Athina Giokarini

Level Design Complexity In Match-three Games:

A study of level design structural complexity in modern, casual, mobile match-three puzzle games

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Thesis Supervisor Miikka Junnila

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Author: Athina Giokarini

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Abstract

Despite the financial success of casual mobile match-three games and the consistent engagement of millions of players on a daily basis, there is little public research concerning their level design. Commonly casual games are perceived as lacking challenge, depth and complexity of level design. However, my professional experience as a match-three level designer indicates otherwise. In fact, the simplicity of their core gameplay interaction; connecting three or more similar elements in order to make them disappear, permits the combination of multiple variations of the main interaction, thus enriching the player experience.

The aim of this thesis is to examine the level design of top-grossing, casual match-three mobile games and specifically in what ways the structural complexity of their level design varies along different player progression points. My hypothesis is that their level design becomes more complex over time, with the complexity increase being related to the matching system and the amount of gameplay elements introduced during onboarding.

To evaluate this hypothesis, the level design properties of ten top-grossing, casual match-three mobile games were studied. The research was conducted by the examination of video footage of gameplay, uploaded on public social media platforms by players. A framework was developed to categorise and analyse the material, focusing on tracking gameplay elements that could signify variations on the structural complexity of the designs. Three brackets of ten levels were examined per game, specifically levels 1-10, 101 - 110 and 1001 - 1010. The accumulated material was analysed both in comparison to other studied games and each section studied in comparison to the other sections of the same game.

The framework used yielded valuable information on which design elements can affect a design's complexity. Indeed, it was proved by the study that the complexity of levels increases over time. There are indications that the matching style affects the degree of complexity, however more research is needed. Likewise, the sample size is not sufficient to fully confirm a correlation of mechanics introduced and future complexity. It is recommended to conduct a larger study in the future, potentially utilising automations to assist the accumulation of information. Potentially interesting areas of research would be the level design of a whole game, as well as a comparison of a larger games' sample. Furthermore, the framework itself can be used as an assessment tool while studying or designing future content.

Keywords: game design, level design, match-three games, mobile games, casual games, free-to-play games

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Introduction

The aim of this thesis is to examine the level design of top-grossing, casual match-three mobile games and specifically in what ways the complexity of their level design varies at distinct player progression points for each game's funnel.

Despite the financial success of the casual genre and the consistent engagement of millions of players on a daily basis, there is little public research concerning the game content and the methods it achieves to captivate players. It is a common misconception that casual, match-three games are not challenging and lack depth and complexity of level design (Juul, 2007). However, as a professional level designer working in the field, I strongly disagree. Initially, match-three games seem deceptively plain, given the simplicity of their core interaction; the connection of three or more similar elements in order to make them disappear, yet multiple layers of mechanics can be combined with it and thus enrich the player experience (Costikyan, 2005, p. 19; Juul, 2007).

Considering that casual games' players typically gravitate towards games with a comfortable degree of difficulty and tend to abandon games when they become too hard for their taste, it is in the games' best interest to provide appropriate challenge to retain their audience (Juul, 2012a, p. 148; Koster, 2005, p. 38). The first indicator of a level's difficulty is it's appearance, i.e. the objective and move count, the construction of the game board and the complexity of the combination of the gameplay elements used. Since players evaluate the presented information by extrapolating from previous experience, a level must feel immediately attractive and appropriate to the players expectations (Hodent, 2017, p. 163; Koster, 2005, p. 38). Thus, game developers place special effort into making the level designs representative of the level's intended difficulty (Hodent, 2017, p. 163).

Based on the above information, it is clear that the study of level design in terms of their structural complexity can benefit level design processes overall. For that purpose, in this thesis I evaluated the level design properties of ten top-grossing, casual match-three mobile games focusing on the elements that signify higher structural complexity of level design varies at different player progression points. My hypothesis was that the level design becomes more complex the longer a player plays, with the complexity increase being relative to the matching system and gameplay elements introduced in the very first few levels. In order to validate this hypothesis I devised a framework to study levels based on their structural complexity. Specifically, I compared 300 levels from ten top-grossing match-three games using tile-swapping, blasting and line-matching matching styles, in terms of structure of their levels and the ways they impacted their complexity over their early game, mid-game and late game.

Although the results confirmed that the level design complexity does indeed increase as players proceed in a game, the scope of the study did not provide enough information to connect the relation of matching style and onboarding with the complexity of the levels. Overall, the framework provided a useful tool to dissect level design of match-three games, and yielded some useful information concerning the use of different elements in the games. Therefore I would suggest conducting further research, focused both on the thorough examination of specific games, and on a broader examination of the genre in general.

Background

Casual mobile free-to-play match-three games, which are games where players must connect three or more similar elements in order to make them disappear, consistently dominate top-grossing charts in the current mobile market. Impressively, some of these games remain available continuously for almost a decade following the "games-as-a-service" business model and thus consistently outputting new content through live-operations (live-ops) updates, often amounting to thousands of unique levels.

Typically, casual game audiences tend to display a limited tolerance for complexity (Juul, 2012a, p. 148). Thus, they frequently abandon a game once its complexity has crossed a certain threshold. Considering that player retention is invaluable for free-to-play games, it is logical to assume that game developers calibrate their content design to cater to their audience's preferences; therefore it is both appropriate for their skill level and remains fresh, interesting and unique throughout the game (GDC, 2019; Hodent, 2017, p. 160). Nevertheless, although routinely introducing new gameplay mechanics helps players retain a sense of novelty, it inevitably increases the degree of complexity of level design (GDC, 2019). Clearly, finding the balance between innovation and acceptable challenge across the whole range of content of a game is an uphill battle, especially because the content of live-ops games tends to change significantly over time. Therefore, studying this iterative process can be educational for a game designer, particularly because of the constant feedback loop between content design and players, as well as the creative process, which is highly restricted by the genre's features: a limited playspace and a very structured system of interactions between gameplay elements.

However, little academic research exists on the genre of match-three games, and even less around the field of level design. In fact, established systems to evaluate match-three content from a level design perspective are nonexistent; indeed, it is common to establish design decisions solely around the measurable performance of the content –specifically analytics concerning monetisation or balancing– instead of immeasurable values like well-designed content and satisfying player experience.

Consequently, the lack of academic studies leads to a scarcity of comprehensive resources and training material for new designers, who are thus limited to empirical methods of learning or depend on the study of game design theory and level design principles without sufficient relevant applied use-cases. Undoubtedly, analysing games of interest is a valuable learning method. However, establishing a common language of communication, concerning casual level design patterns would benefit all game designers involved in the field.

Thus, devising a framework to evaluate the structural complexity will be the goal of this thesis. The observation of highly performing casual games and the methods they use to maintain a balance between their level design's complexity and novelty may provide insight into level design best-practices, as well as trends in the industry overall.

Research goals

The aim of this thesis is to evaluate different top-grossing match-three games on their level design's structural complexity at different progress points of each game's progression. To elaborate, a level is an isolated, standalone section of a game which contains a specific challenge and has individual victory conditions. Typically, on match-three games the levels become available to the players in a linear order and a new level cannot be accessed before the current one is completed. Therefore, the player progression on a game is directly tied to the levels completed. In this case the progression points examined include player's onboarding, reaching a mid-game milestone and reaching a late-game milestone. The specific level brackets chosen were levels 1-10, levels 100-110 and levels 1000-1010, because they represent a player's experience after playing for a day, a week and 100 days, under the assumption that a player may complete on average 10 levels per day of playing.

For the purposes of this research, the relevant levels have been accumulated through publicly available video sources; players playing the designated levels themselves and uploading their playthrough on Youtube (https://www.youtube.com/). Then the accumulated material was examined under a framework I devised, using criteria based only on the information visible on the videos, and therefore excluding any information the developers could collect by level analytics.

The games chosen are amongst the current top 200 sustainable grossing games in the puzzle or casual genre in the US, according to *Game Refinery* (https://www.gamerefinery.com), with a preference towards games that display diverse core mechanics and use one of the three most prominent matching styles; tile-swapping, blasting and line-matching. Games studied, in order of ranking are: *Candy Crush Saga (King, 2012b)*, *Toon Blast (Peak, 2017)*, *Homescapes (Playrix, 2017)*, *Gardenscapes (Playrix, 2010)*, *Candy Crush Soda Saga (King, 1024)*, *Toy Blast (Peak, 2015)*, *Matchington Mansion (Firecraft Studios, 2017)*, *Fishdom (Playrix, 2015)*, *Best Fiends (Seriously Digital Entertainment, 2014)* and *Candy Crush Friends Sag*a (King, 2018).

Match-three games

This chapter focuses on the analysis of match-three games from different perspectives. First, the genre of match-three games is defined followed by an analysis of the evolution and history of the genre, in order to contextualise the form and common features of modern, free-to-play, casual, mobile match-three games. Then, the typical traits of match-three games and different features of their gameplay and metagame are examined, to assist the evaluation of different aspects of the games to be studied based on the complexity and depth they present to the players. Finally, common practices of game and level design are discussed, in order to illustrate the term of complexity in this study's context.

Origins of the genre

There are multiple ways to classify games in a genre, sorting by gameplay mechanics being the most common one. Every genre of games is based on a certain gameplay mechanic, specifically an action that the players perform (Costikyan, 2005). In the case of match-three games, the defining mechanic is matching tiles, and the defining player action is connecting three or more tiles of similar properties. More specifically, "[m]atching tile games are video games where the player manipulates tiles in order to make them disappear according to a matching criterion" (Juul, 2012a, p. 84). In many matching tile games, that criterion is to position a specified amount of tiles of equal properties so that they become adjoined to each other. That amount is frequently three, which is the reason why these games are called match-three games (Juul, 2007).

Furthermore, a genre can be defined by the combination of said defining mechanic with other aspects of the games, for example its theme, aesthetics and interface conventions.

Commonly, match-three games display a positive and bright theme (Juul, 2012a, p. 68) and therefore connect to audiences with a preference for relaxed, pleasant and casual experiences. The following paragraphs focus on the genre, the mechanics and the elements that create a distinct gameplay experience for match-three casual games, while the aspects of theme, aesthetics and target audience will be discussed in later chapters.

There is a debate as to whether match-three games are a genre of their own or a subcategory of a larger genre. According to Juul, the term “match-three games'' became popular after the success of *Bejeweled (Popcap Games, 2001)*, while earlier match-three games have been considered derivatives of *Tetris (AcademySoft, 1984)* and members of a broader collection of matching tile games (Juul, 2007, 2012a, p. 98). Despite relying on a very simple fundamental interaction, connecting similar elements, matching tiles present a significant variety of gameplay experiences. The very simplicity and small combination of gameplay elements in matching tile games is the reason why minimum variations in design aspects, such as different forms of timing, tile manipulation and matching conditions, can drastically alter a game’s feel (Costikyan, 2005, p. 18; Juul, 2007, 2012a, pp. 88–92). In the words of Costikyan, “[a] petty little distinction, right? But that petty distinction produces very different styles of play” (Costikyan, 2005, p. 18).

Such variations in game-feel lead to different taxonomies of matching tile games. For example, some matching tile games categorisations distinguish “tile-matching puzzles”, “falling block puzzles” and “Puzz Loop variants” (Juul, 2007). In other taxonomies though matching tile games are distributed within different subcategories of larger genres; “marble poppers” such as *Zuma (Popcap Games, 2003)* are considered “action & arcade” games, while match-three games are seen as part of “puzzle games” (Juul, 2007, 2012, p. 100). For the purposes of this thesis match-three games will be treated as a sub-genre of puzzle games.

Puzzle games focus on problem-solving utilising skills of logic, pattern recognition and sequence-solving. In fact, as Koster argues, pattern identification is the cornerstone of all games (2005). Indeed, matching similar elements to each other is a familiar, well-used mechanic, widely utilised in analog games -like card games, *Dominoes*, *Mahjong*- before being translated to digital games (Juul, 2007). Contrary to most traditional puzzle games, the puzzles in match-three games do not have a single, unique solution, rather each individual level provides a well-defined victory condition which can be achieved in multiple ways. Thus, failure is not the product of a single mistake, rather the accumulation of multiple ones (2012a, p. 42).

It is highly unlikely for a player to repeat the exact same actions while playing a match-three level twice. Randomisation of the game board contributes to the uniqueness of the experience both at the start of a level and while playing it (2012a, p. 42). Whenever a successful match is performed, an equal amount of tiles of random attributes is added to the playspace, essentially resetting the board after each turn. Hence discovering a method to optimise player's available resources towards a victory condition is their prime point of attraction. Luck does affect the outcome of each move, but player skill is crucial to the long term result (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.; GDC, 2019). To conclude, challenge in all matching tile games lies in the identification of useful patterns and creating order on a seemingly chaotic board, thus match-three games display one of the most essential aspects that people enjoy in games; “looking for a pattern, finding it, and moving on, in search of ever more patterns” (Juul, 2007).

Since the release of Bejeweled, match-three games have noticeably matured. As is typical for game development, match-three games follow a pattern of gradual evolution, performing small changes to their core mechanic, while maintaining a sense of familiarity for the public. Undoubtedly, striking a balance between familiarity and innovation is challenging. “Cloning” -a derogatory term referring to games that copy other games extensively- can be unavoidable, especially considering that a game's success depends on potential players capacity to recognise and associate a game with their previous experiences (Juul, 2012, p. 67). Essentially, developers are expected to create content that is simultaneously reminiscent of the existing products in the market - thus validating players' competency and comprehension of the new game - and still innovative in their own right (Juul, 2012, p. 67).

There are different areas where innovation is possible. First and foremost, novelty elements can be found on the core gameplay -for example in the combination of matching with other mechanics the introduction of new goals and the complexity of the levels. Likewise, the introduction of elements of metagame have allowed to explore newfound depth in the games - map progression, role-playing game (RPG) elements such as inventory management and social features such as leaderboards are nowadays commonly combined with the puzzle-solving typically associated with match-three games. Hybridisation of mobile games, the practice of adopting gameplay aspects commonly encountered in different genres, is frequently observed nowadays (*An Interview With King — Using Mobile Data to Inspire Creativity Within a World Class Gaming Company | App Annie Blog*, n.d.-a, *App Annie State of Mobile 2020 Report*, n.d.).

Undoubtedly, modern match-three games have evolved from their predecessors enough to make comparisons with early representatives of the genre futile. Hence for the purposes of this thesis the focus will remain on later games, specifically match-three games developed for mobile devices after 2010. Before concentrating on modern match-three games, the transition from early match-three games to more recent ones will be shortly examined.

Evolution of the genre

Before focusing on the analysis of modern match-three games' gameplay, it is useful to contextualise their current incarnation, by looking at their evolution over time and platforms. Although the study of the economy of modern games is not within the scope of this thesis, a lot of the decisions that affected their design were driven by business factors. Consequently, match-three games' history is interconnected with their platforms of distribution; they thrived in markets that were niche and reached an audience that was frequently disserviced: the casual audience. (Juul, 2012a, p. 79). Hence, the success of match-three games is a result of a successful combination of provider, genre and intended audience in different points in time.

Downloadable casual games are a prime example of this alignment. Notably, downloadable casual games abandoned the traditional brick-and-mortar stores opting instead for online-only distribution through specialised websites (Juul, 2012a). In their majority downloadable casual games are two-dimensional (2D) games that take place in a contained screen space, utilising a clear user interface and easily understandable themes and requiring little knowledge of video game conventions to be played (Juul, 2012a, pp. 5, 79). Typically, most downloadable games of the time had a limited size and contained a finite amount of content, for an affordable price (Juul, 2012a). Additionally, a free playable version of the games could be accessed and tested for a limited time before committing to a purchase, and upon the end of the trial, players were required to buy the game in order to continue playing (Juul, 2012a). This business practice and game format resonated with the casual player audience (2012a, p. 79). In fact, in the early years of downloadable casual games, matching tile games were top-selling with *Bejeweled* being one of the most prominent (Juul, 2012a, p. 79).

While the popularity of downloadable casual games waned over time, a new market was located within browser games and social network games (2012a, p. 79). Unsurprisingly, ease of access, clarity of design and a devoted audience were the aspects that help casual games establish themselves as browser games and social network games become more prominent (Kultima, 2009). Given that browser games were provided to players free-of-charge, the need for a new business model was born. Contrary to the established "pay once and play" model, the "free-to-play" or "freemium" business model allowed free access to the game and monetised through marketing and in-app purchases, such as virtual assets, in-game currency, and in-game advertisements (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.; Juul, 2016). Free-to-play games allowed the democratisation of access to games and thus significantly expanded their player base (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.).

In addition to a reinvented business model, social network games enhanced the player experience through the combination of simple games and a social context (Juul, 2012a, p. 148; Kultima, 2009). Social network sites provided users the resources to create a public profile, connect with friends and associate with further connections within the system (Boyd & Ellison, 2007, pp. 210 – 230). Thus, players could now connect with other social media users who played the same game, or recommend a game to their connections and bond around it (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.; Rossi, 2010). The introduction of this meta-layer of social connections through gaming rejuvenated the genre of casual games (Juul, 2012a). Furthermore, the ability to retain players' progression in their account and seamlessly continue playing from any online device became a popular quality of life feature (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.). In 2011, Facebook (https://www.facebook.com/) hosted more than 845 million monthly active users (Omori & Felinto, 2012). Consequently, the free-to-play game *Candy Crush Saga* became the most-played game of Facebook (https://www.facebook.com/) for 2013, a significant milestone that rekindled player interest for match-three games (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.).

Meanwhile mobile phones evolved into a new, prominent platform for gaming, one accessible by a significantly broader audience. Indeed, it was estimated that by the end of 2019 3.2 billion people, almost 50% of the global population, would be in possession of a smartphone (Cullen, 2019). Modern touch-screen phone devices introduced a new method of interaction with games, allowing for the creation of games that feel tactile, pleasant and easy to approach

(Browne & Anand, 2012; Y. Chen et al., 2018). Furthermore, embedded platforms of distribution for games and other software applications assisted not only the immediate download of content on the devices, but also allowed for the maintenance and update of downloaded content through central distribution channels (Desatoff, 2020). In fact, this distribution system was so efficient that annual worldwide downloads of new mobile applications grew by 45% between 2016 and 2019, amassing over 204 billion application downloads in 2019, while an average user spent approximately 3.7 hours daily on mobile devices in 2019 (*App Annie State of Mobile 2020 Report*, n.d.). According to AppAnie's State of the Mobile report for 2020 "[t]he mobile market is the most lucrative gaming sector in the world, and there's no evidence that this won't continue to be true in 2020" (*App Annie State of Mobile 2020 Report*, n.d.). Indeed, mobile gaming comprised almost 75 percent of global mobile revenue during the first half of 2019 (Valens, 2019).

An important contributor to this success, as well as a significant evolution for games overall, was their transformation from a complete product to an ongoing service. The term ”games-as-a-service” (GaaS) refers to games constantly evolving and iterating, implementing as many current design trends as possible along its existing core. Central to the "service" aspect of said model is a live-operations-based (live-ops) update cycle, focused on frequent game updates, iterations on the existing content and the consistent output of new content, based on an endless iterative design circle (Hodent, 2017, p. 175). Contrary to single-purchase items, services rely on retaining customers and repeated purchases to monetise.

The monetisation model of modern match three games will not be further examined, as it is beyond the scope of this thesis, however the GaaS business model directly affected the design philosophy of modern mobile games. Indeed, the core gameplay of modern mobile match-three games became entangled with the requirements of a living product, i.e. a stimulating metagame layer, frequent gameplay novelties and practically endless level content.

Candy Crush Saga, the consistent leader of top-grossing charts since its release for mobile platforms in 2013, is a prime example of this dependency. In 2016 *Candy Crush Saga* released its 2000th level, contained more than 5000 levels in 2019 and has been constantly expanding with bi-weekly updates, a practice followed by all successful free-to-play match-three games (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.; GDC, 2019). Naturally, maintaining an appropriate level of challenge for a game that is growing at such pace requires inventive design, aimed to create a sense of progression and innovation in gameplay, regardless of the player's pace of progression. Designing content under this context, is a challenge on its own.

As discussed, match-three games managed to utilise their recognisability and simplicity of gameplay to evolve and adapt to different platforms and social norms. In 2012 Juul claimed that "it is not that matching tile games are going away, but rather they have moved from the top tier of downloadable casual games into other contexts and onto new platforms" (Juul 2012, page 101). In 2020, this statement proves to be just as relevant, with challenges rising from an oversaturated market, as the list of top-downloaded match-three games seems unchanging and the top-grossing charts are dominated by few successful companies (Desatoff, 2020). Discoverability for new games is challenging and the costs of advertising and user acquisition are significant, especially for smaller developers (*Match3 – meta layers and matching types | GameRefinery*, 2018). While established games are thriving in the current mobile economy, an innovation for this genre seems unavoidable in the future. It will be exciting to observe the next iteration of the genre.

Casual game audience and design

Casual games are within the fastest-growing sectors of the gaming industry, a success accomplished by catering to the needs of a very broad yet particular audience (Kultima, 2009). Indeed, 44% of the total time spent on mobile games globally in 2019 was invested on casual games, with 34% of these being puzzle games, the parent genre of casual match-three games (*App Annie State of Mobile 2020 Report*, n.d., *Mobile Gaming Report [NPD, 2020] – IGDA*, n.d.). However, the term "casual games" is associated both with casual audiences and casual game design practices, whose properties and association will be discussed in this chapter (Kultima, 2009).

The casual audience includes a range of players broader than the contrived "hardcore" audience for videogames, composing a more heterogenous player-base, with high representation of women and people of older age (Juul, 2012a; Kultima, 2009). Casual players have vastly varying personality profiles, skills, preferences and economic background and may have varying degrees of gaming literacy, hence may play casual games for different reasons (Kultima, 2009). Common attractors to the genre are its accessibility, portability, social nature, and ease of suspension of play sessions (Y. Chen et al., 2018; Juul, 2012a; Kultima, 2009). In terms of usability, casual games assume little to no prior knowledge of video game conventions, thus requiring the use of simple, clear and intuitive interfaces, a slow and clear onboarding process and incremental increase of difficulty (Y. Chen et al., 2018; Hodent, 2017; 2012a, p. 50). Commonly, casual games are experienced as short moments of escapism between other tasks (Y. Chen et al., 2018). Fittingly, King's design philosophy of games that are easy to engage with and experience with commitment of short periods of time per session, condensed in the term "bite-sized brilliance", appropriately reflects these attractors to casual games from the developer's perspective. (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.; GDC, 2019).

