaces are often deployed to nudge consumers into making purchases they did not intend to or to make it difficult for users to opt out of services.

In one study, Mathur et al. (2019)[MAF+19b] conducted an extensive crawl of 11,000 shopping websites, identifying over 1,800 instances of Dark Patterns across the sites. These Dark Patterns exploited consumer biases, such as the scarcity effect, by displaying false countdown timers or creating an illusion of urgency. This type of design not only manipulates user behavior but also raises significant concerns about consumer protection and digital transparency. Mathur et al.'s findings underscore how pervasive these manipulative practices are, suggesting a broader ethical problem that stretches across various digital sectors.

Similarly, social media platforms often employ Dark Patterns to increase user engagement and data collection. For instance, deceptive interface designs are commonly used to make it difficult for users to disable data tracking features. Social capital-based Dark Patterns, such as social proof and peer pressure mechanisms, are used extensively to manipulate user behavior. These designs can have significant psychological effects, particularly on younger users, who may feel compelled to maintain high levels of social engagement due to fear of social exclusion [GKB+18]. In games, this can translate into higher user retention, as players are pushed to keep playing to maintain their standing among peers.

The ethical implications of Dark Patterns, regardless of the digital environment in which they are used, cannot be overstated. With growing awareness of these practices, various regulatory bodies have started advocating for stricter controls on the use of such designs. For instance, the European Union's General Data Protection Regulation (GDPR) seeks to give users more control over their personal data, which includes the right to clear, unambiguous consent. However, even under such regulations, companies continue to find loopholes to exploit user behavior. In response, policymakers and researchers are pushing for more comprehensive solutions that address the underlying ethical issues of

Dark Patterns, not just their legal compliance [MNC21].

By looking beyond mobile games and analyzing Dark Patterns in other digital ecosystems, it becomes clear that these manipulative practices are widespread and have significant consequences. This broader perspective allows for a deeper understanding of the ethical and regulatory challenges that industries face, particularly as these Dark Patterns continue to evolve alongside technological advancements.

6.6 Long-Term Psychological Impact of Dark Patterns in Games

The long-term psychological impact of Dark Patterns, especially in mobile games, is often underappreciated. These patterns, while initially designed to increase user engagement, can have lasting negative effects on players' mental health and well-being. In particular, mechanics such as variable rewards and fear of missing out (FOMO) exploit cognitive biases, creating compulsive behaviors that can lead to addiction. This can result in players spending more time and money than they initially intended, driven by a fear of losing progress or falling behind in the game.

Studies have shown that such mechanisms trigger the brain's reward system in a way similar to gambling, encouraging players to continue playing despite potential negative consequences. According to Zendle and Cairns (2018)[ZC18], the psychological effects of loot boxes and similar reward mechanisms mirror those of gambling, which can lead to addictive behaviors, particularly among younger players. As a result, some governments, like Belgium and the Netherlands, have gone as far as to ban loot boxes in games, classifying them as a form of gambling.

In addition to addiction, players often report feelings of guilt and frustration when they realize they have been manipulated into making in-game purchases or spending excessive amounts of time. This can erode trust in game developers and diminish long-term player satisfaction. Addressing these psychological impacts requires both greater transparency from game developers and increased awareness among players regarding the design techniques being used to manipulate their behavior.

6.7 The Role of Player Agency in Mitigating Dark Patterns

An important but often overlooked aspect of addressing Dark Patterns is the role of player agency. By educating players on how these patterns operate, they can make more informed decisions about their interactions with mobile games. Player awareness campaigns, much like those used to combat phishing attacks or data privacy issues, could help reduce the effectiveness of Dark Patterns.

Tools such as browser extensions or apps that identify and highlight Dark Patterns could also empower players by making these manipulative tactics more visible. Research by Narayanan et al. (2020)[NMF20] suggests that players who are aware of Dark Patterns are less likely to fall victim to them. Additionally, game developers could be encouraged to

design games with clearer choices and more honest communication about the implications of in-game actions, ensuring that players have a sense of control over their gaming experience.