Juul examines the traits of casual players in the context of gameplay preferences and in association to the traditional archetype of the hardcore gamer (2012a). Stereotypically, casual players have little experience in gaming, prefer easy games requiring small time commitment and gravitate towards positive and pleasant fictions (Juul, 2012a, p. 29). On the contrary, stereotypical hardcore games are committed to gaming, willing to devote significant time and resources for it, while appreciating challenging games with darker themes (Juul, 2012a, p. 29). Initially, the differences between the two player stereotypes are glaring, however Juul's research draws different conclusions. Actually, casual players can display significant commitment and appreciate an appropriately challenging game, provided the challenge is reflected in a clear and concise manner (Juul, 2012a). Furthermore, a game being casual does not mandate that the players will engage with it in a casual manner (Juul, 2012a; Kultima, 2009). Notably, the audience of casual games is rather flexible in their genre preferences and gaming behaviours and may play games outside of the casual genre (Juul, 2012a; Kultima, 2009).

Concerning difficulty, and in extension the punishment for failure, casual games do not shy away from challenging gameplay, however they do not punish players harshly for failure. For example, players are not forced to replay large sections of a game upon failing and single player games are especially lenient with failure (Y. Chen et al., 2018; 2012a, p. 50). Indeed, failing a level of a match three game requires only to replay the same content and typically after multiple failures games will provide support mechanisms such as in-game hints and dynamic difficulty adjustments to assist players (Y. Chen et al., 2018; GDC, 2019; Hodent, 2017).

Finally, the common characteristics regarding the theme and overall gamefeel of casual games have to do with the sense of positiveness and pleasure (Y. Chen et al., 2018; Juul, 2012a, p. 50). Casual games utilise bright and positive fictions and themes that are relaxing and attractive (Y. Chen et al., 2018; 2012a, p. 50). The importance of excessive positive feedback, commonly known as “juiciness”, needs to be highlighted as well (Y. Chen et al., 2018; Juul, 2012a, p. 50). Casual games feel rewarding and satisfying, leaving players with a feeling of accomplishment after every successful action (Y. Chen et al., 2018).

Furthermore, fun is not the only reason players play games. Indeed, practice, comfort, meditation and an interest for their narrative aspect, are valid reasons to enjoy a game (Koster, 2005, p. 100). Casual games seem to be well suited to cater for most of those needs, as their gameplay and design philosophy actively creates a safe and comforting environment for players.

Gameplay features of modern match-three games

This chapter we will focus on the core gameplay aspects of modern match-three games, in order to understand level design principles of the genre. Game mechanics are the building blocks of games and define the feel and features of a genre. In the following chapter we will examine some of those building blocks and devise some categorisations based on the ways they affect the overall gameplay of match-three games. Since the topic is technical, a companion glossary of common match-three design terms is included in the Appendix A. As observed, distinguishing match-three games from the whole of matching-tile games may be subjective. Given the lack of formal taxonomy, internal consistency of categorisations will be prioritised.

As has been established, match-three games create impressive gameplay depth utilising only minor iterations of their building blocks. According to Juul “matching tile games are a well-defined design space that allows numerous variations based on a few simple building blocks" (2012b, p. 92). However, as (Costikyan, 2005, p. 19) discusses, "[t]rivial differences in the specific mechanics you use can produce major differences in player behavior" (2005, p. 19). It is thus imperative to shed some light on these genre-defining elements, specifically the matching systems, time and objective constraints, level layout features and metagame elements.

Tile manipulation and matching style

Match-three games are defined by the way their core interaction, tile manipulation, is implemented. *Tile manipulation* is the action performed by the player to connect suitable tiles of a specified minimum amount, in order to make them disappear from the board. The minimum amount of suitable tiles is determined by the method of interaction of the player with the tiles, the matching system of the game. Consequently, the action of matching creates the framework around which all other actions and gameplay mechanics of the game are designed. The physical and mental requirements of a game determine its complexity and usability and affect the player experience in multiple ways (Hodent, 2017, p. 127). Therefore the matching system of the game is the most distinctive quality of the genre.

The scope of match-three games for this research includes only games where players directly manipulate tiles in order to create a match. Typical formats of this, in order of popularity, are: tile-swapping, blasting and line-matching (*Match3 – meta layers and matching types | GameRefinery*, 2018). Conversely, matching-tile games where tiles are indirectly manipulated through an in-game interface, for example bubble-shooter games like *Bubble Witch Saga (King, 2012c)* are excluded from this study.

The most popular matching system is *tile-swapping*, or swapping, where players swap the positions of two adjoining tiles in order to procure a match of at least three tiles. Initially popularised by *Bejeweled* and later *Candy Crush Saga*, this system appears most prominently on games. Variations of the swapping system, for example swapping any two suitable tiles on the board exist, for example *Pokemon Shuffle (Nintendo, 2015)*, yet are rare. The minimum amount of tiles required for a tile match is three, while the maximum is five. A match that contains more than three tiles produces a special block of higher value in the location of the match, commonly a bomb that destroys a different range of blocks upon triggering. If upon cascade blocks form a valid match, the match is automatically resolved for the player, along with potential reactions from special blocks. Player agency is constrained by the effects of chance, thus creating dynamic, and fast-changing gameplay that relies equally on much as player-initiated actions and luck-initiated combos to create interesting, satisfying moments (*Deconstructing Best Fiends Stars | GameRefinery*, 2019). Juiciness of effects enhances that experience.

In games using the *blasting* or collapsing matching system, suitable adjoining tiles are removed from the board upon player input. In mobile devices said input is usually a tap on top of any suitable tile. Once tapped, blocks disappear and the remaining blocks of each column collapse to fill the created void. Depending on the count of blocks removed, special blocks of higher value are produced. Blasting games like *Toy Blast*, *Toon Blast*, or the older *Pet Rescue Saga (King, 2012a)* have a very rigid system of cascade, where tiles always move downwards remaining on the column where they were spawned. Visually they are defined by the use of large, compact tiles, helpful for the pattern identification. In blasting games matches are resolved only upon player interaction. The minimum amount of tiles required for a match is typically two, while there is no upper limit to the amount of tiles matched at once. Higher counts of tiles in a match generate special tiles in place of the tile players interacted with to initiate a match. Players have agency over the outcome of their matches and can strategize in order to achieve an optimal match, as the way the cascade works is more predictable. Interesting situations originate from planning, optimising and executing impactful matches.

Lastly, in *line-matching* or linking games players connect adjacent matchable tiles by drawing a continuous line from the beginning to the end of the intended match. *Best Fiends* and *Line Disney Tsum Tsum (LINE, 2014)* are typical examples of line-matching match-three games. Commonly the minimum amount of tiles for a viable match is three and there is no upper limit. All matches are initiated and fully controlled by the player and valid matches can include tiles surrounding the tile currently selected from any direction, including diagonally. This allows the creation of longer matches and consequently may affect larger areas of the game board in one action. Conversely, performing shorter matches feels lackluster, especially compared to the impact of a match in tile-swapping games. Additionally, special tiles may be produced directly as a result of long matches, or as a cumulative result of the collection of blocks with similar properties, thus encouraging a more strategic gameplay. Line-matching match-three games are overall considered more demanding for the players, as far as planning and motor-skills go, and thus they are less prominent in the market.

Following the examination of the three most popular matching systems, a comparison of them is now possible. Concerning interaction usability, Hodent emphasises the importance of consistent controls in a game’s usability, particularly due to the player's physical interaction with the game heavily relying on implicit memory (*muscle memory*) and thus potentially becoming an automated action (Hodent, 2017, p. 126). Furthermore, the rotation of the mobile screen and the ease of access of all areas with thumbs and fingers may affect players’ range of motions (2017, p. 128). Comparing the three matching systems in terms of complexity of interaction, blasting is the least complex and line-matching the most complex. Swapping and tapping blocks are both simple, intuitive gestures performed on mobile devices daily, therefore more likely to be automated, while linking blocks is a less familiar gesture, requires more precise attention and can be challenging for users with limited motor-skills or small screens. Generally, a mechanic commonly used in games -in this case tile-swapping - is easier to grasp, while less standardised, specialised mechanics, such as line-matching, can be harder to grasp (Hodent, 2017, p. 181).

Concerning cognitive load, Hodent emphasises the merit of minimizing players' required mental and physical exertion, both by reducing unnecessary memory sinks and distractions and by reducing the intensity of physical interactions (2017, pp. 126 – 128). The upper limit of five tiles per match in tile-swapping games, along with the automated resolution of existing matches eliminate the cognitive load required to recognise the optimal matches significantly. Conversely, although the tapping interaction itself is rather simple, coordinating it and evaluating the placement for an optimal match is more mentally challenging. Line-matching games are even more demanding.

Furthermore, it is worth noting the value of familiarity and consistency of mechanics amongst different games, as it allows players to adopt gaming conventions quickly and focus on the unique gameplay challenges of a new game instead (2017, p. 126). Therefore, tile-swapping has been the most popularised matching system not only because it feels more intuitive less cognitively demanding, but also due to its early market reach (*Match3 – meta layers and matching types | GameRefinery*, 2018).

Time constraints and objectives

Each level in match-three games has a victory condition, which needs to be fulfilled either in a limited time, or within limited turns, depending on the game. In time-based games, players must complete their objectives before time runs out. *Time-based* levels focus on fast reflexes and player reactions and therefore allow for unlimited matches within a specific time-frame. For example, *Bejeweled* and *Line Disney Tsum Tsum* feature time-based levels. On the contrary, in *turn-based* levels the objective must be fulfilled within a limited amount of interactions, or turns. Each player-performed action is counted as a turn where new tiles are added only after the player has made a move. The absence of time pressure encourages players to optimise their actions, thus leading itself better towards puzzle-oriented challenges. Most modern games use primarily the later format.

Victory conditions may be static, or flexible. A static, or *goal-completion victory* is achieved when the player fulfills a preassigned task, eg. clears the board, reaches a given score, or achieves a collection or other goal set at the start of the level. However, a flexible, or *high-score victory* is based on a scoring system, where players aim for a high score within defined time or turn-based constraints. Players obtain points for each match and higher scores are awarded for more complex matches, such as those involving a greater number of tiles. Goal completion victories are more common in turn-based levels, while score-based victories are more common for timed levels.

Level layout

Depending on gravity and physics simulation used, games can be either grid-based or physics-based. In *grid-based* games tiles have a defined size and distance from each other and a predetermined trajectory for their cascade, while in *physics-based* games tile-size and tile proximity may vary depending on tile properties and positioning. Examples of grid-based games are *Gardenscapes* and *Candy Crush Saga*, while examples of physics based games *Line Disney Tsum Tsum* and *Angry Birds Dream Blast (Rovio Entertainment, 2018).*

Additionally, the size of the level board impacts the feeling of gameplay significantly. In fact, the available surface area of a level is one of the main aspects that affect the level design possibilities on a level. Typically tile-swapping games use larger level boards because the constraint of maximum match length allows a bigger variation of matchable tiles on the board. On the other hand, blasting and line-matching games use more constrained level areas, to prevent needlessly long matches. Occasionally levels may have multiple boards that are unlocked in a sequence once intermittent goals are completed. This allows the fracture of a level in shorter sections with individual challenges, but may increase level complexity.

Besides the regular matchable blocks, levels may contain tiles with special properties. Special tiles behave differently than the matchable blocks, for example by being permanently or temporarily indestructible, or by destroying surrounding tiles when involved in a match. Modern matching games use special blocks in abundance, as they allow for creating more complex interactions. Some of the most common properties of special tiles are: having multiple health states, cascading, being collectible, damaging other tiles, allowing the collection of other tiles, covering other tiles, lying below other tiles, spawning other tiles and moving across the game board on set or random patterns (*Match Game Mechanics: An exhaustive survey*, n.d.). Furthermore, apart from the special tiles that are placed in the level by default, there are special tiles that act as power-ups. These can have different functions, for example clear lines, clear-neighbouring tiles, clear the whole playing field, collect a particular kind of tiles, etc, and can be generally categorised as *bombs*. Power-ups can be added in the level by the players, for example as pre-level or in-level boosters, or they can be spawned in the level automatically, as a result of player actions, or as a default function of the gameplay. *Candy Crush Friends Saga* for example allows players to select some bombs before starting a level, provides the players the option to use some other special bombs during the gameplay, and has a hero character in each level, who automatically spawns a bomb on the gameboard once a required amount of tiles has been collected.

Finally, the basic matching functions of the game may have additional special effects. For example, in many games connecting a number of tiles higher than the minimum, allows the creation of combos, which, depending on the game have various effects, from exponentially increasing the score of the player, to generating special tiles or abilities in-game. For instance, *Toy Blast* and *Toon Blast* replace one of the matched tiles of a match with more than three tiles with a special bomb of increasing value depending on the size of the match.

Metagame

The *metagame* encompasses all aspects of player experience that are not immediately attached to the core gameplay, i.e. playing a level. As a result of hybridisation, which is the act of infusing the core gameplay of a genre with gameplay concepts adopted from different genres, modern match-three games are often a combination of different layers of metagame arranged over the typical match-three gameplay experience (*An Interview With King — Using Mobile Data to Inspire Creativity Within a World Class Gaming Company | App Annie Blog*, n.d.-b; Smadja, 2018).

The metagame encompasses all systems that affect player progression, such as skill trees, in-game economy, character collection, or social interaction systems (Smadja, 2018). Gamerefinery discusses various common examples of metagame elements encountered in free-to-play mobile games, for example narrative elements, such as character collection and base-building may be connected with an internal economy based on trading, or gacha systems (*Match3 – meta layers and matching types | GameRefinery*, 2018). Likewise, social gameplay aspects can be expressed through collaborative or competitive gameplay events, while time-limited activities and scheduled global events are also popular additions to games (*Match3 – meta layers and matching types | GameRefinery*, 2018). For match-three games in particular, metagame elements enhance the experience produced via puzzle-solving by associating the action of completing levels with larger external goals and additional motivations for the players to progress in the game.

In match-three games, the metagame may be directly affecting the core gameplay, providing a complimentary layer of interactions, or it may perform as a separate but synergising layer. Systems that directly affect gameplay may be reward systems for player's success. For example a win-streak mechanic may reward continuous player victories, by providing them with tools to decrease the difficulty of upcoming levels, like in-level power ups. Conversely, a ranking system may be only impacting the social component of a game, while a character-collection system may simultaneously affect and be affected by player progression in the game, as each player victory provides the necessary resources to obtain stronger characters or abilities, thus making the next levels easier in turn.

Concerning player progression, there are three common topics. First is the way games display player progression in their game environment, commonly a dichotomy between the direct representation of level progression in the game world or not. Games like *Candy Crush Saga* present their level content in a sequential, linear fashion; the levels are attached to a world map, a system commonly named *saga progression*. The world map "moves along" with every completed level, and different regions are unlocked over time, with distinct visuals and possibly new unique special tiles associated with them. This allows players to visualise their prowess directly in their environment, by noticing the difference in their surrounding game world and being able to revisit locations encountered previously. Conversely, games like *Gardenscapes*, *Fishdom* or *Matchington Mansion* separate the levels from the game world and instead they provide a more compact, often narrative-driven game world environment for players to inhabit. In that case, levels function as a means to advance the metagame's narrative. Usually levels can be accessed sequentially and only one at a time, and cannot be revisited by the players. Instead, games that follow this format typically associate player progression to different gameplay aspects, like resource accumulation, score or social prestige. For example, in base-building games like *Fishdom*, players need to complete levels in order to collect resources to make the desired improvements to their base, in this case they would collect currency to improve their aquarium. Finally, a hybrid approach can be noticed in games like *Toon Blast*, where there is no strong association of the levels with the world map, however neither is there a strong narrative association with the metagame. In this case the indication of progression is a result of a competitive metagame that emphasises the collection of resources and player's social status through individual and team-wide ranking.

Additionally, level replayability may also affect the feel of progression in games involving a scoring system, such as *Toon Blast*. In games where a completed level can be revisited and replayed infinite times, the pressure for immediate success is alleviated as players can replay levels to improve their score. Contrary, when levels cannot be replayed once completed players are urged to achieve their optimal performance every time they play. Finally, as discussed, the existence of a ranking system can be an indirect way to measure player progression. Ranking systems are usually designed around the more competitive players of a game and may be connected with other social systems such as guilds.

However, out of the multitude of metagame systems available, the ones most relevant to this thesis are systems that directly affect the core gameplay. The most prominent metagame elements out of these, concern power-ups. Power-up systems help players proceed through a level faster, by removing challenges either through simplifying the level itself, for example by providing the players with special tiles, typically bombs, to help achieve their goals, or by providing more turns to complete it. Depending on the time they are available for purchase, they can be encountered before a level starts, while playing the level, or when a player loses a level. The most common ones are pre-level power-ups, and in-level power ups, which are opt-in elements that can help a player advance in a level. On the other hand, win streak features are triggered automatically based on players success to complete consequent levels. Additionally, some games offer features like boost mode, that temporarily decrease the overall difficulty of the game, or provide players with an ample amount of power-ups, to help them proceed through levels faster.

Although metagame elements are not going to be prominently featured in this study, they represent a design philosophy behind the games, can be indicative of a game's level difficulty progression and can provide external motivations for players to complete levels. Furthermore, they are indicative of the age and evolution of each game and thus allow for a better understanding surrounding its design decisions. Thus it is wise to keep the metagame layer in mind when studying a game's level design.

Level design and player experience

The following chapter will explore how level design nurtures a positive player experience, through flow, pacing and difficulty balance. Then we will discuss how those properties are expressed in the structure of a level, and how challenge can be interpreted by a level's structural complexity.

Level design is a composite role, encompassing elements from disciplines such as art, design and engineering (GDC, 2019; Totten, 2019, p. 43). Level design translates the rules and systems produced by game design into actionable elements, essentially creating the gameplay experience (GDC, 2019). Looking into design through the lens of the MDA framework, designers create mechanics, the rules that govern the game, that dynamically interact with each other, creating systems, in order to achieve the component of aesthetics, in essence the fun that players experience (Hunicke et al., n.d.). Level design can be perceived as the expression of dynamics into aesthetics, or the transformation of abstract systems into cohesive fun (GDC, 2019). According to Fullerton, games are an "elusive combination of challenge, competition, and interaction that players just call 'fun'" (Fullerton, 2014, p. xxv).

Fun and flow

However, fun is an ambiguous and highly subjective term. Koster claims that fun is a form of enjoyment, resulting from physical stimuli, aesthetic pleasure or direct chemical manipulation (Koster, 2005, p. 40). Learning, mastering patterns, understanding the underlying systems of a game and progressing through it are essential contributors for fun, as is the sense of discovery upon encountering novel components (Koster, 2005, p. 40). Conversely, repetition and lack of appropriate challenge result in boredom and disassociation from a game (Juul, 2012a; Koster, 2005, p. 50).

A property commonly associated with fun is that of “flow”, as developed by Csikszentmihalyi (Csikszentmihalyi, n.d.). A state of flow is a state of absolute concentration, that allows a feeling of control, a perfect balance between skill and challenge, resulting in profound happiness (Csikszentmihalyi, n.d.). Chen encourages the use of flow theory elements while designing player experiences, while Schell defines one of the game designer’s objectives as that of creating experiences that are interesting enough to captivate players and lead them into a state of flow (2007; 2008). Sweetser and Wyeth adapted flow theory elements into the GameFlow model, recognising eight core elements of player enjoyment in a game: concentration, challenge, skill, control, clarity of goals, feedback, immersion, and social engagement (2005). Accomplishing a flow state is a result of balancing the current player abilities and knowledge, with the challenge provided by the game. Indeed, the tasks imposed on the players must be appropriate for their current experience level -neither too hard or too easy - and the game should retain a balance between successful and unsuccessful outcomes. Furthermore, attention must be put into the pacing of the game, as well as elements that may distract the players and break their immersion (Hodent, 2017, p. 169). Common ‘flow breakers’ can be unclear obstacles or unfair defeats for the player, as well as distracting user experience elements such as forced cutscenes or tedious tutorials (Hodent, 2017, p. 169).

Challenge, pacing and difficulty

Naturally, for most games level design is on the frontier of creating a positive flow experience, as levels are the primary medium through which players experience the systems of the game (GDC, 2019). Therefore, the elements that need to be taken into account in all stages of level design are the intended challenge, as defined by the difficulty curve of the game, the rhythm and pacing of the game, as well as the expected player learning curve (GDC, 2019; Hodent, 2017, p. 169). For modern match-three games these elements are entwined and constantly evolving, as games extend their content and have to manage with new and returning players alike, or players of various experience levels.

Indeed, every game employs a different difficulty curve and consequently every level represents a different point in said difficulty curve (GDC, 2019). This overarching difficulty curve defines the rhythm and pacing of the overall player experience as they traverse through the game over a long period of time. Furthermore, each individual level has its own unique difficulty curve, with an internal pacing and challenge requirement. Where the lifelong gameplay flow relies on players gradually mastering the internal systems of the game, the moment-to-moment flow of a level requires a clear, cohesive design that retains players' attention for a short period.

When examining a game macroscopically, the overarching difficulty curve is a more useful tool. However, although defining the relationship between required challenge and current player ability is crucial to attaining flow, this relationship is not linear throughout the game (Hodent, 2017, pp. 163 – 165). Instead, the challenge scope of the game should change overtime from introducing a new player to the game's systems, to teaching them more complex mechanics and finally expanding their competences (Hodent, 2017, pp. 163 – 165). Indeed, when players start a new game their primary challenge is mastering its basic functions, therefore the inherent difficulty of the content must be lower, to assist onboarding and player retention (Hodent, 2017, pp. 163 – 165). However, upon reaching a basic understanding of the game, the level of challenge should start increasing linearly and in parallel with a player's mastery of the game, in order to foster a further sense of growth through overcoming adversity (Hodent, 2017, pp. 163 – 165). Furthermore, the difficulty curve should be adjusted to a proper degree of challenge when introducing new concepts, and allow for variation of the intensity and player focus required.

Ideally a game should alternate between demanding, challenging sequences and peaceful, contemplative ones. This can be expressed by smaller peaks and dips in the difficulty curve, a method commonly referred to as the “challenge saw tooth” (Hodent, 2017, pp. 163 – 165; Totten, 2019, p. 82). Besides, these variations in difficulty provide a basic structure for the game’s pacing. Pacing refers to the tempo of a game; it involves appropriately balancing all elements that may influence the player experience by creating tension or relief, for example time constraints, interruptions, harsh failures and long continuous strains of concentration, or easy victories, relaxed sections and rewarding moments (Hodent, 2017, pp. 163 – 165). Notably, the difficulty curve of a match-three game should provide players “a rollercoaster experience” by the fluctuation of difficulty, the diversity of gameplay challenges and the cadence of introduction of new content (GDC, 2019).