6.8 The Role of Algorithms and Machine Learning in Optimizing Dark Patterns

In modern mobile games, algorithms play a crucial role in personalizing user experiences and optimizing engagement. Game developers often use machine learning models to analyze user behavior in real-time, allowing them to deploy Dark Patterns more effectively. These models can predict user actions, such as the likelihood of making in-game purchases or how often they return to the game after being prompted by notifications. By leveraging predictive analytics, developers can fine-tune manipulative mechanisms, such as targeted offers or variable rewards, to maximize player engagement.

For instance, reinforcement learning, a subset of machine learning, is frequently used to create personalized gaming experiences that adapt based on the user's behavior. By monitoring a player's progress and decisions, these systems can dynamically adjust difficulty levels, the frequency of rewards, or in-app purchase prompts to keep players engaged. These systems can also identify when a user is most likely to disengage, prompting a well-timed notification or reward offer to bring them back.

One example of a machine learning approach is the use of multi-armed bandit algorithms to optimize in-game rewards. These algorithms continuously experiment with different strategies (e.g., varying the type of in-game rewards or the timing of notifications) to find the optimal balance between short-term engagement and long-term retention. The real-time nature of these systems allows developers to test and deploy manipulative design patterns at scale, without requiring manual intervention [THL21].

While these technologies offer incredible opportunities for game designers, they also raise significant ethical questions. As machine learning models become more sophisticated, they could be used to create even more effective Dark Patterns, making it harder for users to recognize and resist manipulation. This highlights the need for ethical guidelines and regulatory oversight to ensure that these technologies are not used to exploit players.

6.9 Software Architecture and Dark Pattern Implementation

The technical architecture of mobile games can influence how Dark Patterns are deployed and optimized for performance. Many mobile games use a microservices architecture to manage different aspects of the game's functionality, including user behavior tracking, in-app purchases, and user notifications. In a microservices-based system, each Dark Pattern can be treated as a separate service, allowing for more flexible deployment and management of manipulative design patterns.

For example, a notification service might be designed to handle push notifications that re-engage users at specific times. This service could leverage event-driven architectures

to send notifications based on in-game triggers, such as completing a level or failing a challenge. By decoupling the notification logic from the core game logic, developers can easily experiment with different types of Dark Patterns without impacting the game's core functionality [Ric20].

Similarly, in-app purchase mechanisms often use a service-oriented architecture to handle payment processing, inventory management, and pricing models. These services can be tightly integrated with Dark Patterns like pay-to-win mechanics, allowing the game to dynamically adjust the difficulty or offer time-limited discounts based on player behavior. By distributing these responsibilities across separate services, developers can iterate more quickly on manipulative strategies, ensuring they remain effective over time.

Additionally, the backend infrastructure often involves databases that track detailed user metrics, such as session length, purchases, and engagement with notifications. These databases enable developers to analyze user data at scale, using SQL or NoSQL systems to identify patterns in player behavior and refine Dark Patterns. This approach allows for continuous optimization, where the system adapts to maximize both engagement and revenue.

6.10 User Interface Design and Interaction Patterns

User interface (UI) design plays a critical role in the deployment of Dark Patterns in mobile games. Modern UI frameworks, such as React Native or Flutter, allow developers to create highly interactive and visually appealing interfaces, but they also make it easier to integrate Dark Patterns. For example, deceptive navigation techniques, such as hiding "cancel" buttons or making undesirable options less prominent, can be easily implemented using conditional rendering techniques in these frameworks.

In mobile games, components like modal dialogs, tooltips, and pop-ups are often used to manipulate player choices. These UI elements can be programmed to appear at specific moments, such as when a player is low on in-game currency or about to complete a level. The timing and placement of these elements are crucial for maximizing their impact, and this is typically handled using state management libraries like Redux or MobX [Par21].

A common technique is to use "Dark Pattern flows," where users are guided through a series of steps that lead to unintended actions, such as making an in-app purchase. This is often done through progressive disclosure, where information about the true cost or consequences of an action is revealed incrementally. By using event-driven UIs, developers can dynamically adjust the flow based on player behavior, making it harder for users to back out of the purchase process.