Clearly, achieving a well-paced game is essential for live operations games, where maintaining the attention of players over long periods of time is crucial. Obviously, the large-scale pacing of those games is not solely dependent on their level content, it also involves the design of metagame elements, which will not be further discussed in the context of this thesis. While remaining engaged long term requires the consideration of the design of the whole game’s difficulty curve, maintaining the moment-to-moment flow of a level, requires a more narrow focus. The inherent difficulty of a level, feeling of progression while playing it as well as the overall clarity and complexity of the design affect the overall player experience in different ways.

Progression is a form of pacing and concerns the overall player experience while traversing through a level and accomplishing the intended objectives. A well-designed level progression not only motivates players towards the intended goal, but provides the necessary tools to indicate the optimal route there, using signposting, intermediate goals and assisting hints whenever needed (GDC, 2019). However, a design that is too restrictive, or where the intentions of the designer become blatantly obvious may feel stilted and unsatisfactory (GDC, 2019). Furthermore, the progression of a level should feel appropriate for it's difficulty and the complexity of the design.

While challenge is an intrinsic feeling of achieving something beyond a player's comfort level, and thus may vary for individual players, a quantifiable metric of the intended challenge is required in order to design a successful level. This metric is the difficulty of the level, and a common property indicating a level's difficulty is that of average failure rates. Tracking how many attempts on average were required before a level was completed, provides a reliable picture of the level's challenge. Naturally, players fail less often on easier levels, and more often on harder levels. While designing a level, the process of balancing ensures it is attuned to the intended difficulty. Balancing includes adjusting the amount of objectives, moves, rewards, as well as the structural elements of the level, such as obstacles, until the intended average failure rate is reached (GDC, 2019).

Determining the correct level of difficulty during development is hard, as it relies heavily on a small pool of designers and testers, with varying skill capacity and a long-term exposure to the game (Costikyan, 2005; GDC, 2019; Hodent, 2017). Therefore, multiple methods of testing and verification are required to achieve the correct level balance, including self-testing, internal testing and player-wide testing using analytics data (GDC, 2019; Hodent, 2017). Nevertheless, levels are frequently poorly balanced upon publishing. Fortunately, though, it is nowadays possible to reconfigure the live content through live-ops content updates.

Achieving the correct content difficulty can be complex. The capacity and degree of expertise of a player greatly affects their problem-solving capacity and flow zones (J. Chen, 2007; Hodent, 2017, pp. 163 – 165). Generally, more skilled players enjoy content of higher difficulty than novices, which often leads to the implementation of performance-based dynamic difficulty systems (Costikyan, 2005; Hodent, 2017, pp. 163 – 165). Dynamic difficulty systems may increase challenge for very skilled players, preventing them from being bored, but also may reduce the challenge and allow newcomers, players returning from a long hiatus, or even players who just need a less stressful experience, to feel welcomed and relaxed. Creating an environment of the appropriate difficulty, pacing and flow can massively enhance player experience. Furthermore, continuous learning and growth opportunities are crucial to maintain player engagement and challenge, as well as appropriate rewards for their progress (Sweetser & Wyeth, 2005).

Complexity

A successful game translates sensations such as flow, fun and challenge using the available systems of the game. Naturally, level design is the process of this interpretation. By definition, level design is a way of composing gameplay elements into a cohesive experience (Totten, 2019). In that sense, level design combines simple elements to generate a cohesive entity of higher complexity. Norman separates the terms complexity and complicated, claiming that being *complicated* is a state of mind, while being *complex* is a state external to the person (2010, p. 2). Therefore, complexity emerges out of the combination of "intricate and interrelated parts" (Norman, 2010, p. 2). In the context of this thesis, the complexity of a level is the result of the combination of multiple gameplay elements in one whole. As Totten claims, levels can be perceived as "prepared environments of interactive objects for players to utilize" (2019, p. 165). The term of emergence can also be associated with this, in the context of emergent gameplay being the product of interactions of simpler mechanics with each other.

According to Norman, the aim of good design is to regulate the complexity to a degree that is manageable without being confusing, while Totten emphasises the importance of clear communication through each element placed in a level, and the virtues of a functional level environment (2010, p. 2; 2019). As discussed, being in a state of flow is about being in control and able to understand and respond to the challenges of the game. Indeed, the time it takes to learn something can be correlated to its complexity (Norman, 2010, p. 2). While some complexity is desirable in all circumstances, in most cases people gravitate towards a medium degree of complexity, as oversimplified things feel dull, and overcomplicated things feel alienating and confusing (Norman, 2010, p. 14). Furthermore, the ideal level of complexity evolves along with the expertise of the users; the more competent they become, the more complexity they crave (Norman, 2010, p. 14).

It appears that complexity and challenge function rather similarly; the more experienced a player is, the more challenging and complex content they will crave. However, the complexity of a system does not necessarily indicate its difficulty, rather the time required to understand its function and potential solution. Indeed, the difficulty of a level can be adjusted independently and affected by parameters that do not increase the system's complexity, for example how many blocks of the same kind must be collected within a certain time. Furthermore, increased complexity can sometimes decrease a level's difficulty, for instance, by adding another power-up in the level the overall complexity of the system is increased, but completing the goals of the level might be easier.

Evidently, a match-three level's complexity is expressed through its structure. The construction of a match-three level is typically the result of the composition of different modular elements into a functional entity. Provided that each gameplay element has a unique and individual function, the amount of different elements used in a level is a good indicator of its overall complexity, for example, having multiple different collectible blocks in a level makes completing it more complex. In fact, the degree of repetition of the same element can in some cases indicate variations in complexity. Indeed, having more copies of one collectible block in a level requires more time to analyse their locations and their connections with the rest of the level's composites. In addition to that, the types of special functions each of these elements have increase the overall degree of complexity accordingly. For instance, portal tiles that can reposition other elements in the level have a larger impact on a level's complexity than a breakable block that just disappears once it has been damaged. Furthermore, the size of the level's board, the matching system, and other design elements such as automated power-ups, can increase the complexity of the system. Indeed, larger boards allow for the presence of more elements at once, while smaller boards may imply that there is stronger connection between the present elements. Likewise, automated hero abilities, like those in *Best Fiends* or *Candy Crush Friends Saga*, may require players to take into account special conditions for each level.

Nevertheless, by the nature of their design, match-three games expose all the elements that can impact their gameplay, and thus making it feasible to study and evaluate them. Understanding the relationship of a level's structural elements with the player experience, can enhance the comprehension of other design aspects of those games, such as the pacing, structuring of flow, and the tools used to balance a level.

Value of study

As discussed already, maintaining a consistently fun and flowing experience is essential for free-to-play games. The primary feature of match-three games is their levels, therefore studying the elements that assist the creation of an optimal flow in levels is crucial. Provided that there is no available public data to study the levels' performance in terms of difficulty and player feedback, the most effective way to study them is through the direct examination of their level design. For that reason, a level design's complexity is a good indicator of the pacing and intended difficulty of a game, although difficulty and complexity are not directly correlated. Therefore, studying the complexity of match-three games level design is a valuable area of research and can help broaden the understanding of free-to-play game design, and match-three games’ level design in particular.

Research

The following segment of this thesis focuses on the research conducted in order to assess the level design complexity of match-three games. First the scope of the research, research question and methodology are defined and then the results yielded by the research are analysed.

Research Scope

The aim of this thesis is to evaluate the structural complexity of the level design of different top-grossing free-to-play match-three games. For that purpose a selection of levels from different progress points of each game's funnel will be examined. Specifically, the points of interest concern three sections of each game: its onboarding, first major milestone and late game major milestone. Ten levels were chosen to represent each of those sections, levels 1-10, levels 100-110 and levels 1000-1010. The chosen level brackets represent a player's experience after playing for a day, a week and 100 days, under the assumption that a player may complete on average 10 levels per day of playing.

The games studied were chosen from the top 100 sustainable grossing games in the puzzle or casual genre in the USA for the month of September 2019, according to Game Refinery (https://www.gamerefinery.com), with a preference towards games that display diverse matching styles. Games studied, in order of ranking are: *Candy Crush Saga*, *Toon Blast* , *Homescapes*, *Gardenscapes*, *Candy Crush Soda Saga*, *Toy Blast*, *Matchington Mansion*, *Fishdom*, *Best Fiends* and *Candy Crush Friends Saga*. These games were selected by ranking and by criteria concerning their level design. Categorically, all studied games must contain at least 1010 levels with unique level design; specifically containing a distinct board layout design and goals.

Therefore match-three games that use procedurally generated content, such as *Empires and Puzzles (Small Giant Games, 2017)*, were excluded from the research.

The typical time required to reach the 1000th level of a match-three game ranges from several months to a year. Given the time limitations of a thesis study, personally achieving such player progress for multiple games was impossible, thus the examination of third-party material was necessary to evaluate the levels. Provided that the structural complexity of a level can be adequately evaluated through the examination of image or video material, the review of preexisting, player-submitted video material was deemed sufficient. Furthermore, only information directly available to the players was taken into account. Therefore there was no use of any analytics data concerning the games studied, only player-submitted video sources.

Research question and hypothesis

The question this study intends to answer is how does the complexity of level design of casual, mobile, match-three games evolve over the course of their levels' progression. The hypothesised result is that the complexity of the level design of match-three games increases the longer a player plays. Furthermore, it is hypothesised that the complexity increase is relative to the complexity of the matching system and the amount of gameplay elements introduced in the very first few levels.

The proposed increase of complexity over time would mean that the earlier levels observed in will contain less gameplay elements than the later levels observed. Furthermore, it is suggested that the complexity of the levels is increasing based on the complexity of the matching style. As discussed earlier, tile-swapping is the least complex of the studied matching styles, blasting is of medium complexity, and line-matching is of higher complexity, due to the required interactions of players with the game board. Therefore it is hypothesised that the level design of line-matching games will present more complex elements than of blasting games and even more than tile-swapping games. Finally, it is suggested that the complexity of the onboarding section will affect the complexity of the following sections, specifically the more complex the onboarding section will be, the higher the increase of complexity will be for the other studied segments. In practice this would mean that games that introduce more gameplay elements in the first ten levels studied, will introduce more elements in the next segments studied as well.

Research methodology

In order to conduct this study, I devised a framework to measure a level's complexity, which was applied to existing levels. Specifically, the study was performed by examining videos of levels and counting all the present components of their structure. After accumulating data for all ten games and all thirty levels within the three segments studied, i.e. levels 1-10, 101-110 and 1001-1010, I compared and interpreted the accumulated data for each game with the rest of the sample, per segment and as a whole. Additionally, I collected data concerning each game's overall design, including significant variations of gameplay, metagame aspects and others, in order to obtain a more spherical understanding of the games. Finally, I combined the above information to reach a conclusion concerning the factors affecting a game's complexity.

Through the study, I attempted to collect primarily quantitative data, in order to provide a consistent and reliable system of evaluation. Using videos from similar sources and evaluating all samples with the same criteria increases the consistency of the accumulated information. However, there are clear limitations concerning the accuracy of the study. First of all, the level's content may be frequently altered over a game's lifetime, so it is possible some information is outdated. Secondly, there is variation in the gameplay of each game that cannot always be accounted for. In order to maintain the highest possible objectivity of results the criteria of the framework were general enough to be as inclusive as possible. Nevertheless, upon such occasions a subjective interpretation of the data was included along the aggregated material. The following sections will examine in depth the sourcing methods for the video material, and then the study framework itself.

Level data accumulation criteria

The material studied was sourced from publicly available videos uploaded on YouTube (https://www.youtube.com/), a popular platform where players share videos displaying their playthroughs of different games. The videos selected for the study comply with a set of criteria concerning the age of the levels examined, the user variation and the usage of power-ups or extra moves. Specifically, the levels that were examined were selected from videos published within a year from the start of the research, in October 2019, with preference to levels that Mancwere submitted closest to the date of study, if possible. Videos displaying consequent gameplay of multiple levels by the same player were preferred over videos of individual levels or submitted by different users, whenever possible, because it was easier to confirm there was no use of power-ups. For reasons of consistency, videos using extra moves to solve levels, or power-ups activated before the first player move, as well as videos displaying multiple attempts for the same level, were discarded.

As live products, mobile games have the chance to iterate on their content on each update. Indeed, it is a common practice to iterate on existing levels during different update circles, meaning that levels uploaded on Youtube (https://www.youtube.com/) years ago, may no longer be the same (GDC, 2019). Unfortunately, there is no practical way to validate the state of the examined content other than limiting the research parameters to uploads of a certain age. Therefore the criteria of period of upload within a year from the research date was arbitrarily chosen, and the most recent available levels fitting the rest of the criteria were preferred from that range.

Provided there are usually some variations on a level's layout for each playthrough, each level was studied using only one video. Exceptionally, if the video displayed some behaviors that could distort the data, for example the use of in-level power-ups or extra moves, or seemed to be older than the submission date suggested, if for example the aspect ratio or quality of the video looked outdated, a second video was used instead. Otherwise no duplicates of levels were examined.

Obviously, levels look different for each player and each playthrough due to randomization of the cascade and the preplaced matchable blocks on the level board. Therefore elements like the exact amount of matchable tiles per color were not tracked in a minute degree. Likewise elements that could be affected by player skill level were ignored. For example, a level's move count and overall balance may vary in different platforms or countries, or be affected by metagame features such as win-streak, or the influence of player-performance-based dynamic difficulty (GDC, 2019). The exact framework used for data collection and analysis is described in the following chapter.

Level data analysis framework and process

This section describes the process followed to collect, categorise and analyse the data studied. After selecting the games of interest, defining the ranges to be studied and recovering appropriate footage, I determined a list of properties to be tracked in each level. Clearly, the criteria used are quite broad, because the games display enough variation in their overall gameplay beyond their core matching mechanics to not be consistently comparable. However, a lot of my insights are based on my professional experience and learnings, so I believe it is sufficiently thorough. Once the framework's criteria were established, I applied it to all the levels studied. The following section will discuss the framework's criteria and the way they were applied to the examination of levels. As a reminder, brief definitions of the various properties encountered in the following section can be found in Appendix A.

The first step in the process consisted of a preliminary visual evaluation for each level. In this stage I attempted to gain insight on how the level might feel for the players without applying any specific research criteria on it. This was achieved by examining the starting layout of the level, before watching the playthrough video and trying to subjectively evaluate it. In short, I tried to simulate the way players evaluate a level upon encountering it for the first time. Of course, it is important to note that my perspective as a professional level designer is rather more biased than average players, however the criteria used were general enough to accommodate that. Nevertheless, this evaluation provides a useful baseline for comparing my personal perception of the level to the measurable results provided by individually tracking the elements that comprise the level, such as components of its layout structure and gameplay.

For the visual assessment of the level, the two main aspects examined were the available playspace and the flexibility of the victory condition. The initial impression of a level originates from the feeling of *openness* or *closeness* of the available playspace. Typically, a more open playspace provides more possibilities, therefore a higher chance for optimal matches, and a more relaxed experience overall. In contrast, more closed layouts may require more concentrated effort in order to be decluttered, have more complex associations between special tiles used, or result in suboptimal matches more frequently (GDC, 2019). However, it is important to note that in many cases a seemingly closed playspace can be significantly expanded by the use of available gameplay elements, for example bombs. In fact, this practice is quite frequently encountered as a pacing tool in level design. Likewise, very open structures may feel overwhelming due to an excess of options, or feel more constrained because of the use of a larger variation of matchable elements. Clearly, it is impossible to accurately predict the feel of a level solely by examining its starting layout, yet, given that this will be the first impression of the players it is an important quality to highlight.

Concerning the goal completion, levels were divided into puzzly and free-form levels. *Puzzly* levels have a rigid solution and may demand a specific sequence of actions in order to be resolved, while *freeform* levels may be completed in multiple ways and rely more on the random factors of a level. Typically, levels that have a very strict process towards a solution, for example collecting an object that is surrounded by multiple layers of obstacles, feel more challenging and complicated, as they require for the player to decode the required process and actively concentrate towards achieving it. Conversely, levels that have a less strict approach, for example levels requiring the collection of a matchable block of a specific type, can feel more approachable and easier to complete, while also feeling less repetitive if they need to be replayed.

After this initial evaluation, I focused on the overall level structure, as it is presented before players perform their first match. This structure includes the level board as well as the supporting UI elements, for example indicators displaying the objective count, starting move count, and possible rating and level difficulty. Concerning the UI elements, a lot of the information present in the levels is not directly usable in the research, and this was factored in the way they were evaluated.

For example, tracking the objectives of each level was challenging. Each of the studied games has at least one mandatory objective. They typically refer to the collection of a specified amount of blocks of a kind, for instance collecting 20 rubber ducks on *Toy Blast*, however there are exceptions, such as the Slug objective of *Best Fiends*, which requires players to cast a certain amount of damage to an enemy external to the level board. The amount of blocks collected for each objective can vary significantly for different block types, as well as for different level configurations. Therefore, the individual amounts of required blocks per objective are incomparable across different levels and different games. Nevertheless, the count of different objectives present in a level is a useful metric, because it is a sufficient indicator of how many different things a player needs to pay attention to while playing a level.

Likewise, the starting move count for a level can be contextually useful, but the collected information is not accurate. Adjusting a level's move count according to individual players' skill level is a common practise for games featuring dynamic difficulty systems. Therefore a struggling player may be provided with more moves for the same level if they repeatedly fail it, or a skilled player may be assigned significantly less moves than other players (GDC, 2019; Hodent, 2017, p. 160). Since it is impossible to know how many times players played each level before capturing the studied videos, and also their overall competence in the game, it is impossible to know the effect of dynamic difficulty in the studied levels. Thus, although the starting move count was noted, it should be used mindfully when drawing conclusions about the levels studied.

Additionally, some games use difficulty indications to highlight levels of particular challenge for the players. However I decided to exclude the information from the research, because they were only encountered sporadically and unreliably. Difficulty indications are often displayed only in the loading screen of a level, which was occasionally unavailable in the videos studied. Furthermore, the difficulty scale used is subjective for each game, thus the difficulty assessment varies wildly. Nonetheless, although these difficulty elements are not affecting the level board in any way, they do affect players' perception of the level's difficulty, so it was interesting to highlight them wherever possible and try to individually assess potential correlation with the observed level structure and other accumulated metrics. Finally, other UI elements, for example available boosters in a level, were not tracked individually because they vary significantly amongst games.

Completing the documentation of UI elements allows a shift of focus towards the central part of a level, the level board. The l*evel board* is the available playspace with which the player can interact at any given moment. Thus its size is directly influencing the perception of openness or closeness of a level. A level may consist of multiple level boards, each of them being a self-contained section, unlocked sequentially. The amount of boards available in a level can significantly affect the player experience, from the duration (move count) of a level to the objective distribution and overall feeling of gameflow. Therefore, it is important to track how many boards each level consists of.

Correspondingly, the size of the level board directly affects the possibility space for a player's actions. Typically match-three games' level boards are structured in an orthogonal grid, where one square represents the space occupied by one tile or one block. Therefore the maximum dimensions of a level board as well as the total surface area -thus the total available tiles- can be tracked per level. The size and variance of dimensions of game boards seem to be affected by the matching style of each game as well as the orientation of the board, a hypothesis that would be interesting to validate.

The total surface area of a level does not always correspond to the total available playspace. The presence of *static blocks* -indestructible, immovable obstacles- must be addressed, as they can limit the playspace area significantly. Static blocks' visual representation varies within games, from them being represented as voids, transparent tiles that create negative space within the game board, or displayed as solid blocks. Furthermore, some immovable elements may allow interaction with players, in which case they function as indestructible special tiles, with unique visualisation. Both categories of static blocks were separately accounted for and excluded from the available playspace.

The importance of creating a sense of flow and progression in a level has already been established. One of the tools used to create this feeling is the gradual expansion of the available playspace of the level. This process is assisted by the use of various obstacles in the starting layout of the game, to be incrementally removed by the players. The initial state of a level can be significantly affected by the amount of such obstacles, therefore it is important to take them into account. The category of *breakable elements* includes all destructible blocks that can be removed from the level board after an appropriate action has been performed. Breakables are special tiles, and thus they can have a variety of different properties, for example they may have multiple health states, and they may be able to cascade, or have a fixed position on the board. Additionally, some breakables function solely as obstacles while others function as collectible elements or even bombs. Despite their varying properties, they all essentially function as obstacles and thus they were all counted for as one entity. Comparing the amount of existing breakable elements to the total available space at the start of the level creates a better understanding of the available space at the start of the level, however it still does not provide the full picture.

For example, the empty space available at the start of the level, affects the overall feel of it. Frequently, levels start without any blocks present on some areas of the game board. The negative space created as a result helps the readability and visual cohesion of a level (Hodent, 2017; Totten, 2019). I chose to include the empty tiles to the available playspace calculations from the start of the level, as the tiles themselves are not technically blocked. Likewise, certain obstacles, like the chocolate from *Candy Crush Saga*, can expand to further tiles in the future but this potential expansion was not taken into account for, as it is too unpredictable to track consistently (*Chocolate Spawner | Candy Crush Saga Wiki | Fandom*, n.d.). In fact, I applied the same principle for any elements that could potentially expand in further tiles, tracking only their area coverage at the start of the game. Thus all breakable, overlay and underlay elements with the potential to expand in other tiles were only tracked at their starting state.

The majority of modern match-three games use level boards with multiple layers. Typically, the main layer is the layer where the matchable tiles are placed. Players can directly interact with tiles there and affect their position, and the tiles that replace tiles removed by a match appear on the same layer. Most gameplay mechanics with which the players can interact are located on the same layer, yet certain mechanics can cover the tiles placed on the *main layer*. The layer that covers tiles on the main layer is called an ***overlay layer*** and usually contains mechanics with which the player can interact only indirectly. An example of this functionality can be found in the licorice locks of *Candy Crush Saga*, which can only be removed using a bomb or a match that includes the tile that is covered by the locks (*Liquorice Lock | Candy Crush Saga Wiki | Fandom*, n.d.). Conversely, some mechanics utilise a layer beneath the main layer, the *underlay layer*, and thus are covered by tiles. Usually players interact with underlay mechanics indirectly, by performing actions on the main layer to reveal or remove them. Jelly, from *Candy Crush Saga*, for example, can only be removed from a tile if a match or explosion is triggered above it, and soda, from *Candy Crush Soda Saga*, can only be released if a pop bottle is activated on the main layer (*Jelly levels | Candy Crush Saga Wiki | Fandom*, n.d., *Soda levels | Candy Crush Soda Wiki | Fandom*, n.d.). Overlay and underlay elements introduce interesting variations of gameplay because they require more strategic thinking and may encourage players to perceive the level board with a shifted focus. Meanwhile, they increase the degree of complexity of the levels significantly, especially in cases where the levels use a rather rigid structure.

Furthermore, the game feel of a level can be affected by the player's agency and opportunities for meaningful decisions (*Interesting Decisions*, n.d.). The sense of *agency* in match-three games can be mainly expressed through the ability of players to make impactful choices and perform optimal matches. Indeed, the variation of available *matchable tiles* in a level is a great balancing tool and may transform a seemingly very limited playspace to a very enjoyable one, or a seemingly open playspace to a very challenging one (GDC, 2019). As the amount of tiles increases, the spawn variation in the level also increases, lowering the chances for a favourable, long match and possibly increasing the effort required from the player to identify available matches. Also, the time required to remove obstacles can increase with the addition of more tile variants, compared to a level with a higher chance to create longer and more efficient matches faster (GDC, 2019). It is safe to assume that, typically, levels with less variation in matchable tiles feel easier and are less complex. However, there are exceptions to this rule, especially in more puzzly levels where the challenge does not lie in the action of matching itself, rather in the optimal use of special tiles present in the level.

Another parameter to take into account concerning the matchable tiles, is the existence of spawners in the level. *Spawners* are special tiles that allow the generation of certain tiles directly within the game board. Spawners override the spawn probabilities set on the level cascade, thus providing a new method of distribution of gameplay elements in the level. Depending on the implementation, spawners may increase a level's unpredictability or act as a reliable source of a required collectible or obstacle in the level, nevertheless they increase the complexity of the design. Also, they allow more design control over the randomness of a level, thus assisting the improvement of the level flow.

It is also worth noting elements that can directly alter or situationally affect the way *cascade* works for a level. For example conveyor belts in *Candy Crush Saga* force tiles to move to a certain direction, or areas covered with soda in *Candy Crush Soda Saga* may force blocks to move upwards instead of following the normal gravity direction of the level, or portals in *Homescapes* move blocks that land on them to a completely different location of the level (*Conveyor Belt | Candy Crush Saga Wiki | Fandom*, n.d., *Homescapes: Portals*, n.d., *Soda levels | Candy Crush Soda Wiki | Fandom*, n.d.). Such features affect the way players understand the movement of tiles in the board, thus it is interesting to observe how the overall complexity of the level is affected in response. For the purposes of tracking these features, I noted whether a level has elements that alter its cascade, and the surface area of the level affected at the start of the level. For special tiles that can expand from their starting area, like soda, only the amount of tiles affected at the start of the level was taken into consideration.

A significant parameter to take into account when studying the level design of match-three levels is their use of different special tiles. As established, the more distinct gameplay elements that are encountered in a level, the more complex the level is. When constructing this framework I had to define which tiles would be counted as special tiles, and which tiles would be considered part of the basic matching gameplay for each game. Thus, I assumed that interactions that happen in every single level of a game will not be counted as distinct special tiles, with the exception of the first time that they are introduced in the game, which for basic interactions, such as matching, creating bomb power-ups, charging hero power-ups and collecting matchable tiles, the usually happens within the first five to ten levels of the game. To elaborate, actions such as creating power-up bombs, charging the special bombs of *Gardenscapes*, *Fishdom*, *Candy Crush Friends Saga* and *Best Fiends*, and damaging enemies on *Best Fiends*, are not tracked beyond their first introduction.

Thus, tracking the total amount of special tiles used in a level means tracking everything that is special on the level board. Furthermore, if a gameplay element uses more than one type of tiles in association, all tiles are tracked individually. For example, the filling hearts mechanic of *Candy Crush Friends Saga* is a composition of three distinct elements; the empty heart slot, the movable heart block and the underlying track that the hearts use to move around (*Heart levels | Candy Crush Friends Wiki | Fandom*, n.d.). All the above elements are counted separately. The only exception to this rule concerns tracking special tiles that may appear in a level with multiple different health states, such as basic breakable blocks. These are counted as one special tile, regardless of their initial health state, as their primary function remains the same regardless of their initial health state.

Besides tracking the total count of distinct gameplay elements in a level, it is interesting to highlight the variation of special tiles within the studied sections. Generally, after their initial introduction, new special tiles are used in combination with pre existing ones, and the complexity of the combinations increases overtime (GDC, 2019). Therefore special tiles with more common or simple functions, for example basic collectible tiles, tend to appear in levels more frequently than others. Yet, the frequency of appearance of the most common special tiles makes it impractical to track the special tile variation by calculating all different types of tiles encountered in the research.

However, one interesting metric for tracking variation in levels is that of counting the new special tiles encountered in a level. Naturally, it is impossible to know if a special tile has been introduced at an earlier level excluded from the research sample, unless clear onboarding signs are indicated in this level, or if it was encountered in the first ten levels. Therefore the term *unique special tiles* is preferred over the term new special tiles, meaning in this case mechanics that I have not encountered previously in the research sections studied. Looking at a high amount of unique tiles in a late game section, we can presume that there is larger variety in the special tiles used in that part of the game overall, while a lower amount of unique tiles can mean that there is generally less variation of features used in the section. A more cohesive section can be seen as generally less complex, as the main featured elements are known to the players and require less effort to be understood.

The above concludes the analysis of the criteria included in the framework used to study the levels. Attached at the end of the chapter is a table (Table 1) containing the criteria used for accumulating data along with a short description of them. The same framework was used to manually track the aforementioned properties for each level, along with screenshots of the initial layout of levels and links to the video sources. Appendix B contains tables with all the raw data collected by this method. The aforementioned data should provide sufficient information to directly compare the different sections and games to each other, and possibly allow for further relative comparisons.

Needless to say this methodology poses risks. Firstly, the manual process of tracking information is not only painstaking and time consuming, but also rather error-prone. Despite my best efforts mistypes and miscalculations are a possible and unavoidable side-effect of this process. Furthermore, the inconsistency and the variance of use of similar gameplay mechanics required a subjective and possibly liberal interpretation, in order to produce a unified dataset. For instance, it is possible that if another study interprets differently what constitutes a special tile, the results may vary significantly. However, I believe this research still has merit, because it attempts a deeper examination of a field that is rarely discussed and is conducted with integrity and on the basis of professional experience in the field studied.

Table 1
Framework for level complexity evaluation

Layout	Open or closed?	Personal assessment: Open layout: allows multiple movements and level flow is less rigid. Closed layout: more deterministic and constrains player interactions.
	Puzzly or freeform?	Personal assessment: Freeform: Goals may be completed by following multiple different paths. No fixed victory solution Puzzly: A set sequence of actions is required to win the level. Clear process towards solution
Board	Multiple boards	Count of boards per level. Levels with more than one board are more complex.
	Maximum board width	Total maximum width of the board
	Maximum board height	Total maximum length of the board
	Maximum playable tiles	Total surface area of the level including static blocks (Total Width*Total Height of boards)
Static Blocks	Static blocks (not-interactable) in level	Count of indestructible, non-interactable blocks that remain on the level board.
	Special tile static blocks (interractible)	Count of indestructible, interactable blocks that remain on the level board.
	Total non-matchable tiles	Unused space on the level board (Total Static Count)

	Total matchable tiles	Total available space on the board (Total surface area - Total Static count)
Spawners	Number of spawners in level	Are there elements in the level that affect the normal spawning of tiles?
Breakables	Preplaced breakable blocks	Count of destructible blocks on the level board
Fences	Number of fences in level	Count of linear obstacles placed on the gap space between two tiles. May be breakable or static.
Matchables	Unique matchable tiles in level	How much variation do matchable tiles present? Typically high variation (many different matchable tiles) means higher complexity
Overlays	Tiles that contain an overlay	Count of tiles covered by a destructible element
Underlays	Tiles that contain an underlay	Count of tiles placed on top of a destructible element
Special Tiles	Total special tiles in level	Count of different special tiles used in the level
	Unique gameplay mechanics in level	Count of special tiles that have not been encountered before in the studied sections of this game
Cascade	Level Cascade is manipulated	Presence of elements level that affect normal cascade flow
	Tiles affected by cascade	Size of special cascade area at the start of the level
Moves	Moves in Level	Move count at the start of the level
Objectives	Number of objectives in level	Count of types of objectives present on the level
Difficulty	Difficulty indication	Presence of difficulty indication in level

Results

The following section focuses on the analysis on the games based on the previously described framework. An overview of the games examined is included, to help create a clearer understanding of the background factors affecting their level design. Following is an analysis comparing the accumulated data for each game, aimed at understanding how the difficulty and complexity within a game evolves and the potential effects of the matching style or age of the game. Finally, a summary of the collected results follows, along with an interpretation of the most interesting facts.

Game overview

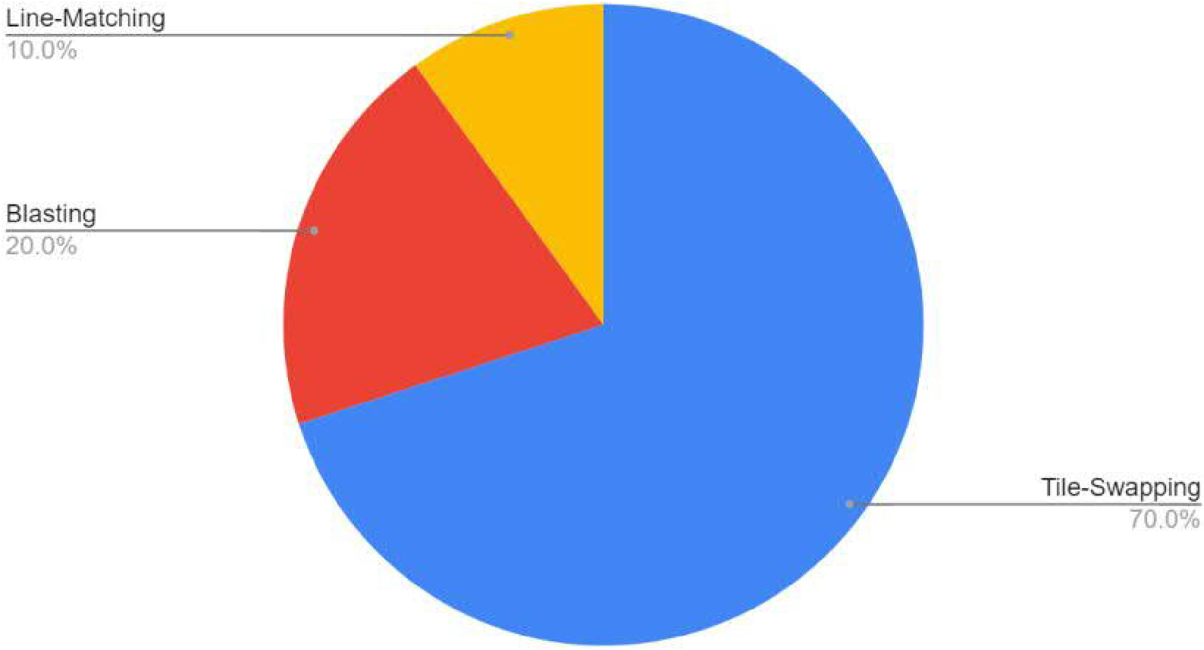
The following chapter will focus on a holistic analysis of the studied games concerning their design decisions around level design and metagame elements. The parameters taken into account concern each game's age, their developers, their matching style, theme and metagame. Although the impact of each factor for this study differs, they provide useful context concerning the function of level design on the games. Table 2 contains a brief version of most topics discussed in this section.

Table 2
Studied games overview, sorted by ranking in Game Refinery

Rank	Game	Company	Matching style	Launched
1	Candy Crush Saga	King	Tile-Swapping	2012
2	Toon Blast	Peak Games	Blasting	2017
3	Homescapes	Playrix	Tile-Swapping	2017
4	Gardenscapes	Playrix	Tile-Swapping	2016
5	Candy Crush Soda Saga	King	Tile-Swapping	2014
6	Toy Blast	Peak Games	Blasting	2015
7	Matchington Mansion	Firecraft Studios	Tile-Swapping	2017
8	Fishdom	Playrix	Tile-Swapping	2015
9	Best Fiends	Seriously	Line-Matching	2014
10	Candy Crush Friends Saga	King	Tile-Swapping	2018

Upon investigation of the studied games, a clear trend emerges concerning the developers of the games. As seen in table 2, eight out of the ten most successful games of the genre are products of three companies: King, Playrix and Peak, specifically the lineup contains three games developed by King, three by Playrix, two by Peak, one by Seriously and one by Firecraft Studios. Furthermore, the games originating from the same company utilise the same matching system, but may pair it with different metagame systems. Unsurprisingly, amongst the parameters that affect this decision are the expertise and technology aggregated while developing one title, the ease of targeting similar audiences with better performing user-acquisition methods and the brand familiarity overall.

Figure 1
Distribution of studied games per matching style



Furthermore, as seen in Figure 1, there is a clear indication of the success of tile-swapping gameplay over other formats. A majority of seven games are tile-swapping, with two of the remaining games being blasting and one line-matching. The success of tile-swapping games can be attributed to both the higher usability and broader familiarity of the swapping format, and to the more complex gameplay of line-matching and blasting games. Indeed, the consistently high ranking of the original *Candy Crush Saga* game over time could indicate that casual players get attached to familiar styles of gameplay in the long term. Conversely, both *Toy Blast* and *Toon Blast* are newer games and thus they most likely resonated with a different audience upon their launch. Indeed, there is a notable increase in the available blasting games between 2018 and 2020 according to Game Refinery (*Match3 – meta layers and matching types | GameRefinery*, 2018). The matching system of the games defines their core experience, and despite the gradual evolution of the genre it remains highly unaltered.

Table 3
Games studied sorted by year of release

Game	Matching style	Launched
Candy Crush Saga	Tile-Swapping	2012
Candy Crush Soda Saga	Tile-Swapping	2014
Best Fiends	Line-Matching	2014
Toy Blast	Blasting	2015
Fishdom	Tile-Swapping	2015
Gardenscapes	Tile-Swapping	2016
Toon Blast	Blasting	2017
Homescapes	Tile-Swapping	2017
Matchington Mansion	Tile-Swapping	2017
Candy Crush Friends Saga	Tile-Swapping	2018

Indeed, upon consideration of the age of the games (Table 3) it is possible to perceive the design innovation elements of them. The mobile version of *Candy Crush Saga* is now eight years old. At the time of its development the design focus was on creating a satisfying gameplay experience, utilising clear linear progression accompanied by simple social features, a metagame design approach that remains persistent (*Candy Crush Saga Postmortem: Luck in the Right Places*, n.d.). Following its success, *Candy Crush Soda Saga* introduced more innovative gameplay elements, increasing the design space of levels. *Best Fiends* launched earlier in the same year, displaying a different matching style, along a character-driven gacha system. Similarly, Toy Blast, released in 2015, utilised a different matching system, with less innovation on its metagame's format. The release of *Fishdom* and *Gardenscapes* in 2015 and 2016 signifies a pivot towards a metagame-oriented innovation. Both games utilise the familiar tile-swapping format, with the addition of an auto-triggered power-up, and both incorporate level progression into a base-building metagame, which in the case of Gardenscapes includes a strong narrative. *Homescapes* and *Matchington Mansion* adopt the same formula. *Toon Blast*, however, which was released the same year, eliminates most of the typical progression techniques, in favour of introducing progression-based limited time events of both cooperative and competitive nature. This change can imply a stronger association with a competitive contingent of casual players, less engaged in narrative or environmental storytelling. Finally, *Candy Crush Friends Saga*, the newest of the studied games combines the typical tile-swapping gameplay with a character-driven gacha system. Concluding, innovation in gameplay seems to pivot overtime from significant iterations on the core level gameplay towards larger investments in metagame (*Match3 – meta layers and matching types* | *GameRefinery*, 2018).

Currently the metagame is the most flexible and expandable aspect of match-three games. As established, the term metagame may include all systems that do not directly affect the core gameplay experience of the game. Usually it involves monetisation (power-ups, currencies), progression (linear saga, base-building), socializing (guilds, leaderboards) or retention (character collection, win streak) elements. Clearly, the metagame layer of a game evolves over time, because the nature of live-ops games permits the fast implementation and iteration of new systems. Therefore, games presently examined may be significantly altered shortly. Evidently, the longer a game has been in the market, the more likely it is to have developed a suitable metagame layer, thus improving its overall performance. In contrast, games currently in development are required to implement a more cohesive metagame structure upon release, in order to maintain a competitive edge. This challenge frequently hinders the potential success of newer games, by either increasing development costs or affecting user retention. Furthermore the metagame of a game rarely remains static. Instead games across the same or different genres influence each other, thus encouraging the imitation of similar features across multiple titles. Unsurprisingly, most games utilise as many single-player features as possible, though multiplayer based features are also encountered situationally.

Another attractor of casual games is that of a pleasant, relaxing theme. There are two distinct directions concerning the narrative of the games, saga adventure and the base building. Typically, saga adventures utilise linear narrative which progresses along a whimsical world map that incorporates level access points. Their main attractor is the exploration of the world along the completion of levels, and commonly levels themselves incorporate elements of the world building in their art and special gameplay blocks. Limited time events are frequently themed as special adventures and may be attached to separate world maps. The world is the protagonist of those games and the story is narrated primarily through environmental storytelling, but usually there are also characters attached to the world. Six out of the ten games studied follow variations of this format.

On the other hand, base-building games focus on improving and expanding a limited space provided to the players at the beginning of the game. Typically levels are not attached to the location itself, rather they are utilised as a means to earn the required resources to improve their property. The majority of the narration is based on dialogue and usually is not strictly linear, although the levels are accessed in a sequential fashion. For example, players are called to fulfill multiple quests assigned by game characters, in order to achieve required improvements. The order of completion is up to the players, and so is the amount of levels played before completing a quest, however, they can only access each level once and in a set order. Because of the strong narrative component of the games, as well as the familiarity of the concept of building, base-building games tend to have a more specific theme and narrative. Out of the four games following this style of narration, two focus on home improvement, one on gardening and one on designing an aquarium.

Looking at the age of the released games, the popularity of the saga model has decreased over time, but has not been completely eclipsed. Furthermore, games of the same company are more likely to use the same system. It is also interesting to note the case of *Toon Blast*, which does use a traditional world map, utilising interesting background images to assist storytelling instead. There seems to be no clear correlation between the theme and the matching style of the games, which validates that metagame aspects can be used interchangeably with different matching systems.

The orientation of the games in mobile devices can affect the player experience in terms of usability, as well as in terms of game design (Hodent, 2017). A level with landscape orientation can potentially allow for a larger gameboard, which in effect contributes to the degree of complexity and the ease of operation for the players. Notably, five out of seven of the tile-swapping games use primarily landscape orientation, while all blasting and line-matching games use primarily portrait orientation. This can be justified by the inherent properties of each matching style, specifically the requirements for creating a valid match. While blasting and line-matching games can cover broad sections of the gameboard per match, the tile-swapping games are limited to a maximum of five valid tiles per match, thus requiring a larger playspace to be reasonably expressed. This should be further analysed upon examining the data concerning each game's board size. Naturally, despite the observation that the studied games follow this pattern, it is not a strict requirement for all games to follow this convention. Furthermore, many primary landscape games support a portrait mode, and vice versa. Chronologically, the portrait mode started being preferred more in newer games, which can be justified by the popularisation of larger screens on mobile devices.

Additionally, the choice of orientation affects the display of other user-interface elements on the level-board. For example, levels using a landscape orientation have a more prominent placement of in-level player-assisting elements such as power-ups, on the sides of the level board. Conversely, in portrait mode such information is usually positioned on the above or below the level board. Furthermore, portrait mode is popular for games using in-game hero characters, like *Best Fiends* and *Candy Crush Friends Saga* because it allows a more comfortable division of the level screen in distinct sections for in-level elements and external elements affected by them, such as for example the opponents being combated in Best Fiends.

Finally, it is interesting to look at design elements that affect the level design more directly. All studied games display a pop-up window before transitioning from the main game screen to the level screen. This pop-up functions as a briefing including the goals of the level, the option to place power-ups on the initial layout and potential indicators concerning the difficulty of the level or the progress of other metagame events, for example that of a win-streak and potentially the selection of characters used in the level, as in the case of *Candy Crush Friends Saga*. Out of the studied games, only *Best Fiends* does not feature pre-game boosters, but the initial pop-up functions similarly otherwise. Finally, some of the games will display the score requirements needed to achieve a certain score bracket, most commonly visualised as three golden stars.

Upon entering the level, we can distinguish between the level board and the surrounding UI elements. Most of the following chapters will be focused on analysing the level board, therefore in this section emphasis will be given on the UI elements. A summary of the UI elements discussed can be found on Table 4. All levels use indicators to display the goals required to complete the levels, and the available move count. Furthermore, nine out of ten levels use a performance ranking system, for which there is an indicator on the level. With the exception of *Best Fiends* that does not use pre-level or in-level power-ups, all games allow players to use a different set of power-ups while playing the level. Usually these are placed either besides or below the level and opposite the level requirements section.

Some of the games studied combine the player's progress with an external power-up that charges over-time and is free to use in the level. In the case of *Gardenscapes* and *Fishdom* this powerup is standard for all levels and is visualised as an object embedded in the UI structure. Conversely, *Best Fiends* and *Candy Crush Friends Saga* use the same principle with interchangeable, collectible hero characters instead. In this case the hero characters are displayed more prominently on the level board, as obtaining new heroes and upgrading existing ones is an important part of the metagame of those games. In the case of *Best Fiends* the screen space is further divided to include a combat section, that is indirectly affected by the player's actions on the level board. Interestingly, older games by King evolve from a simpler gameplay to introducing more hero-based elements, while Playrix's games remove the charging element for their later games. These practices can be justified by the need to satisfy preferences of different audiences and provide enough variation in the core gameplay layer beyond that of the metagame.

Finally, upon exhausting a level's moves, all games display a different pop-up, prompting players to purchase additional moves. Conversely, upon successfully completing a level all games display a pop-up indicating victory and, if applicable, the degree of success achieved, i.e. the stars collected while playing the level. Some of the games transform these stars into rewards, while others display the ranking of the player compared to others who completed said level. Finally, games that utilise a gacha system, i.e. *Best Fiends* and *Candy Crush Friends Saga*, provide players with relevant rewards before transitioning to the main scene.

Table 4
Common level features in studied games

	Prelevel indications		In-level indications				Power-ups			Rewards
Game	Difficulty indications	Win streak	Rating system	Move counter	Goal counter	External elements	Pre-level boosters	In-level boosters	Hero power-ups	Victory rewards
Candy Crush Saga	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Toon Blast	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Homescapes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Gardenscapes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Candy Crush Soda Saga	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Toy Blast	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Matchington Mansion	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Fishdom	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Best Fiends	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes
Candy Crush Friends Saga	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

To conclude, the majority of the games use the same matching style and display similar metagame elements. The age of the games, as well as preexisting games by the same developers seem to be amongst the parameters that affect decisions concerning the metagame and matching style implementation of each game. However, a slow iteration process can be perceived over time, especially within games originating from the same source, as the genre evolves.