In addition, mobile games often rely on animation and visual feedback to reinforce manipulative design patterns. For example, animations can create a sense of urgency, making players feel they need to act quickly to take advantage of limited-time offers. These animations are usually implemented using frameworks like Unity or Unreal Engine, which allow for fine-grained control over timing, easing functions, and transitions [Var19].

7 Discussion

The present research set out to examine the impact of Dark Patterns in mobile games, focusing on their influence on player behavior, engagement, and monetization. By designing a mobile game with different versions, this study provided a detailed analysis of how Dark Patterns affect players' decisions and their interactions with the game. These manipulative design techniques, though effective in increasing short-term metrics like engagement and in-game purchases, raise significant ethical concerns that extend beyond game design to broader user experience and well-being.[AKBD22]

The experimental data demonstrated that Dark Patterns are highly effective at driving player engagement, as evidenced by the number of levels started and finished, app usage frequency, and player retention. The group exposed to all Dark Patterns (DarkPatterns On) showed the highest interaction levels, indicating that such manipulative elements keep players hooked and motivated to continue playing. However, these same patterns also led to feelings of frustration and dissatisfaction among users, confirming that Dark Patterns manipulated users into spending more time and money than they might have otherwise intended.

Notably, the Fear of Missing Out (FOMO) and Variable Rewards (VAR) groups highlighted the psychological mechanisms that make Dark Patterns so compelling. Players driven by FOMO showed significant engagement and a strong inclination to make in-game purchases. This aligns with broader findings in the field of behavioral psychology, where fear of missing out can serve as a powerful motivator, even in non-game contexts. On the other hand, the VAR group exhibited fewer overall interactions but much higher engagement during active play, suggesting that variable rewards create a more intense but intermittent connection with the game. [KDG11, ZM10]

Survey data further supports these findings, with a majority of users reporting that notifications prompted them to return to the game when they were bored or had free time. However, the continuous exposure to Dark Patterns through notifications led to heightened stress and feelings of compulsion, revealing the negative long-term implications of such manipulative techniques on mental health.

From an ethical perspective, the use of Dark Patterns in mobile game design raises important questions about player autonomy and consent. While these patterns are effective in monetizing the game, they often erode player trust and satisfaction. The ethical dilemma is whether it is justifiable for developers to employ tactics that prioritize short-term gains at the cost of user well-being. This research underscores the need for a balanced approach to game design, where engagement and monetization can be achieved without resorting to manipulative practices.

The study also calls attention to the regulatory challenges surrounding Dark Patterns in games. Although some regulatory frameworks, such as the Digital Services Act

(DSA) and the Digital Markets Act (DMA) in the European Union, aim to limit the use of manipulative design in digital platforms, the specificity and enforcement of these regulations remain insufficient. More stringent and clearer guidelines are needed to protect vulnerable user groups, such as children and adolescents, from the harmful effects of Dark Patterns. [Bre24]

7.1 Regulatory and Policy Responses to Dark Patterns

The growing concern over the use of Dark Patterns in mobile games and other digital platforms has led to increasing calls for regulation. Several countries and regulatory bodies have begun to explore the ethical implications of these practices and how they affect consumers. One of the key challenges in regulating Dark Patterns is the difficulty of defining them in legal terms, as they often involve subtle manipulations that are hard to classify under existing consumer protection laws.

A significant step in this direction has been the introduction of the Digital Services Act (DSA) by the European Union, which aims to increase transparency and accountability in online platforms. While the act primarily focuses on content moderation and transparency, it also addresses user interface manipulations that can lead to consumer harm. Under the DSA, online platforms could be required to provide clearer information about how their interfaces are designed and give users more control over their data and engagement with the platform (European Commission, 2020) [Com20].

In the United States, lawmakers have introduced the Detour Act, aimed at curbing the use of deceptive design practices by large technology companies. Although this legislation is still under debate, it signals a growing recognition of the need to address the ethical concerns posed by Dark Patterns [Bri21].