Game-wide data analysis

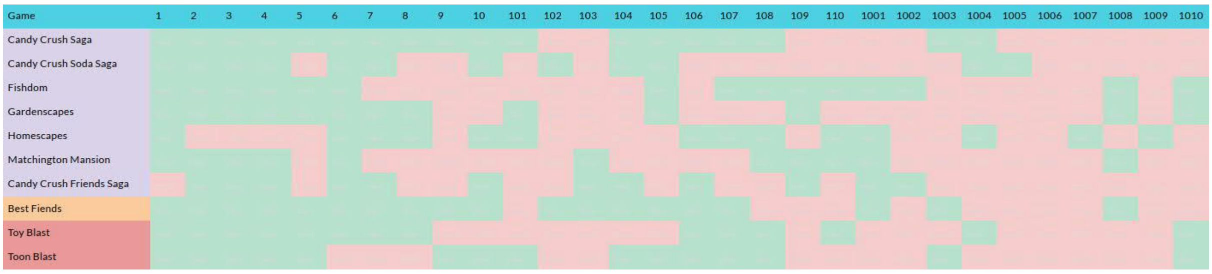
The following section examines the properties identified in the research framework, as they apply to the whole range of studied levels, and to the whole range of studied games. The aim of this section is to identify trends related with matching style, age, or other properties that can be encountered in all examined games. Before proceeding with the assessment of observable data, it is worth discussing the initial empirical evaluation concerning the overall feel of the levels in terms of openness of gamespace and challenge of the design. Following is the data analysis, divided in three broad sections; the layout, gameplay and balancing analysis. Initially the layout analysis focuses on the composition and structure of the gameboard, particularly the elements that affect the size of the board or the actual available playspace for it. Secondly, the gameplay section combines the layout elements with information related to interactive gameplay elements and the way they inform a level's complexity. Lastly, the balancing section contains any insight related to objectives, move counts and other properties that do not directly affect the playspace, but enhance the player experience.

The most useful tool for analysis has proven to be the heatmap. It allows for a quick and clean visualisation of the accumulated data and enhances the relationship between correlated values. While studying the data, heatmaps were utilised in most cases, followed by further examination when deemed necessary. Simplified versions of the most relevant heatmaps studied will be accompanying the following sections, to assist comprehension.

Personal Assessment

The first pieces of information we receive about a level concern the size and feelings of openness and closeness of it. Typically, a level with a large game board may provide opportunities for optimal matches, great combos and a freeform, explosive gameplay. In contrast, a level with a limited gameboard may require more strategic matching and be more challenging. Upon initially seeing the levels, I produced an empirical assessment of how I would expect them to feel, concerning openness and mental challenge. It will be interesting to compare this assessment with the accumulated data.

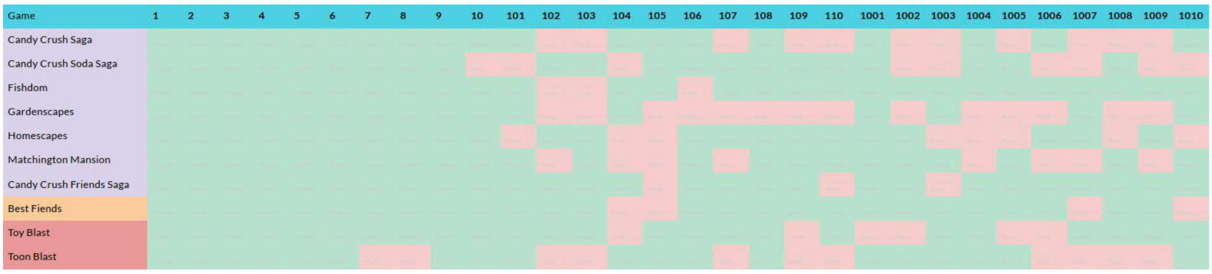
Table 5
Heatmap of open (green) and closed (red) level layouts



The above (table 5) heatmap of openness versus closeness for all the studied sections displays a clear progression from open towards closed structures by player age. This is unsurprising, considering that the starting section of a game tends to focus on tutorials, that generally tend to be designed to provide a positive and relaxed experience to players. Interestingly, while the ratio of opened and closed levels clearly favours the more open structures, mid-game the amount of open and closed levels is rather even. Transitioning to the late game, the ratio of open to closed levels favours closed layouts. There does not appear to be a strong connection to the genre of the games, however it is likely the age of the games affects the onboarding section, as newer games do not need to spend as much time introducing basic concepts as their predecessors. Concerning the pacing of levels, the most common pattern seems to be that levels of similar properties are grouped together.

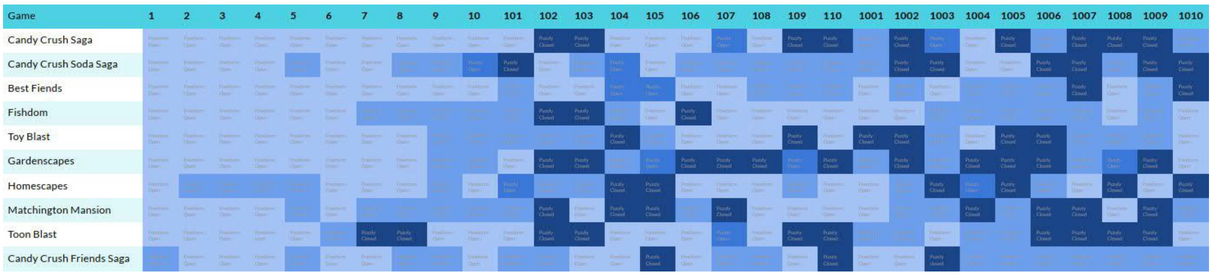
Evaluating a level's requirements for strategy upon completing an objective lead to the criteria of puzzly versus freeform levels. This is an even more subjective evaluation, however should provide some insight concerning the pacing of levels. As expected, the early game segment consists of freeform levels, with rare exceptions, while the ratio of puzzly to freeform levels is on average 1:3 in both following sections. *Gardenscapes* appears to contain the most demanding levels in the studied section, while *Candy Crush Friends Saga*, *Best Fiends* and *Fishdom* have the lowest count of puzzly levels in the studied sections (Table 6).

Table 6
Heatmap of freeform (pink) and puzzly (red) level layouts



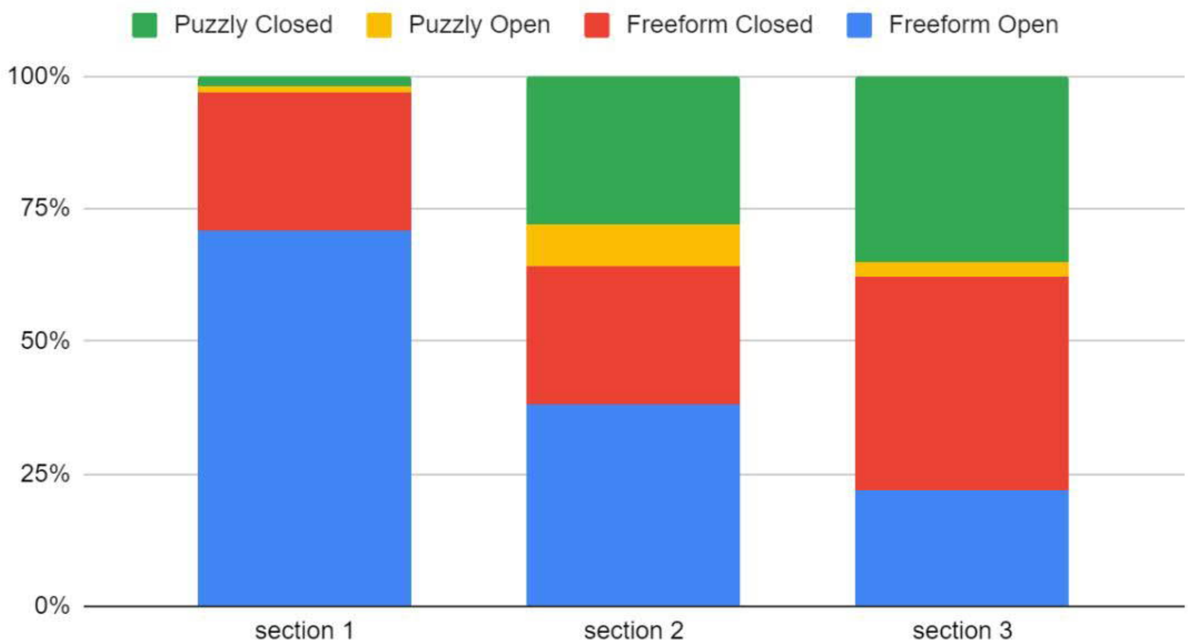
An additional heatmap (table 7) combining both properties provides a more accurate image of the distribution of levels within the studied sections. Freeform and open levels are the easiest to digest and provide players with a lot of freedom to experiment. Unsurprisingly, they appear in higher frequency during the early game, yet rather less often later on. Freeform but closed levels would be levels that provide a limited playspace, at least initially, but can be completed with ease. They appear consistently in all stages of games, however they appear rather prominently in the late-game section of some games, for example *Fishdom* and *Candy Crush Friends Saga*. Puzzly but open levels are the least frequently encountered levels in this study. Lastly, puzzly and closed levels are encountered primarily in middle and late-game sections. *Gardenscapes*, *Toon Blast* and *Candy Crush Saga* have the highest observed count of this type of levels. The distribution of different types of layouts per section can be better seen in figure 2.

Table 7
Heatmap of freeform/open (pale blue), freeform/closed (light blue), puzzly/open (blue) and puzzly/closed(dark blue) level layouts, sorted by age



With the exception of the early game, that looks generally homogeneous, the distribution per level type seems to vary significantly per game. Concerning the matching style of the games, it appears that tile-swapping and blasting games follow rather similar patterns, while the line-matching game uses more open layouts in comparison. Given the sample size, this may not be significant, however.

Figure 2
Evaluation of levels layouts per section



Examining the games by age, as seen in Table 7, the increase in complexity of the early game becomes more prominent. Indeed, *Candy Crush Saga* invests more time in educating players over simple mechanics in a safe layout, than the following *Candy Crush Soda Saga*, while the latest game studied, *Candy Crush Friends Saga* seems to use more restrictive layouts from the very start. Furthermore, *Toon Blast* seems to be introducing significantly more complex levels earlier than other games. Conversely, the middle and later section of the game remain harder to interpret. In any case, the distribution of levels appears more fractured, with levels of different degrees of flexibility alternating frequently. There is a small increase in the frequency of puzzly and closed levels in the late game compared to the mid-game in some cases, however it is not observed frequently enough to determine a pattern.

Before proceeding to the analysis of numerical data, it is important to reiterate that these are empirical data, noted before observing players complete the level. Therefore it is likely some estimates are not accurate. However, they should provide a good baseline when compared with numeric data analysis

Layout

The following section concerns all elements that are present at the start of a level and affect its structural composition as a whole. Thus, the layout analysis will start from the game board itself. The size of the board defines the maximum available playspace of a level and can predispose a player to the potential challenge of the level. First we will examine the variation in the amount of boards per level and then will focus on the dimensions of the board. Following, we will examine obstacles placed in the level, both in permanent and impermanent form, specifically static and breakable elements including fences, matchable elements and elements present in the overlay and underlay layers. Although other aspects of the level design, for example cascade manipulation, or spawners might be mentioned in this section, they will be thoroughly analysed in the next chapter.

As discussed, the amount of game boards of a level can significantly alter the player experience, as the use of multiple boards allows for fragmenting the level in shorter sections with intermediate objectives. Commonly, match three games contain only one board per level. Indeed, levels consisting of multiple boards were encountered only in three of the studied games: *Candy Crush Soda Saga*, *Homescapes* and *Candy Crush Friends Saga*. In fact, only twelve of the 300 levels studied, contained multiple boards. Specifically, eight out of twelve levels were divided into two parts, three levels had three sections and one level had five individual sections. Notably, all the multi-board levels encountered use a tile-swapping matching system. Unsurprisingly, most multi-board levels utilise some method of cascade manipulation, to allow the transition from one board to another.

Turning now to the tracking of the dimensions of the gameboard, examining first the width and length of it. For levels with multiple boards, the complete width and length of the board has been calculated based on the direction towards which the camera moves when changing boards. For example in a level where completing the first board initiates a move downwards, the following boards' length is added to the original, while in a level where the camera moves sideways, the width is the value increased. To improve readability of the heatmaps, these outlier levels have been excluded from the range and highlighted with different colours.

Looking at the width of level boards, the median board width is of nine tiles. Few boards are observed that have less than seven tiles, while in single-board levels twelve tiles appear to be the maximum width. Seven levels use multiple boards, with 22 being a common value there. One interesting outlier is level 102 of *Candy Crush Soda Saga*, which is a multi-board level with a total of five boards and a total width of 45 tiles. With the exception of multi-board levels, the width of the level boards in most games remains relatively stable. This is to be expected, as the available play space can be limited by other means as well, for example static blocks. Generally the games favouring wider boards; ie. *Fishdom*, *Gardenscapes*, *Homescapes* and *Matchington Mansion*, use primarily landscape orientation. Conversely, games like *Best Fiends* and *Toon Blast* are limited to a narrower gameboard, due to their portrait orientation. Interestingly, C*andy Crush Saga*, *Candy Crush Soda Saga* and *Candy Crush Friends Saga* are limited to a width of up to 9 tiles per board, which can be justified by the intention to be playable in both landscape and portrait mode.

Sorting the boards by matching style (table 8) reveals an association of the delta of dimensions with the matching style. Indeed, all tile-swapping games use larger grids, usually between nine and twelve tiles, while blasting and line-matching games typically fluctuate between seven and nine tiles. There appears to be a larger fluctuation in the dimensions of the board for matching tile games, from 5 to 12 tiles, which can partly be justified by the larger playspace available in these games. Blasting games range from 7 to 9 tiles in most cases, while line-matching games retain the same width in all observel levels. There does not appear to be a pattern in the width's variation.

Table 8
Heatmap of level width, sorted by matching style

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	8	9	7	9	6	5	9	9	8	9	7	9	7	9	9	9	9	9	9	7	9	8	9	9	8	9	9	9	9	9
Candy Crush Soda Saga	5	9	9	9	9	8	9	9	21	9	9	45	9	9	9	9	9	9	9	7	9	18	9	9	9	9	9	9	9	9
Fishdom	7	10	12	11	9	11	9	12	11	9	12	12	12	12	12	12	9	11	12	11	12	12	12	12	10	11	12	12	12	12
Gardenscapes	7	9	12	12	11	11	11	12	11	11	9	11	12	12	11	11	9	9	10	12	12	12	12	12	12	11	12	12	11	12
Homescapes	7	8	11	10	9	9	11	9	11	11	11	11	11	11	11	22	22	11	11	11	22	11	11	11	10	11	9	11	18	11
Matchington Mansion	9	12	8	12	11	11	8	8	11	7	9	9	12	11	11	9	12	12	11	12	9	10	9	9	9	12	10	11	12	9
Candy Crush Friends Saga	5	7	7	7	7	9	9	9	7	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	9	9	9	9
Best Fiends	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Toy Blast	9	7	7	9	9	7	9	9	9	9	9	9	9	9	9	9	9	9	7	9	9	4	9	9	9	9	7	9	8	7
Toon Blast	7	9	9	9	9	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	7	9	9	9	9	9	9	9	9	9

Looking at the board's height (table 9), the most prominent board length amongst the studied was nine tiles. With the exception of multiboard levels, whose total length is also a multiple of nine, nine tiles appears to be the maximum length dimension chosen for all games, regardless of their orientation. Exceptionally, *Best Fiends* use persistently a board with a length of seven tiles. Occasionally there appear boards with smaller lengths, in rare cases as small as four tiles, as for example in the first level of *Candy Crush Friends Saga*, that has a board of only 5*4 tiles.

Furthermore, sorting by matching style indicates a larger variation of board dimensions for tile-swapping games; dimensions fluctuated between four and nine tiles, compared to blasting games, whose dimensions fluctuated between six and nine tiles. Additionally, there does not appear to be a pattern in the height's variation, however different board lengths are observed more frequently in blasting games than tile-swapping games. As mentioned earlier, line-matching games do not display any fluctuation of dimensions.

Table 9
Heatmap of level height, sorted by matching style

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104
Candy Crush Saga	5	9	7	9	9	9	9	9	7	9	9	9	9	9
Candy Crush Soda Saga	7	9	9	9	9	9	9	9	8	9	9	9	9	27
Fishdom	7	8	9	9	9	8	9	9	9	9	9	9	9	9
Gardenscapes	7	9	9	9	9	8	9	8	9	9	9	9	8	8
Homescapes	6	8	8	9	9	9	7	9	7	8	9	9	9	9
Matchington Mansion	7	7	8	9	9	9	8	9	9	9	9	9	9	9
Candy Crush Friends Saga	4	6	7	7	8	9	8	8	7	9	8	9	9	9
Best Fiends	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Toy Blast	6	8	8	9	9	9	9	9	9	9	9	9	9	9
Toon Blast	7	7	9	9	9	9	8	9	9	9	8	8	8	9

Game	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	9	9	9	9	9	9	9	8	9	9	9	9	9	9	9	9
Candy Crush Soda Saga	9	9	9	9	9	12	9	9	9	18	9	9	9	9	9	9
Fishdom	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Gardenscapes	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Homescapes	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Matchington Mansion	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Candy Crush Friends Saga	9	27	9	9	9	9	9	9	9	18	9	9	9	9	9	9
Best Fiends	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Toy Blast	9	9	9	8	9	9	9	8	8	9	9	6	9	9	8	9
Toon Blast	9	9	9	9	9	8	8	9	9	9	9	9	9	8	9	9

It appears that the maximum dimensions for a game board are of 12 tiles in the wider dimension and 9 tiles in the narrower dimension. Games that are designed primarily for portrait orientation do not stray from boards larger than nine tiles in their narrow dimension, which would lead to the conclusion that this is the maximum feasible size for acceptable readability and accessibility on small screen devices. Likewise twelve tiles appear to be the maximum width for landscape games.

Looking into the aspect ratio of the levels on table 10, allows a better understanding of the shape variations among them. Upon examination of the initial data, it is clear that there is a large variation amongst board shapes. However, it is clear that the most prominent aspect ratio is 1:1, namely a square. Indeed 162 out of 300 levels are of square shape, while over 30% of the levels value width over length. This is not surprising given the majority of the games use landscape orientation.

Table 10
Heatmap of level aspect ratios

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	8:5	1:1	1:1	1:1	2:3	5:9	1:1	1:1	8:7	1:1	7:9	1:1	7:9	1:1	1:1	1:1	1:1	1:1	1:1	7:9	1:1	1:1	1:1	1:1	8:9	1:1	1:1	1:1	1:1	1:1
Toon Blast	1:1	9:7	1:1	1:1	1:1	1:1	9:8	1:1	1:1	1:1	1:1	1:1	1:1	8:9	8:9	1:1	1:1	1:1	1:1	9:8	7:8	1:1	1:1	1:1	1:1	1:1	1:1	9:8	1:1	1:1
Homescapes	7:6	1:1	11:8	10:9	1:1	1:1	11:7	1:1	11:7	11:8	11:9	11:9	11:9	11:9	11:9	22:9	22:9	11:9	11:9	11:9	22:9	11:9	11:9	11:9	10:9	11:9	1:1	11:9	2:1	11:9
Gardenscapes	1:1	1:1	4:3	4:3	11:9	11:8	11:9	3:2	11:9	11:9	1:1	11:9	3:2	3:2	11:9	11:9	1:1	1:1	10:9	4:3	4:3	4:3	4:3	4:3	4:3	11:9	4:3	4:3	11:9	4:3
Candy Crush Soda Saga	5:7	1:1	1:1	1:1	1:1	8:9	1:1	1:1	21:8	1:1	1:1	5:1	1:1	1:3	1:1	1:1	1:1	1:1	1:1	7:12	1:1	2:1	1:1	1:2	1:1	1:1	1:1	1:1	1:1	1:1
Toy Blast	3:2	7:8	7:8	1:1	1:1	7:9	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	9:8	7:9	1:1	1:1	1:2	9:8	1:1	1:1	3:2	7:9	1:1	1:1	7:9
Matchington Mansion	9:7	12:7	1:1	4:3	11:9	11:9	1:1	8:9	11:9	7:9	1:1	1:1	4:3	11:9	11:9	1:1	4:3	4:3	11:9	4:3	1:1	10:9	1:1	1:1	1:1	4:3	10:9	11:9	4:3	1:1
Fishdom	1:1	5:4	4:3	11:9	1:1	11:8	1:1	4:3	11:9	1:1	4:3	4:3	4:3	4:3	4:3	4:3	1:1	11:9	4:3	11:9	4:3	4:3	4:3	4:3	10:9	11:9	4:3	4:3	4:3	4:3
Best Fiends	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1
Candy Crush Friends Saga	5:4	7:6	1:1	1:1	7:8	1:1	9:8	9:8	1:1	1:1	9:8	1:1	1:1	1:1	1:1	1:3	1:1	1:1	1:1	1:1	8:9	1:1	1:1	1:2	1:1	1:1	1:1	1:1	1:1	1:1

Cleaning up the heatmap by organising the aspect ratios to three categories; wide (pink), tall (green) and square (blue), and sorting by matching style, reveals the correlation between shape and orientation (Table 11). Games with primarily portrait orientation use primarily square layouts and occasionally wider taller layouts, while games with primarily portrait orientation rarely use square or tall game boards. As previously discussed, there appears to be a correlation between the orientation of games and matching styles, which can be extended to the preferred layouts for matching styles. For example, the highest concentration of wide layouts appears on tile-swapping games, because they benefit from larger boards to produce optimal matches. Conversely, line-matching and blasting games that can affect larger areas of the game board per match utilise narrower layouts to help players focus on matching.

Table 11
Heatmap of level aspect ratios: square (blue), wide (red), tall (green)

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	8:5	1:1	1:1	1:1	2:3	5:9	1:1	1:1	8:7	1:1	7:9	1:1	7:9	1:1	1:1	1:1	1:1	1:1	1:1	7:9	1:1	1:1	1:1	1:1	8:9	1:1	1:1	1:1	1:1	1:1
Candy Crush Soda Saga	5:7	1:1	1:1	1:1	1:1	8:9	1:1	1:1	21:8	1:1	1:1	5:1	1:1	1:3	1:1	1:1	1:1	1:1	1:1	7:12	1:1	2:1	1:1	1:2	1:1	1:1	1:1	1:1	1:1	1:1
Fishdom	1:1	5:4	4:3	11:9	1:1	11:8	1:1	4:3	11:9	1:1	4:3	4:3	4:3	4:3	4:3	4:3	1:1	11:9	4:3	11:9	4:3	4:3	4:3	4:3	10:9	11:9	4:3	4:3	4:3	4:3
Gardenscapes	1:1	1:1	4:3	4:3	11:9	11:8	11:9	3:2	11:9	11:9	1:1	11:9	3:2	3:2	11:9	11:9	1:1	1:1	10:9	4:3	4:3	4:3	4:3	4:3	4:3	11:9	4:3	4:3	11:9	4:3
Homescapes	7:6	1:1	11:8	10:9	1:1	1:1	11:7	1:1	11:7	11:8	11:9	11:9	11:9	11:9	11:9	22:9	22:9	11:9	11:9	11:9	22:9	11:9	11:9	11:9	10:9	11:9	1:1	11:9	2:1	11:9
Matchington Mansion	9:7	12:7	1:1	4:3	11:9	11:9	1:1	8:9	11:9	7:9	1:1	1:1	4:3	11:9	11:9	1:1	4:3	4:3	11:9	4:3	1:1	10:9	1:1	1:1	1:1	4:3	10:9	11:9	4:3	1:1
Candy Crush Friends Saga	5:4	7:6	1:1	1:1	7:8	1:1	9:8	9:8	1:1	1:1	9:8	1:1	1:1	1:1	1:1	1:3	1:1	1:1	1:1	1:1	8:9	1:1	1:1	1:2	1:1	1:1	1:1	1:1	1:1	1:1
Best Fiends	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1
Toy Blast	3:2	7:8	7:8	1:1	1:1	7:9	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	9:8	7:9	1:1	1:1	1:2	9:8	1:1	1:1	3:2	7:9	1:1	1:1	7:9
Toon Blast	1:1	9:7	1:1	1:1	1:1	1:1	9:8	1:1	1:1	1:1	1:1	1:1	1:1	8:9	8:9	1:1	1:1	1:1	1:1	9:8	7:8	1:1	1:1	1:1	1:1	1:1	1:1	9:8	1:1	1:1

Finally, looking at the surface area of the game boards (Table 12), with the inclusion of multiboard levels, the average playable area is 84 tiles, while for single-board levels it is 79 tiles. Notably, the maximum playable area encountered on a multi-board level was 405 tiles and 108 tiles on a single board level, while the minimum was 20. With the exception of *Best*

Fiends, all games display some fluctuation of the maximum board size, which is more pronounced in the first section. There does not appear to be a clear pattern concerning the size's fluctuation.

Table 12
Heatmap of maximum board sizes of levels

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	40	81	49	81	54	45	81	81	56	81	63	81	63	81	81	81	81	81	81	63	81	64	81	81	72	81	81	81	81	81
Toon Blast	49	63	81	81	81	81	72	81	81	81	64	64	64	72	72	81	81	81	81	72	56	81	81	81	81	81	81	72	81	81
Homescapes	42	64	88	90	81	81	77	81	77	88	99	99	99	99	99	198	198	99	99	99	198	99	99	99	90	99	81	99	162	99
Gardenscapes	49	81	108	108	99	88	99	96	99	99	81	99	96	96	99	99	81	81	90	108	108	108	108	108	108	99	108	108	99	108
Candy Crush Soda Saga	35	81	81	81	81	72	81	81	168	81	81	405	81	243	81	81	81	81	81	84	81	162	81	162	81	81	81	81	81	81
Toy Blast	54	56	56	81	81	63	81	81	81	81	81	81	81	81	81	81	81	72	63	81	81	32	72	81	81	54	63	81	64	63
Matchington Mansion	63	84	64	108	99	99	64	72	99	63	81	81	108	99	99	81	108	108	99	108	81	90	81	81	81	108	90	99	108	81
Fishdom	49	80	108	99	81	88	81	108	99	81	108	108	108	108	108	108	81	99	108	99	108	108	108	108	90	99	108	108	108	108
Best Fiends	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
Candy Crush Friends Saga	20	42	49	49	56	81	72	72	49	81	72	81	81	81	81	243	81	81	81	81	72	81	81	162	81	81	81	81	81	81

Comparing the board sizes of the games, *Fishdom*, *Gardenscapes* and *Matchington Mansion* have the largest available play area, particularly 108 tiles, using on average 99 to 90 tiles per level. *Homescapes* and *Candy Crush Soda Saga* have slightly smaller play-area per board, however they frequently utilise multi-level boards, thus increasing their average board size. Excluding *Best Fiends*, the remaining games have a maximum board size of 81 tiles with an average board size of 75 tiles. Finally, *Best Fiends* has the smallest board of all studied games, using only 49 tiles. Although the blasting and line-matching games studied use smaller boards overall, there is no clear indication that the board size strictly correlates with the matching style itself. As discussed previously, a more likely cause for the chosen board dimensions is the game interface's orientation.

Furthermore, is it interesting to examine the frequency of use of the maximum board size per game. Clearly, the games with the largest available area use the whole extent significantly less often, while games with smaller available space exhaust it all more frequently. Naturally, larger game boards allow for more variation of design than smaller boards.

Calculating the available playspace provides a good indication of the openness of a level's layout. However, the total surface area of a level is further reduced by the use of permanent and impermanent obstacles on the board. Therefore, to reach a more accurate depiction of the playspace, the amount of permanent obstacles and the resulting playspace must be taken into account. As discussed, there are a variety of elements that may act as permanent obtrusions in a level. Consequently, the initial calculation of obstacles in the level can be further refined by considering the function of the obstacles themselves. Indeed, static elements that interact with players may limit the playspace, but enrich the gameplay experience.

Unsurprisingly, all games use static blocks to some degree, as seen on Table 13. Indeed, on average 24 out of 30 studied levels per game contained studied blocks, with counting up to 74 blocks in a level. A level contains 12 static blocks on average, however the usage per game varies significantly. Indeed, on average *Matchington Mansion's* levels contain 17 static blocks, while *Candy Crush Saga's* levels contain only seven. Interestingly, the use of static elements is slightly higher on sections one and 3, although the amount of tiles used in late game is overall higher than in the other ranges.

Table 13
Heatmap of static blocks per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	8	4	12	10	0	2	8	10	4	0	9	9	0	2	0	4	12	20	0	8	8	4	0	10	0	12	22	20	0
Toon Blast			24	12	16		12	9	10	14				8	6	24	14	19	10			12		24	12	9	22	24	9	16
Homescapes	0	12	25	38	20	8	4	13	8	30	8	10	5	10	14	26	19	21	18	9	43	22	10	6	22	17	4	19	18	28
Gardenscapes	4	12	14	20		14	10	28	2	24	6	3	16		36	14		13	14	22	20	12	30	38	24	10	16	24	27	22
Candy Crush Soda Saga	0	0	18	7	0	4	0	0	74	11	17	0	4	21	18	0	0	0	0	8	0	55	18	12	0	5	16	18	15	13
Toy Blast			4	16	16	9	23	10	20	24	25	5		9		4	20		3	15	9	8	18	40	30	8	9	33	16	
Matchington Mansion	4	28	12	12	36	44	0	20	22	4	4	21	14	15	11	4	32	16	22	10	12	24	9	0	20	39	22	3	28	11
Fishdom	4	12	28	4	12		10	22	6	4	30	23	26	18	11	28	12	8	20	16	12	22	12	24	24	17	28	8		16
Best Fiends	28	26	18	18	15	16	16	8	21	6	6	3	1	4	2	4	0	0	0	3	14	12	8	3	12	8	8	16	9	8
Candy Crush Friends Saga					6	6	5		6	3	8	4	12		21	8	12	4	4	17			17	35	13	13	10	12	8	4

Out of the 245 levels containing static blocks, 44 contain interactable static elements. They are encountered in games of all matching styles, primarily on the middle and late game sections. As seen on Table 14, they seem to appear with less frequency in tile-swapping games, however there is not enough information available to validate this.

Table 14
Heatmap of special static blocks per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candy Crush Soda Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fishdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	2
Gardenscapes	0	0	0	0	0	0	0	4	0	0	0	3	0	0	36	14	0	0	14	6	20	12	14	0	12	10	16	0	26	4
Homescapes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Matchington Mansion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
Candy Crush Friends Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	8	12	4	3	4	0	0	0	1	8	1	4	0	2	0
Best Fiends											3	3	1	4	2	2				3							1	7		4
Toy Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	2	0	4	1	0	0
Toon Blast																		4									9			

Looking into the ratio of static blocks compared to the total available playspace for each level, an average decrease of 14% can be noticed on the total playspace (Table 15). *Best Fiends*, *Matchington Mansion* and *Toy Blast* display the highest percentages of decrease, while *Candy Crush Soda Saga* and *Candy Crush Friends Saga* display the lowest ones. Levels on the early game and on the late game sections appear to use higher amounts of special static blocks than in the mid-game section.

Table 15
Heatmap of % area covered by static blocks per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0%	10%	8%	15%	19%	0%	2%	10%	18%	5%	0%	11%	14%	0%	2%	0%	5%	15%	25%	0%	10%	13%	5%	0%	14%	0%	15%	27%	25%	0%
Toon Blast	0%	0%	30%	15%	20%	0%	17%	11%	12%	17%	0%	0%	0%	11%	8%	30%	17%	23%	12%	0%	0%	15%	0%	30%	15%	11%	27%	33%	11%	20%
Homescapes	0%	19%	28%	42%	25%	10%	5%	16%	10%	34%	8%	10%	5%	10%	14%	13%	10%	21%	18%	9%	22%	22%	10%	6%	24%	17%	5%	19%	11%	28%
Gardenscapes	8%	15%	13%	19%	0%	16%	10%	29%	2%	24%	7%	3%	17%	0%	36%	14%	0%	16%	16%	20%	19%	11%	28%	35%	22%	10%	15%	22%	27%	20%
Candy Crush Soda Saga	0%	0%	22%	9%	0%	6%	0%	0%	44%	14%	21%	0%	5%	9%	22%	0%	0%	0%	0%	10%	0%	34%	22%	7%	0%	6%	20%	22%	19%	16%
Toy Blast	0%	0%	7%	20%	20%	14%	28%	12%	25%	30%	31%	6%	0%	11%	0%	5%	25%	0%	5%	19%	11%	25%	25%	49%	37%	15%	14%	41%	25%	0%
Matchington Mansion	6%	33%	19%	11%	36%	44%	0%	28%	22%	6%	5%	26%	13%	15%	11%	5%	30%	15%	22%	9%	15%	27%	11%	0%	25%	36%	24%	3%	26%	14%
Fishdom	8%	15%	26%	4%	15%	0%	12%	20%	6%	5%	28%	21%	24%	17%	10%	26%	15%	8%	19%	16%	11%	20%	11%	22%	27%	17%	26%	7%	0%	15%
Best Fiends	57%	53%	37%	37%	31%	33%	33%	16%	43%	12%	12%	6%	2%	8%	4%	8%	0%	0%	0%	6%	29%	24%	16%	6%	24%	16%	16%	33%	18%	16%
Candy Crush Friends Saga	0%	0%	0%	0%	11%	7%	7%	0%	12%	4%	11%	5%	15%	0%	26%	3%	15%	5%	5%	21%	0%	0%	21%	22%	16%	16%	12%	15%	10%	5%

Comparing the amount of statics on the available space per level with the amount of static block for the maximum possible board for each game we see that the average space covered is actually closer to 13%. This is a result of the way games use their available space. For example, *Best Fiends* uses the max board dimensions for all levels, thus any shaping of the level board is done with static blocks, while Homescapes uses a variation of maximum board sizes, therefore static blocks are only present in cases where the game board needs further alterations. Furthermore, there does not appear to be a clear correlation between the amount of static blocks and the matching style. The higher count of static blocks encountered in *Best*

Fiends compared to other games can be justified by the level construction methods mentioned above.

After calculating the amount of static elements in a level, it is possible to measure the total playable area of a level. The average play area where a player can perform actions is 72 tiles. However, there is large variance between the size of boards for each game, as seen on Table 16. While Best Fiends fluctuates between 49 and 20 tiles, *Gardenscapes* fluctuates between 40 and 99 tiles. Comparing the available area for matching with the maximum board surface for each game, indicates that on average 73% of a level's board is available for matching.

Table 16
Heatmap of matchable area per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	40	73	45	69	44	45	79	73	46	77	63	72	54	81	79	81	77	69	61	63	73	56	77	81	62	81	69	59	61	81
Toon Blast	49	63	57	69	65	81	60	72	71	67	64	64	64	64	66	57	67	62	71	72	56	69	81	57	69	72	59	48	72	65
Homescapes	42	52	63	52	61	73	73	68	69	58	91	89	94	89	85	172	179	78	81	90	155	77	89	93	68	82	77	80	144	71
Gardenscapes	45	69	94	88	99	74	89	68	97	75	75	96	80	96	63	85	81	68	76	86	88	96	78	70	84	89	92	84	72	86
Candy Crush Soda Saga	35	81	63	74	81	68	81	81	94	70	64	405	77	222	63	81	81	81	81	76	81	107	63	150	81	76	65	63	66	68
Toy Blast	54	56	52	65	65	54	58	71	61	57	56	76	81	72	81	77	61	72	60	66	72	24	54	41	51	46	54	48	48	63
Matchington Mansion	59	56	52	96	63	55	64	52	77	59	77	60	94	84	88	77	76	92	77	98	69	66	72	81	61	69	68	96	80	70
Fishdom	45	68	80	95	69	88	71	86	93	77	78	85	82	90	97	80	69	91	88	83	96	86	96	84	66	82	80	100	108	92
Best Fiends	21	23	31	31	34	33	33	41	28	43	43	46	48	45	47	45	49	49	49	46	35	37	41	46	37	41	41	33	40	41
Candy Crush Friends Saga	20	42	49	49	50	75	67	72	43	78	64	77	69	81	60	235	69	77	77	64	72	81	64	127	68	68	71	69	73	77

Notably, there is large variation between the sizes of matchable boards within the same game, as seen on Table 17. For levels with multiple boards, the levels with the smaller board observed can be almost 90% smaller in relation to the largest boards observed. For single board levels, this difference is closer to 50%. As noted in earlier discussions as well, the variation of size of the board is relative to the available board's size. Indeed, *Gardenscapes*, having a max board of 108 tiles, displays much larger variation in board size than *Best Fiends*, with a maximum board of 49 tiles.

Table 17
Variation of matchable board sizes in studied games

Game	max board	min board	delta	% delta
Gardenscapes	99	45	54	55%
Matchington Mansion	98	52	46	47%
Fishdom	108	45	63	58%
Homescapes	179	42	137	77%
Candy Crush Saga	81	40	41	51%
Candy Crush Soda Saga	405	35	370	91%
Candy Crush Friends Saga	235	20	215	91%
Toon Blast	81	48	33	41%
Toy Blast	81	24	57	70%
Best Fiends	49	21	28	57%

After looking at the permanent elements affecting the game board, it is time to examine the temporary elements of the level, i.e. breakable elements such as obstacles and collectibles, fences, overlays and underlays. These elements organise the structure of the board and dictate the flow and pacing of a level. As discussed, due to the variation of special blocks between games, the categorisation of elements has been as broad as possible.

Concerning breakable blocks, there appears to be high use of them in all games (Table 18). On average, there are 8 breakable blocks per level in the early game, 27 in mid-game and 32 in late game. This can be justified by the fact that the category of breakables contains multiple different kinds of special blocks, for example collectibles, power-ups and obstacles, thus it is more likely to encounter higher variation during later stages of the game. There does not appear to be a distinct pattern over the distribution of breakable blocks per level.

Table 18
Heatmap of breakable tiles per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	0	0	0	0	0	16	21	4	26	21	10	42	0	11	18	37	16	29	32	16	24	37	38	10	36
Toon Blast	0	0	0	0	0	36	48	36	3	6	16	20	40	36	42	45	35	53	24	30	21	54	45	34	42	50	45	40	56	38
Homescapes	0	0	0	0	0	0	0	0	0	0	45	18	40	39	47	100	4	29	0	51	49	29	46	14	24	44	49	38	42	34
Gardenscapes	0	0	0	0	0	0	0	0	19	69	9	40	40	52	6	60	24	10	18	32	36	69	52	54	28	66	74	8	27	48
Candy Crush Soda Saga	0	0	0	0	0	0	0	66	3	3	0	0	25	0	0	0	3	0	3	0	0	0	0	19	29	49	13	8	4	0
Toy Blast	0	0	0	0	0	2	3	4	36	25	47	16	75	66	36	2	2	10	20	2	56	12	18	19	0	29	36	12	44	21
Matchington Mansion	0	0	0	0	0	0	35	51	40	15	43	30	38	72	16	18	48	52	24	35	10	50	32	64	45	45	48	58	42	42
Fishdom	0	0	1	0	0	15	31	34	63	0	58	3	26	44	15	42	42	40	38	15	60	26	32	15	8	30	16	48	81	50
Best Fiends	0	0	0	0	2	3	22	30	16	19	1	1	6	10	3	1	14	13	4	2	13	13	15	13	16	9	7	3	18	5
Candy Crush Friends Saga	0	0	0	0	0	0	0	0	0	0	22	59	33	33	26	133	38	28	35	28	24	45	50	34	44	38	16	46	35	10

Looking at the coverage of the matchable space by breakable elements, as plotted on Table 19, we can see a wide variation from levels using preplaced breakables in a very limited fashion, to levels covering over 90% of the initial board. On average, there is about 30% coverage of the matchable areas with breakable elements. There does not appear to be a strong correlation of matching styles and breakable elements, however there is a correlation of level's board size and board coverage, implying that games with larger boards must utilise more breakable elements to provide structure to the levels. Furthermore, the frequency of use of breakables increases for levels with larger board size.

Table 19
Heatmap of breakable tiles area coverage per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	25%	29%	7%	32%	27%	12%	55%	0%	18%	29%	51%	29%	38%	40%	26%	30%	54%	64%	16%	44%
Toon Blast	0%	0%	0%	0%	0%	44%	80%	50%	4%	9%	25%	31%	63%	56%	64%	79%	52%	85%	34%	42%	38%	78%	56%	60%	61%	69%	76%	83%	78%	58%
Homescapes	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	49%	20%	43%	44%	55%	58%	2%	37%	0%	57%	32%	38%	52%	15%	35%	54%	64%	48%	29%	48%
Gardenscapes	0%	0%	0%	0%	0%	0%	0%	0%	20%	92%	12%	42%	50%	54%	10%	71%	30%	15%	24%	37%	41%	72%	67%	77%	33%	74%	80%	10%	38%	56%
Candy Crush Soda Saga	0%	0%	0%	0%	0%	0%	0%	81%	3%	4%	0%	0%	32%	0%	0%	0%	4%	0%	4%	0%	0%	0%	0%	13%	36%	64%	20%	13%	6%	0%
Toy Blast	0%	0%	0%	0%	0%	4%	5%	6%	59%	44%	84%	21%	93%	92%	44%	3%	3%	14%	33%	3%	78%	50%	33%	46%	0%	63%	67%	25%	92%	33%
Matchington Mansion	0%	0%	0%	0%	0%	0%	55%	98%	52%	25%	56%	50%	40%	86%	18%	23%	63%	57%	31%	36%	14%	76%	44%	79%	74%	65%	71%	60%	53%	60%
Fishdom	0%	0%	1%	0%	0%	17%	44%	40%	68%	0%	74%	4%	32%	49%	15%	53%	61%	44%	43%	18%	63%	30%	33%	18%	12%	37%	20%	48%	75%	54%
Best Fiends	0%	0%	0%	0%	6%	9%	67%	73%	57%	44%	2%	2%	13%	22%	6%	2%	29%	27%	8%	4%	37%	35%	37%	28%	43%	22%	17%	9%	45%	12%
Candy Crush Friends Saga	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	34%	77%	48%	41%	43%	57%	55%	36%	45%	44%	33%	56%	78%	27%	65%	56%	23%	67%	48%	13%

The use of fences was limited in the studied section (Table 20), with only five games using them. Notably, *Candy Crush Soda Saga* is the only game introducing fences in the first 10 levels of gameplay, however fences are featured most prominently in *Best Fiends*, appearing in all mid-and late game levels studied. Given that fences are positioned in the spaces between tiles, in order to restrict movement between adjacent tiles, they can be utilised for various purposes. Thus they can be used topically or in an extended area, therefore there is large variation in the amount of fences encountered per level. However, conversely to other obstacles encountered, the board size does not seem to affect the amount of fences used. Rather, it appears that the matching style is more relevant in the application of fences, as line-matching games, which rely on affecting larger areas of the board per match, seem to display fences most prominently and with the highest average count. Indeed, the use of fences in tile-swapping games is scarce, and in blasting games it is non-existent.

Table 20
Heatmap of fences used per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Candy Crush Soda Saga	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	9	0	9	0	0	0	0	0	0	0	0	0	0	0
Fishdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0
Gardenscapes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10	0	0
Homescapes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	16	0	0	0	30	0	0	0	0	0	0
Matchington Mansion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	20	0	18	0
Candy Crush Friends Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Best Fiends	0	0	0	0	0	0	0	0	0	0	16	10	23	14	17	23	32	17	27	13	4	12	22	32	19	4	7	12	12	14
Toy Blast																														
Toon Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The next block type to be examined is overlay elements. Overlays occupy a separate layer in the game, and thus can cover both matchable spaces and spaces containing static blocks with a function. They can also cover breakable blocks, therefore there is some overlap concerning how much space of a level they occupy. All games use some form of overlay, though their functions may vary per game. As seen on Table 21, they appear more prominently in the second and third section and there does not appear to be a correlation with matching systems. Candy Crush Soda Saga uses overlay most prominently, in 25 levels out of 30, while Matchington Mansion the least. Overlays are limited in the early game, appearing only in four games, but their use is more ubiquitous in the other sections.