As these regulatory frameworks continue to evolve, there is an opportunity for the gaming industry to adapt by prioritizing user-centered design principles that emphasize transparency, informed consent, and ethical engagement strategies. This would not only benefit players but also create a more sustainable and trustworthy relationship between developers and their audiences.

7.2 Limitations

This study faced several limitations that could affect the generalizability of the findings. First, the sample size and participant base were limited, with a focus on users from Austria. While this offered a controlled environment for analysis, it may not fully represent global gaming behaviors and preferences. However, the uniformity within this demographic provides a clearer understanding of the core mechanics of Dark Patterns in gameplay without regional variances potentially skewing the results.

Additionally, the study concentrated on a specific type of mobile game—a match-three puzzle game—aimed at casual gamers. This choice could limit the applicability of the findings to other game genres, such as role-playing games or strategy games, where Dark Patterns might influence user behavior differently. Still, given the popularity of

match-three games among casual users, this genre offers valuable insights into how Dark Patterns affect a broad user base.

Another limitation involves the duration of the study, which was relatively short. While the thirty-day period allowed for a snapshot of user behavior and responses to Dark Patterns, longer-term effects—such as potential desensitization to Dark Patterns or increased user frustration could not be fully examined. However, the study's findings are still valuable for understanding immediate reactions and short-term engagement patterns.

Furthermore, the reliance on self-reported data, particularly in surveys about user perceptions and feelings, introduces potential biases. Participants' responses may be influenced by recall bias or a tendency to underreport negative experiences. Despite this, survey data provided important qualitative insights that complemented the quantitative findings.

Finally, the simulation study format, while useful for controlled observation, may not capture the full spectrum of behaviors users might exhibit over a longer time in a real-world setting. Despite these limitations, the insights gained are robust within the study's scope and offer a valuable foundation for understanding Dark Pattern impacts in mobile gaming.

8 Conclusion

Dark patterns are increasingly prevalent in almost every application and on every website. These deceptive design practices are highly relevant in today's digital landscape, and addressing this issue is expected to become more important in the coming years. As more applications are uploaded daily to various app stores, the potential for Dark Patterns to negatively impact users grows. Mobile games, often seen as a source of fun and relaxation, can also play a positive role in people's lives by not only entertaining them but also offering educational value. When designed with educational content, these games provide a constructive way for players to spend their time.

However, there is a darker side to mobile games when they incorporate Dark Patterns. These design choices can be harmful, affecting users financially and psychologically. When Dark Patterns are used to manipulate players into making purchases or engaging in unwanted behaviors, the consequences can be severe. It is crucial for developers to find a balance in the implementation of these patterns. Instead of imposing them on players and making them necessary for game progression, Dark Patterns should be designed in a way that makes them optional and non-intrusive. This approach would allow players to engage with the game without feeling pressured or manipulated, ultimately creating a healthier gaming environment.

As the digital world continues to expand, the ethical considerations surrounding the use of Dark Patterns will become even more critical. Developers and designers must prioritize user well-being and create experiences that are both enjoyable and fair. By doing so, they can ensure that the growth of digital applications and mobile games contributes positively to society, rather than exploiting users for profit. This balance between innovation and ethical design will be key to fostering a more trustworthy and user-friendly digital landscape.

Looking forward, the results of this study point to several avenues for future research. There is a pressing need to explore the long-term effects of Dark Patterns on player retention and satisfaction. Additionally, more research is required to examine the psychological mechanisms underlying player interaction with Dark Patterns, particularly concerning variable rewards and social pressure. Investigating the role of regulatory interventions in mitigating the adverse effects of Dark Patterns will also be crucial in shaping the future of ethical game design.

In conclusion, while Dark Patterns can drive short-term success for mobile games by boosting engagement and revenue, they pose significant ethical challenges that cannot be ignored. The key takeaway from this research is the need for game developers to adopt more transparent and user-centered design practices. By doing so, the gaming industry can create healthier, more sustainable relationships with its players, ultimately benefiting both users and developers in the long run.

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