Table 21
Heatmap of overlay elements used per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	0	0	0	0	0	0	0	6	6	13	9	8	13	2	18	16	0	14	12	0	24	9	0	10	0
Toon Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	36	0	24	0	23	0	0	0	16	0	20	0	12	0	9
Homescapes	0	0	0	0	0	0	0	20	30	30	34	47	60	0	46	0	26	9	0	0	52	37	0	6	9	0	16	40	30	0
Gardenscapes	0	0	0	0	0	0	0	0	0	0	0	0	8	20	24	0	30	0	8	40	8	21	18	22	24	28	0	30	17	0
Candy Crush Soda Saga	0	8	4	9	26	0	5	0	0	5	40	161	39	81	26	62	30	42	40	48	53	16	37	38	36	0	23	31	17	16
Toy Blast	0	0	0	0	0	0	0	0	0	0	20	76	0	56	45	0	0	0	18	59	0	0	0	0	51	46	0	0	0	63
Matchington Mansion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10	12	0	0	0	0	0	0	0	0	0	0	0
Fishdom	0	0	0	0	0	0	0	0	0	9	0	6	10	12	10	0	0	14	0	12	6	0	0	21	30	12	30	18	0	6
Best Fiends	0	0	0	0	0	0	0	0	0	0	2	15	19	3	7	3	0	0	12	19	0	0	13	13	1	0	0	0	6	9
Candy Crush Friends Saga	0	0	0	0	30	32	34	39	20	24	0	0	0	0	0	8	0	22	0	2	0	6	0	67	0	0	21	0	4	45

Overlay coverage of the game board is on average 12% (Table 22). *Candy Crush Soda Saga* appears to have the highest coverage, averaging 28%, while *Toy Blast* averages a coverage of 20%, and in one case overlay elements are covering the whole level. There does not appear to be a connection between matching styles and use of overlays, or between the frequency of use. On average, the levels of the second section have larger area coverage than the third one, however this may be connected with the variety of special overlay blocks, rather than a general trend of reduced use of overlays overtime. Furthermore, the size of the board does not have a clear effect on the average coverage rate, as the levels with the highest coverage on average use medium-sized boards of a maximum of 81 tiles.

Table 22
Heatmap of overlay area coverage per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	7%	16%	11%	10%	16%	2%	29%	20%	0%	17%	15%	0%	30%	11%	0%	12%	0%
Toon Blast	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	39%	0%	44%	0%	30%	0%	32%	0%	0%	0%	20%	0%	25%	0%	17%	0%	11%
Homescapes	0%	0%	0%	0%	0%	0%	0%	25%	39%	34%	34%	47%	61%	0%	46%	0%	13%	9%	0%	0%	26%	37%	0%	6%	10%	0%	20%	40%	19%	0%
Gardenscapes	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	21%	24%	0%	37%	0%	9%	37%	7%	19%	17%	20%	22%	28%	0%	28%	17%	0%
Candy Crush Soda Saga	0%	10%	5%	11%	32%	0%	6%	0%	0%	6%	49%	40%	48%	33%	32%	77%	37%	52%	49%	57%	65%	10%	46%	23%	44%	0%	28%	38%	21%	20%
Toy Blast	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	25%	94%	0%	69%	56%	0%	0%	0%	29%	73%	0%	0%	0%	0%	63%	85%	0%	0%	0%	100 %
Matchington Mansion	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	9%	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fishdom	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	6%	9%	11%	9%	0%	0%	14%	0%	12%	6%	0%	0%	19%	33%	12%	28%	17%	0%	6%
Best Fiends	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	31%	39%	6%	14%	6%	0%	0%	24%	39%	0%	0%	27%	27%	2%	0%	0%	0%	12%	18%
Candy Crush Friends Saga	0%	0%	0%	0%	54%	40%	47%	54%	41%	30%	0%	0%	0%	0%	0%	3%	0%	27%	0%	2%	0%	7%	0%	41%	0%	0%	26%	0%	5%	56%

Besides the overlay layer, many games utilise a layer beneath the main matching layer, to add more gameplay variation. In fact, eight out of ten games studied use an underlay. Looking at a matching-style distribution (Table 23), there were no underlay elements encountered in blasting games and in line-matching games they were only encountered in the late-game section. Conversely, tile-swapping games use underlays frequently, and starting from the very early game on multiple occasions. On average, 14 tiles are covered per level, with *Fishdom* and *Candy Crush Soda Saga* showing the highest average of covered space.

Table 23
Heatmap of underlay elements used per level, sorted by matching type

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	12	52	12	22	39	0	0	33	18	24	16	8	69	8	0	0	28	31	0	10	0	69	0	16	0
Candy Crush Soda Saga	0	9	9	9	9	26	48	81	48	81	32	11	0	14	35	20	0	18	0	18	53	16	74	20	81	0	1	31	1	14
Fishdom	6	20	37	51	49	0	0	0	31	34	0	49	18	0	63	42	42	48	50	37	0	44	36	0	48	82	70	0	0	0
Gardenscapes	0	0	0	0	38	40	89	0	67	75	36	0	0	32	63	0	48	0	0	42	0	0	0	0	12	0	0	0	10	0
Homescapes	0	0	0	0	0	24	17	8	4	0	0	8	0	22	0	0	51	0	0	0	0	37	20	0	0	0	0	0	28	44
Matchington Mansion	0	0	0	0	0	0	0	0	0	7	0	0	64	0	0	81	0	0	36	0	0	0	0	17	57	69	54	0	48	0
Candy Crush Friends Saga	20	42	25	49	0	0	0	0	49	81	0	77	19	35	0	0	27	77	17	1	8	5	14	33	0	5	71	1	0	47
Best Fiends	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	11	0	0	14	0	0	0	0
Toy Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toon Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Typically, underlays can only be placed under tiles that do not contain static elements, but can be placed under breakable items, or overlay, in fact this is a quite common use case. Looking at the coverage of the total matchable area with underlay elements (Table 24), we can see a high variation in the coverage of levels, ranging from topical usage to covering the whole board. On average 16% of the levels is covered, with *Candy Crush Friends Saga* and *Fishdom* displaying the highest board coverage, 39% and 26% respectably, and Best Fiends displaying the lowest, with only 3%. Notably, the size of the board does not seem to be associated with the average covered area. On average the level coverage ranged from 16% on early game to 18% in the late game.

Table 24
Heatmap of underlay area coverage per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0%	0%	0%	0%	0%	27%	64%	15%	39%	48%	0%	0%	52%	22%	30%	20%	10%	85%	10%	0%	0%	44%	38%	0%	14%	0%	85%	0%	20%	0%
Toon Blast	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Homescapes	0%	0%	0%	0%	0%	30%	22%	10%	5%	0%	0%	8%	0%	22%	0%	0%	26%	0%	0%	0%	0%	37%	20%	0%	0%	0%	0%	0%	17%	44%
Gardenscapes	0%	0%	0%	0%	38%	45%	90%	0%	68%	76%	44%	0%	0%	33%	64%	0%	59%	0%	0%	39%	0%	0%	0%	0%	11%	0%	0%	0%	10%	0%
Candy Crush Soda Saga	0%	11%	11%	11%	11%	36%	59%	100%	29%	100%	40%	3%	0%	6%	43%	25%	0%	22%	0%	21%	65%	10%	91%	12%	100%	0%	1%	38%	1%	17%
Toy Blast	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Matchington Mansion	0%	0%	0%	0%	0%	0%	0%	0%	0%	11%	0%	0%	59%	0%	0%	100%	0%	0%	36%	0%	0%	0%	0%	21%	70%	64%	60%	0%	44%	0%
Fishdom	12%	25%	34%	52%	60%	0%	0%	0%	31%	42%	0%	45%	17%	0%	58%	39%	52%	48%	46%	37%	0%	41%	33%	0%	53%	83%	65%	0%	0%	0%
Best Fiends	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	24%	22%	0%	0%	29%	0%	0%	0%	0%
Candy Crush Friends Saga	100%	100%	51%	100%	0%	0%	0%	0%	100%	100%	0%	95%	23%	43%	0%	0%	33%	95%	21%	1%	11%	6%	17%	20%	0%	6%	88%	1%	1%	58%

Finally, matchable tiles complete the level's starting composition. The range of matchable tiles encountered in the studied section was between two and seven tiles, as seen on table 25. On average, games used five tiles per level. Interestingly, most games use a higher count of different tiles in the first section than the other two. This can be connected to the main purpose of the onboarding section, which is to train players to perform the basic matching interaction and learn the game's conventions. Furthermore, it can be associated with larger and more open game boards for the early segments of most games.

Table 25
Heatmap of matchable tiles per level, sorted by matching style

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	6	6	5	6	5	5	5	5	4	4	4	4	5	5	4	4	4	4	4	4	4	4	5	5	5	5	4	4	5	5
Candy Crush Soda Saga	6	5	5	5	7	6	6	4	5	6	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	5	4	5	5
Fishdom	5	5	5	5	5	5	4	5	4	5	4	6	5	4	5	4	5	4	5	5	5	5	4	5	5	4	5	5	4	4
Gardenscapes	5	5	5	5	5	5	4	4	6	4	4	5	5	5	6	5	5	5	5	5	5	4	5	4	5	5	5	5	5	4
Homescapes	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	4	5	5	5	4	5	5	5	4	5
Matchington Mansion	5	5	5	6	4	5	5	5	5	5	5	5	5	4	5	5	5	5	5	6	5	4	4	4	4	4	5	4	6	4
Candy Crush Friends Saga	5	5	5	5	5	5	5	5	4	5	5	4	4	5	4	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5
Best Fiends	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4	4	4	3	4	4	4	5	4	4	5	3	5
Toy Blast	6	6	5	6	5	6	4	4	4	4	4	4	4	4	4	5	5	4	4	6	4	4	3	4	2	4	3	4	3	4
Toon Blast	6	6	5	5	5	4	4	4	6	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Additionally, there appears to be a clear correlation between matching styles and amount of matchable elements per level. Indeed, tile-swapping levels use a range of four to seven tiles per level, five per average. In contrast, basting games use between two and six kinds of blocks, with four being the most common amount, while blasting and line-matching games fluctuate between three and five kinds, with four being the average. Although this can be justified by the smaller board size of these games, it is also a result of the inherent differences in the matching style. Tile-swapping games are limited by the fact that three adjacent tiles will automatically trigger a match, thus they need to manage a distribution of matchable tiles that will prevent overwhelming the players with automatically triggered matches. On the other hand, in both blasting and line-matching games the matching is player-initiated and a higher count of blocks in a match tends to be positive for the players, thus less variation of matchables allows for more player-positive interactions.

Gameplay

So far, the discussion was aimed at elements present at the start of the level and the overall structure of a level's space. However, the flow of a level is affected significantly by the things that happen during the gameplay of a level itself. Particularly, it is interesting to see potential elements that affect the cascade of the level, the spawn of new blocks, and primarily the presence of special tiles in the level. Indeed, the combination of these elements with the basic structure of the level, is what creates complexity of designs and what allows the creation of so varied designs.

The manipulation of a level's cascade can have a variety of effects in the gameplay. Controlling the locations in which tiles can spawn in a non-random fashion may increase the amount of challenge and complexity in the game, especially in cases where the route cascading tiles need to take to reach the bottom of the level is increased compared to the normal length of a game-board. Additionally, cascade modifications require increased player attention, as they contradict the established flow of the gameplay. Consequently they do increase affected levels' degree of complexity, but may also function as a pacing mechanic by producing a perspective shift in players.

Seven out of ten games use cascade-manipulation mechanics in the studied sections. Specifically, all tile-swapping games use at least one form of cascade manipulation, for example portals or conveyor belts, as seen on Table 26. *Candy Crush Soda Saga* and *Candy Crush Friends Saga* use elements of cascade manipulation the most. Conversely, the blasting and line-matching games studied do not use cascade-manipulation mechanics in the studied sections, potentially due to the method of matching, or their generally smaller game board. Notably, only *Candy Crush Soda Saga* uses a system of cascade manipulation during the first ten levels of gameplay. In fact, although reversing the cascade is one of the game's most essential early game mechanics, it is not encountered as frequently in the later sections examined.

Table 26
Heatmap of tiles containing cascade manipulation elements per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	0	0	0	0	0	0	18	2	0	0	0	8	0	16	0	0	18	32	0	10	0	0	0	16	0
Candy Crush Soda Saga	0	9	9	9	9	0	0	0	94	81	0	0	0	0	0	0	9	0	18	0	0	0	0	0	0	0	1	0	0	0
Fishdom	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0
Gardenscapes	0	0	0	0	0	0	0	0	0	0	0	0	4	0	36	0	0	16	0	28	0	0	0	14	12	0	0	12	10	0
Homescapes	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	8	0	0	0	0	0	0	12	0	0	0	0	8
Matchington Mansion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	16	0	0	6	0	0	0	48	0	0	0	0	12	0
Candy Crush Friends Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	21	8	6	2	4	0	0	64	2	8	2	8	0	73	0

The count of tiles affected by cascade manipulation depends on the design of the special blocks responsible for the effect. Typically portal-like mechanics affect only two tiles directly, the point of entry and the point of exit, while conveyor-belt style mechanics affect all the tiles where belts are located. In levels where the goal is to invert the cascade, as happens with *Candy Crush Soda Saga's* soda objective, the cascade manipulation is dynamic, initially starting from a small portion of the level and eventually covering all or most of the game board. In levels where a large surface area is affected the mechanics used were most likely area-affecting ones such as conveyor belts, while in levels with less affected tiles single-tile effect mechanics were more likely used. Cascade-manipulation elements are highly associated with multi-board levels, as they can assist the transition from one board section to another. Indeed, the levels with the higher counts of tiles affected are all multi-board levels, with a range of affected tiles of 48-84. In contrast, single-board levels rarely have more than 20 tiles affected at the start of the level.

Besides altering the in-level cascade itself, most games studied use spawners as a means to alter the spawn chances of different elements in a level. Spawners can be permanently placed in the level, or be temporary elements. Out of the studied games eight use spawners, in all cases encountered only in the second and third studied section, and on average in four levels per game. Typically, spawners are used sparingly in levels, as seen on Table 27, specifically there were up to nine spawners observed in the studied section, with an average of four per level. There does not appear to be a connection with matching style, or board size as to how the spawners are used.

Table 27
Heatmap of tiles containing spawners per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	9	2	9	4	0	0	6	0	0	6	0	0
Toon Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Homescapes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0
Gardenscapes	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	6	0	3	2	6	0	4	0	2	0	0	3
Candy Crush Soda Saga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	0	3
Toy Blast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	2	0	4	1	0	0
Matchington Mansion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fishdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	2
Best Fiends	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Candy Crush Friends Saga	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	8	0	0	0	0	0	0	6	0	0	0	0

However, the most impactful element affecting the flow of a level is the presence of special tiles and the combination of unique gameplay elements with the basic core of the games. The following section will focus on assessing the variation of mechanics and the presence of new elements in the game.

Depending on the section of the game, different degrees of variation of gameplay mechanics can be encountered in each level, as seen on Table 28. As expected, the levels of the later sections of the game present more complexity and utilise more mechanics at once. Notably, the highest count of mechanics combined at once is eight, encountered in Candy Crush Saga, Gardenscapes and Best Fiends. Concerning the onboarding section, the First ten levels of a game rarely combine more than two gameplay elements, excluding basic matching and block collection. This is to be expected, as this section of the game focuses on slowly introducing new gameplay elements to players. Furthermore, on average, 3.5 elements are used per level in the mid-game section, while 4.1 in the later game, while only 2 mechanics are expected to appear per level in the early game.

Table 28
Heatmap of special tiles per level, sorted by matching style

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	1	1	1	1	1	2	3	4	5	2	4	5	2	4	1	8	6	5	5	6	2	4	3	3	3
Candy Crush Soda Saga	2	3	4	3	2	2	3	3	3	5	2	2	3	2	3	2	4	3	4	2	1	2	3	4	5	3	6	6	4	3
Fishdom	1	2	2	1	1	2	2	2	3	2	1	5	5	5	5	6	2	3	4	3	4	3	6	4	5	5	4	4	3	6
Gardenscapes	0	0	0	0	2	2	2	1	3	3	3	2	5	5	6	4	4	3	5	6	5	6	5	8	6	6	6	4	6	5
Homescapes	1	1	1	1	1	1	1	2	2	1	3	5	4	3	6	2	3	4	1	4	4	5	3	5	4	3	4	4	3	4
Matchington Mansion	1	1	1	1	1	1	1	1	1	1	3	3	4	3	4	4	4	4	4	3	2	1	2	5	4	3	5	6	6	3
Candy Crush Friends Saga	3	2	2	2	2	2	2	2	3	3	3	5	3	4	4	5	6	5	7	6	3	5	4	6	3	7	5	3	5	5
Best Fiends	1	1	2	2	2	3	3	2	3	3	7	8	7	6	4	5	4	4	4	4	3	5	7	4	5	7	8	5	6	8
Toy Blast	1	1	1	1	1	1	1	1	1	1	3	2	2	3	3	1	1	2	3	2	2	2	2	2	2	3	3	3	1	2
Toon Blast	0	1	1	1	1	1	1	1	1	1	1	1	2	2	3	2	2	4	2	3	1	2	2	3	3	3	3	3	3	3

Interestingly, sorting the games based on matching style allows for some more patterns to emerge. Specifically, blasting games use consistently the least amount of gameplay elements in the level, with maximum elements counted in a level being four. The distribution of those elements in levels is also more even compared to other matching styles. This can likely be attributed to the smaller grid and the simpler matching mechanic presented in those games.

While calculating the total amount of gameplay elements per level gives an idea of the pacing of the complexity of individual levels, tracking the rate of introduction of new gameplay elements provides a better idea on the pacing of the game as a whole. Therefore, new gameplay elements encountered in each level studied have been tracked, excluding, of course, the basic matching interaction and any aspects of the gameplay that are directly associated with it. Clearly, for the early game the track of new elements sets the pacing of the onboarding, as everything studied is encountered for the first time for the players and all new elements introduced require individual tutorials. However, for later game levels, encountering elements that had not been spotted earlier in the researched ranges does not guarantee that this is the first time they are being utilised. Instead, encountering new elements is best considered a metric of variation within the level content.

Table 29
Heatmap of unique special tiles encountered per level, sorted by matching style

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	0	0	0	0	0	1	0	0	0	0	2	1	2	1	0	0	0	0	0	1	3	3	1	1	0	0	0	0	0	0
Toon Blast	0	1	1	0	1	1	0	0	1	0	1	0	1	1	1	0	1	1	0	0	1	0	0	1	1	1	1	0	1	1
Homescapes	1	1	1	1	1	1	0	1	0	0	3	0	0	1	2	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Gardenscapes	0	1	1	1	2	0	0	1	1	0	1	1	4	0	2	1	0	1	0	0	1	0	2	1	0	1	0	1	2	0
Candy Crush Soda Saga	2	2	1	1	0	2	0	1	2	0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	1	3	0	0	1	0
Toy Blast	1	1	1	1	1	1	0	0	1	0	2	2	1	0	1	1	0	0	0	0	0	2	0	1	1	1	1	1	1	1
Matchington Mansion	1	1	1	1	1	1	1	0	0	1	1	2	2	0	1	2	1	0	0	0	1	0	0	1	1	1	0	2	0	0
Fishdom	1	1	1	1	0	2	0	0	1	1	0	2	2	1	0	0	1	0	0	0	2	1	1	1	3	2	1	0	1	1
Best Fiends	0	0	1	1	1	1	1	1	0	0	6	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	2	0	0
Candy Crush Friends Saga	3	0	0	0	2	0	0	0	1	0	0	2	1	3	2	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0

Overall, the pace of introducing new elements varies a lot per game, as noted on Table 29. Indeed, it seems that blasting games are introducing new elements more frequently in the range of this study. As discussed, focusing on the early game findings yields the most reliable and clear to interpret data. In the early game segment there is a clear difference in the count of mechanics introduced for each matching style, as seen on table 30. Notably, tile-swapping games on average present the players with more mechanics at the beginning of the game than games using other matching systems, seven over six. This may not appear significant initially, however it is a lot of additional information to pass to the players.

Table 30
Heatmap of unique special tiles encountered within the first 10 levels of a game, sorted by matching style and age

Year	Game	1	2	3	4	6	7	8	9	10	Total	Average
2012	Candy Crush Saga	0	0	0	0	1	0	0	0	0	1	
2014	Candy Crush Soda Saga	2	2	1	1	2	0	1	2	0	11	
2015	Fishdom	1	1	1	1	2	0	0	1	1	8	
2016	Gardenscapes	0	1	1	1	0	0	1	1	0	7	
2017	Homescapes	1	1	1	1	1	0	1	0	0	7	
2017	Matchington Mansion	1	1	1	1	1	1	0	0	1	8	
2018	Candy Crush Friends Saga	3	0	0	0	0	0	0	1	0	6	6.9
2014	Best Fiends	0	0	1	1	1	1	1	0	0	6	6
2015	Toy Blast	1	1	1	1	1	0	0	1	0	7	
2017	Toon Blast	0	1	1	0	1	0	0	1	0	5	6

Additionally, looking at tile-swapping games chronologically, it is not surprising to see that *Candy Crush Saga* introduces new gameplay elements much slower than newer games. As a pioneer of the genre, its tutorial sections focus on educating the players about the core mechanic of the game; tile-matching and combining blocks efficiently. Thus, *Candy Crush Saga's* initial levels slowly explore the core matching techniques and combo system and only after 6 levels introduce the first special block. Conversely, *Candy Crush Soda Saga* builds upon this knowledge, assuming the player base of the original game will be familiar enough with the core matching gameplay and immediately expands upon it. Notably, eleven special elements are introduced within the first 10 levels of the game.

Likewise, the newer *Fishdom* and the following games, *Gardenscapes*, *Homescapes* and *Matchington Mansion*, spend less time during onboarding to teach the basic mechanics, and rather invest more time into educating players around their novel metagame elements.

Although these tutorial sequences were not studied as part of this research, the pacing of introducing new mechanics in the game is clearly accelerated. It is worth noting that *Fishdom* introduces a new persistent gameplay element, a passively charging bomb, which is also encountered in *Gardenscapes*. In both cases it is encountered in level four and it is considered part of the core matching gameplay. Interestingly, the introduction of this element does not appear to delay the introduction of other special elements. Finally, *Candy Crush Friends Saga* introduces less in-game elements than earlier King's titles, but the introduction begins earlier. This can be explained by the fact that the metagame for *Candy Crush Friends Saga*, hero abilities, is directly connected to the core gameplay and needs to be introduced more gradually to the players.

A similar chronological examination can be performed for blasting games. Interestingly, the earlier *Toy Blast* introduces more elements in the early game than the newer *Toon blast*. However, *Toon Blast* introduces a different metagame as well. Finally, *Best Fiends* appears to have a similar approach to Blasting games, where less elements are introduced overall. This can be explained by the more challenging matching system, in combination with the hero-based gameplay design.

The ratio of new mechanics encountered compared to the total amount of mechanics used in a level is a good indicator of how varied the player experience and content is in each section of the games. As expected, most of the early game levels showcase only one special element at a time, usually in a tutorial setting, and only combine more elements at a level on the later parts of the segment. On the second segment, newly encountered special blocks are combined with different blocks more frequently, showing that there is at least one new element in almost half the levels encountered. Additionally, the count of new gameplay elements appearances increases even further for the third segment, meaning late-game levels display even higher variation in the use of gameplay elements. Overall, levels become less homogeneous overtime, as a result of a larger pool of available features to combine, and also due to the more experienced players. There does not appear to be a clear correlation between matching styles and new block usage.

Balance

Finally it is time to look at the properties that affect the balancing of a level, particularly the move count and objectives of a level. While the move count limits the time players are given to complete a level, the different objectives of a level indicate how much a player's attention must be split along different elements. In different ways they both affect the complexity of a level, either by forcing the players to devise a solution quickly, or by requiring increased attention.

Concerning the move count, the vast majority of levels use a turn-based move count system as a way to limit players. However, there is one exception of a level, encountered in Fishdom, in which case instead of move count there is a real-time count-down. On average, a level must be completed within 29 moves, yet there is significant fluctuation on the move counts of actual levels, as seen on Table 31. Indeed in the mid-and late game sections, there were levels observed with up to 60 moves, and as little as 16. Generally the first section displays a larger fluctuation of moves, between six and 99, however the onboarding section is not representative of the rest of the games, as the prevalence of tutorials informs the move counts of levels. Nonetheless, on average the early section has 25 moves per level, the miod-game section 30 moves per level and the late-game section 31 moves per level, showing a slight increase overtime.

The games with the highest move counts overall are Toon Blast and Toy Blast and the game with the lowest move count is Best Fiends. Indeed, it appears that on average blasting games have 37 moves, while tile-swapping games have 27 moves. This can possibly be connected with the difference of matching styles, as Blasting games may frequently produce short matches and do not benefit from the effects of chain reactions in the way tile-swapping games do.

Table 31
Heatmap of move count per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	6	15	18	15	20	16	50	20	25	40	19	29	36	35	28	19	28	23	23	23	35	20	35	25	60	24	27	28	30	22
Candy Crush Soda Saga	16	25	20	20	35	20	20	25	20	15	20	49	20	50	25	25	24	35	35	36	23	35	40	43	30	30	28	30	30	30
Fishdom	24	20	24	28	26	27	22	20	22	23	34	34	33	25	27	26	24	25	22	37	38	35	40	44	Timed: 2:05	23	34	25	30	30
Gardenscapes	23	27	28	25	23	26	25	29	38	30	30	30	36	30	17	30	33	24	29	30	28	28	24	30	26	26	31	29	24	31
Homescapes	26	27	20	30	20	23	22	34	27	22	32	38	30	31	26	31	28	23	26	25	32	30	36	23	24	24	29	27	42	31
Matchington Mansion	25	26	25	30	30	26	30	30	21	22	25	22	25	26	25	22	16	29	25	22	25	27	26	20	24	27	25	25	25	25
Candy Crush Friends Saga	15	25	20	25	20	20	25	20	18	32	28	20	25	28	24	35	25	35	28	32	20	30	30	36	30	25	25	35	29	32
Best Fiends	20	18	15	16	22	22	22	23	22	15	40	29	27	28	28	27	31	31	29	24	25	22	24	23	28	24	27	22	24	23
Toy Blast	15	15	20	30	30	20	25	30	35	28	35	40	40	44	40	40	42	30	30	36	50	46	33	40	55	51	50	52	60	50
Toon Blast	99	18	22	27	26	40	45	42	25	35	40	50	40	26	38	32	45	36	35	34	30	30	25	30	26	40	27	34	42	27

However this might not be the only reason behind this difference. Other options to consider are different difficulty curves and of course the player skill of the players whose videos were examined. As discussed, level move counts are affected by external factors, such as player skill, previous failures and other conditions applying such as a win streak, therefore for the purposes of this research move counts are not a reliable indicator of a leve;s complexity.

Conversely, the count of objectives per level is a more reliable indicator of complexity, as the amount of objectives is not affected by individual player performance (Table 32). Due to the large variation of gameplay elements, only information concerning the count of different objectives was collected, and not the individual amount required for each objective. The observed levels had between one and four distinct objectives, with the average amount being two. *Candy Crush Soda Saga* and *Candy Crush Friends Saga* are the only games that have consistently one objective per level, while *Toy Blast* is the only game that had more than three objectives in a level. The average amount of goals per level seems to increase on the two last sections, which is to be expected as the increase of special tiles in the late game indicates a potential increase in collectible elements.

Interestingly, the blasting and line-matching games appear to have more goals per level than tile-swapping games, despite the smaller board size. This could be associated with the board size, however it could also mean that the total items required per goal are lower than on the games with primarily two objectives.

Table 32
Heatmap of objectives per level

Game	1	2	3	4	5	6	7	8	9	10	101	102	103	104	105	106	107	108	109	110	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Candy Crush Saga	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1	1	1
Candy Crush Soda Saga	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fishdom	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	2	1	1	2	2	2	2	2	2	2	2	2
Gardenscapes	1	1	2	2	1	1	1	2	1	1	1	1	2	1	1	2	2	1	2	2	1	2	2	2	1	2	2	1	2	2
Homescapes	1	2	2	1	2	1	1	1	1	2	1	2	1	2	2	1	2	1	2	2	2	2	2	1	2	1	2	1	1	2
Matchington Mansion	1	2	2	2	3	3	1	2	3	1	1	1	1	1	1	1	1	1	1	2	1	1	2	3	2	2	1	3	2	3
Candy Crush Friends Saga	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Best Fiends	1	2	2	2	1	2	2	1	2	2	3	3	2	2	3	3	3	2	3	2	3	3	2	2	3	2	2	2	2	2
Toy Blast	2	2	2	3	3	2	3	4	1	1	2	2	2	3	1	1	1	2	2	2	2	2	2	2	2	3	3	2	1	2

A final note before summarising the above findings, concerns the difficulty indications encountered in some levels. Indeed, most of the games studied use some form of highlighting levels that they deem particularly challenging. Unfortunately, the information accumulated was not reliable, as many videos studied did not include the pre-level screen, the location where this indication is most often encountered. Therefore, I felt that the use of partial data would not not provide any helpful or reliable insights. However, the information that was collected can still be found in the appropriate appendix.

Summary

The previous chapters contained insights accumulated by observation of the studied games, in the context of overall game design, metagame, level design perception, structure, gameplay and balancing. In this section the most interesting findings will be highlighted and summarised.

Looking at the games holistically, we can identify patterns concerning the matching style, age and developers of the games. Indeed, all studied games produced by the same developers use the same matching style, although it can be combined with different metagame elements. It is clear that tile-swapping is the dominant matching style, with blasting and line matching showing significantly less popularity. Additionally, the age of games correlates with the complexity of their metagame and gameplay innovations, at least within the same matching style. Furthermore, the theme of the games is connected with the metagame and specifically with the progression and narrative of the games. On the interface and gameplay aspects of the games, the orientation of the games seems to affect the gameplay, particularly the size of the level board. The general flow of accessing and completing a level is relatively similar for most games, and includes elements such as power-ups and performance indicators. Moreover, the in-level interface elements are rather similar for most games; a move counter, an objective counter, a performance counter and booster counter, as well as special abilities counters whenever applicable.

Upon a subjective examination of the openness and closeness of levels, there is a clear tendency to move from open to more closed layouts over time. Likewise, the early game displays more freeform levels than puzzly ones, while puzzly levels increase in later segments. Overall, the composition of studied levels significantly favour open and freeform levels, followed by closed and freeform levels, and with much lower rate by open and puzzly and closed and puzzly levels, while, the amount of puzzly levels increases over time, as described. Between different matching styles, tile-swapping games appear to favour open levels more than the other types, however the data is not sufficient to confirm it.

The examination of numerical data began by the layout's features. Looking at the level boards's dimensions, there are limited multi-board levels amongst the tile-swapping games, but most levels use one board of maximum length of 9 tiles, and width of 12 tiles. The primary orientation of tha game interface seems to affect the maximum board dimensions. There is a higher fluctuation of width over length, particularly in tile-swapping games. Concerning the aspect ratio of the games, the most preferred one is a square, followed by wider levels, and taller levels are the least favoured. Furthermore, tile-swapping games seem to favour wider layouts more frequently than the other types, however this can be attributed both to the design of the levels, and the larger boards available compared to them. Overall, the average board size is 79 tiles, with a high fluctuation. Indeed, the game showing the smallest dimensions of a gameboard area is *Best Fiends*, with a maximum board dimension of 49 tiles, while the largest board belongs to *Fisdom*, *Gardenscapes* and *Matchington Mansion*, with 108 tiles. As discussed the matching style does not appear to significantly affect board sizes, while the game's orientation seems to be of significance.

Further limitations of the permanent game board's size are a result of the presence of static blocks. The usage of static blocks is universal, with an average of 12 blocks per level, covering approximately 13% of a level's space. Notably, the second segment studied appears to use less static blocks than the other two sections, however the last section of the game uses a significantly higher amount of static blocks, indicating more intricate design layouts for the later game segment. A small amount of static blocks consists of special elements that interact with the players, and the use of those is higher in line-matching and tile-swapping games, although there is not enough data to fully support this claim. In general, there does not appear to be a clear connection between the amount of static blocks and matching styles. Upon the exclusion of static elements, an average area of 72 tiles, approximately 73% of a level's total area, is left as free matchable space. There is large variation in the final size of level boards, and the degree of variation is relative to the initial size of the boards.

Besides permanent obstacles, the starting layouts contain a significant amount of temporary obstacles. These breakable items appear in increasing frequency on the later game segments, covering approximately 30% of an average level's board. Although there was no correlation with matching styles, larger boards consistently utilized more breakable elements, and with higher frequency. On the other hand, fences were used scarcely, but with increased degree online-matching games over tile-swapping games, and did not appear on blasting games at all. Additionally, overlay elements usage and average area coverage increased overtime, regardless of matching style. Underlays were encountered only in tile-swapping and line-matching games, and only on the last segment of the later, which could signify a potential connection with the matching style. On average they displayed a level coverage ranging from 16% on early game to 18% in the late game. Finally, the amount of different matchable tiles, ranging from two to seven, was highest at the early game segment. Noticeably, line-matching games and blasting games use less colours than tile-swapping games on average, something that can be associated with their matching style.

Besides the initial layout structure, there are elements that affect the overall gameplay complexity on a mechanical level. For example, cascade manipulation, observed in all tile-swapping games, changes the ordinary flow of tiles in the level. Likewise, the less-used spawners adjust the odds of different blocks appearing in a level. However, the most significant effect on the complexity of levels is produced by the presence of different special tiles and their combinations. As expected, the count of special tiles per level increases in the later segments of the game. Furthermore, there appears to be a clear variation in the rate of introduction of new elements for each matching style; tile-swapping games introduce more mechanics at the start of the games than tile-swapping and line-matching games. Commonly in the early game there is only one special tile used at a time, especially when introducing a new mechanic, however in later segments the combination of multiple elements becomes more and more prominent. However, there does not appear to be a pattern connecting matching styles and frequency of use of new elements.

Finally, concerning the balancing of the levels, move counts fluctuate significantly, and matching types seem to affect that, specifically blasting games have significantly longer level durations on average and line-matching games have the shortest. However, the available data is not reliable enough to confirm that. Likewise, although blasting and line-matching games seem to have more kinds of objectives per level, this cannot be fully justified by the matching style. In general, the count of objectives per level increases over time.

After examining the accumulated data, it is safe to assume that the main research hypothesis is correct. Indeed the level design complexity increases over time, as can be proved by the increased variation of board sizes, the higher amount of static and breakable elements and the increased usage of overlays and underlays on the later game segments, which are all elements that affect the structure and composition of a level. Furthermore, the amount of special gameplay elements used and the higher rate of encountering new special blocks in the late game sections can justify the increased complexity of each levels' systems. Concerning the effect of the matching styles on the degree of complexity of a game, the accumulated results are inconclusive. Although there are indications that this might be true, a larger sample of games would be needed to validate the hypothesis. Likewise, the impact of the onboarding to the complexity of levels could not be fully validated.

Overall, the sample size of only ten games and only thirty levels in total did yield some interesting preliminary results. For example, the impact of a game's orientation to the level design was more significant than I had expected. However, in order to achieve more cohesive and usable results, further research is needed.

Discussion

Conducting this research has been an interesting and fruitful experience. I learnt a lot about the field I am working on, evaluated a significant amount of content from some of the most impactful games of the genre at the time of writing and became a better designer by employing critical thinking concerning game design practices. Devising a framework for study and conducting quantitative research were new and educating experiences. Furthermore, I am particularly happy to contribute to the study of a game design field I am particularly interested about, and that is still relatively unexplored. I would also like to note that the framework itself is a useful tool during the design process of a level. It can help designers deconstruct and analyse the components of a level and evaluate their importance.

Naturally, some challenges occurred while conducting this research, and there are issues that could have been handled better. Naturally, conducting research and composing a thesis, while working a full-time job can be tasking, regardless of the relevance of the fields, or the interest of the study. In hindsight, defining an even smaller scope of research would have been a wise choice and if I could restart this process I would only focus on one style of matching, as it would have been simpler to study and more reliable to compare data.

Talking about the reliability of data, it is important to point out the challenges occurring by the fact that each game uses different conventions, and the necessary allowances made in an effort to unify the data accumulated. For example, although studying brackets of ten levels was more manageable and worked well for the purposes of this thesis, the result collected may not be fully representative of that game section. In further research it would be interesting to examine larger sets of levels. Additionally, for games that have over 5000 levels, level 1000 is not necessarily indicative of late game complexity, since a lot of time has passed from its development and it is likely that the design philosophy for the game has evolved since. Of course, it is also possible the level has been reviewed multiple times since its initial development, however without knowing the design processes of different developers, or having actual data for the level it is impossible to know.

Overall, I believe the use of the framework produced some interesting insights as to how levels are structured and how each game's complexity increases overtime. Yet, there is definitely potential for further research on this topic. For example, it would be interesting to compare larger pools of data for each of the studied games, as the brackets chosen were not necessarily representative of their whole progression, due to the sheer amount of levels of most of those games. In fact, it would also be interesting to compare the studied data with data from latest levels released for each game. Likewise, it would be interesting to compare all levels of one game with the same framework, as validating how complexity evolves over time in one game would be more reliable and manageable. It would also be interesting to investigate the degree metagame aspects actually affect gameplay complexity on top of the level design, as a clear evolution of the metagame was noticed amongst games of the same matching style.

Finally, it would be interesting to collect some information about less successful games of the same genre, to validate which learnings were actually meaningful for the developers. For example, comparing top-grossing games with discontinued games from the same companies should provide some insight as to why the design did not resonate as much with the players, although, of course, the reasons for a game's success are much more complicated than that.

Expanding the framework further would also benefit future studies. For example, implementing some form of automation for data collection would speed up the process and ensure accuracy of information collected. The current process of manually counting blocks for all examined levels was a painstakingly long and potentially error-prone. Additionally, automating parts of the data analysis process and using a more specialised pipeline to examine the information and export results would certainly benefit the process. Naturally, it would also be useful to compare data collected with actual analytics provided by the games themselves, concerning the levels' performance. Unfortunately, the scope of this thesis did not justify getting access to such information.

Furthermore, interpreting the data from a player-centric lens could yield valuable information. For example, conducting user research and comparing player thoughts with the conclusions drawn solely from data examination could help clarify the effect of complexity to their perception of a level's difficulty. Furthermore, it is unclear whether the video examined in this study originated from highly skilled players or not, and whether they were paying or non-paying users. Although parameters that are affected by user monetisation were ignored, it would be interesting to see how their perception of complexity and difficulty varies. Likewise, the age and gaming experiences of players could be an interesting lense under which to study design complexity.

To summarise, this study of the complexity of level design of match-three games, proved that the level design does get more complex over time. However, there is room for further exploration on the matter, either by using the same pipeline in different, ideally larger samples, or by expanding the scope of the research and combining the developed methods with more tools.

Conclusion

The aim of this thesis was to study casual mobile match-three games, and particularly their level design in terms of structural complexity. Provided the wide financial success of those games, it is interesting to understand the relationship between their level design and player experience. My hypothesis was that their level design complexity increases over time, with the increase being related to the matching system and the amount of gameplay elements introduced on the ten levels.

For that purpose, a general study of match-three games, from a historical and design perspective was conducted, followed by an examination of the level design properties of ten top-grossing, casual match-three mobile games, utilising some of the most prominent matching styles, tile-swapping, blasting and line-matching. Specifically, the selected games were *Candy Crush Saga*, *Toon Blast*, *Homescapes*, *Gardenscapes*, *Candy Crush Soda Saga*, *Toy Blast*, *Matchington Mansion*, *Fishdom*, *Best Fiends* and *Candy Crush Friends Saga.*

The research was conducted by examining video footage of gameplay, uploaded publicly on Youtube (https://www.youtube.com/) by players. In order to analyse the material, I developed a framework focused on tracking gameplay elements that could signify variations on the structural complexity of the designs, for example the presence of special tiles and the dimensions of the level board. There were 30 sample levels for each game, divided in three sections simulating the early-game, mid-game and late-game experience of a player, specifically levels 1-10, 101-110 and 1001-1010. The accumulated material was compared to other studied games and across sections of the same game.

Indeed, the main hypothesis was confirmed, as there was a noticeable increase of the count and variation of special blocks in the late game, and an increased variation of the shapes and covered area of the level boards themselves. Although there were indications that the matching style did affect the overall complexity increase of levels over time, there was not enough data to draw a strong conclusion. Additionally, the sample size was not sufficient to confirm a correlation of mechanics introduced and later increase of complexity.

Overall, the framework provided some interesting information, however the scale of the study was not large enough to explore its full potential. I would suggest that further study is performed concerning the genre, examining games both broadly - comparing multiple games with small samples and examining few games across large samples. Combining the current framework with potential automations in the recording and interpretation of the accumulated information would improve its efficiency and yield more actionable results. Nevertheless, the framework itself is a useful tool for designers studying content in a limited capacity and can find a broader practical use in the context of evaluating games as a whole over their usability and overall performance. I would be excited to see more data-driven analysis on game and level design aspects of games, as they can help designers hone their craft and innovate more efficiently.

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Appendices

Appendix A: Match-three level design glossary

Since the topic is technical, a small glossary of common match-three design terms is included, to help establish a common vocabulary. Please note that there is no unified terminology for all match-three games, therefore some conventions used here may be referred to differently in other sources.

- **Matching tile game**: Matching tile games are video games where the player manipulates tiles in order to make them disappear according to a matching criterion (Juul, 2012a, p. 84)
- **Match-three game**: Matching tile game where the criterion for elimination is connecting three tiles of the same properties.
- **Matching**: The action of connecting tiles of similar properties. Typically, a match occurs when a number of tiles -equal or higher than the minimum required by the game - of the same type adjoin each other, concurrently being removed from the board. The way matching is performed affects the player experience significantly. Common matching methods are tile-swapping, line-matching, and blasting.
- **Tile or Block**: Singular matchable unit. Player interacts with the game by matching multiple tiles of similar properties.

- **Level**: A unique entity within the game with individual design, challenges and victory conditions.

- **Objective or Goal**: The specific task(s) required for a level to be completed

- **Turn or Move**: In match-three games typically each turn is one player action. Player actions are also called moves. Each level must be completed within a certain number of turns/moves. In the case of a defeat, players may choose to use extra moves to complete the level.

- **Extra moves**: opt-in transaction that allows players to extend the duration of their playtime with a set amount of turns. Typically a microtransaction.

- **Level Board**: The available playspace of a given level. Levels may contain one or multiple boards and board size may vary per level.

- **Level Grid:** The maximum amount of tile units placed in a level, counted width-wise and length-wise. The surface area of the level Grid equals the size of the corresponding level board.

- **Level Layout**: The specific combination of gameplay elements that is depicted in a level

- **Matchable Tiles, Matchable blocks:** Blocks that can be connected with a match, provided they display identical properties. Match-three games always contain at least two variations of matchable blocks.

- **Static blocks, Static Elements:** Indestructible blocks that remain in the level board for the duration of the level, effectively limiting the play-space. They may or may not interact with other gameplay elements.

- **Breakable blocks:** Destructible blocks that can be removed from the level board once an appropriate interaction with them is performed.
- **Collectible blocks:** Destructible blocks that can be collected from the level board once an appropriate interaction with them is performed. They are commonly used as level objectives.
- **Bombs:** Destructible blocks that can remove an amount of suitable blocks from the level board once an appropriate interaction with them is performed.
- **Boosters or Power-Ups:** Optional Elements that can be used to assist the player to complete a level. They are typically not placed on the level, rather activated from a separate interface.
- **Fences**: Linear, one-dimensional obstacles placed on the gap space between two tiles. May be breakable or static.
- **Overlay**: A destructible element covering the surface of a tile.
- **Underlay**: A destructible element placed under the surface of a tile.
- **Cascade:** Once a matching action has been performed, tiles are removed from the board and the remaining tiles are rearranged to fill the void created. Any valid locations of the grid that do not contain tiles after that, are replenished by newly generated, randomised tiles, usually being placed in the level in a cascading fashion from the top of the level towards the bottom, using a gravity simulation. The process of replenishing tiles on the level board in an organised manner is called a cascade.

- **Spawn, Spawn Chances:** The generation of a new block on the board. Usually different types of blocks have different spawn chances, affecting the average count of unique blocks in the level board and the overall balancing of the level.

- **Spawner**: An element positioned on the level board, that allows for the generation of new tiles directly within the game board, following certain criteria. Spawners override spawn probabilities set on the level cascade.

- **Shuffle:** The action of rearranging tiles on the board to generate at least one potential match on the board. Shuffling typically happens automatically once the game reaches an unsolvable state and does not subtract any moves from the player.

Appendix B: Data Tables

Table B1 - Candy Crush Saga, Early Game Data

Candy Crush Saga		Early Game									
Categories	**Level Number**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	8	9	7	9	6	5	9	9	8	9
	Maximum board height	5	9	7	9	9	9	9	9	7	9
	Max playable tiles	40	81	49	81	54	45	81	81	56	81
Statics	Static blocks (not interractible) in level	0	8	4	12	10	0	2	8	10	4
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	8	4	12	10	0	2	8	10	4
	Total matchable tiles	40	73	45	69	44	45	79	73	46	77
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	0	0	0	0
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	6	6	5	6	5	5	5	5	4	4
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	0	0	12	52	12	22	39
Special Tiles	Special tiles in Level	0	0	0	0	0	1	1	1	1	1
	Unique (not encountered before in research) special tiles in level	0	0	0	0	0	1	0	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	6	15	18	15	20	16	50	20	25	40
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B2 - Candy Crush Saga, Mid Game Data

Candy Crush Saga		Mid Game									
Categories	**Level Number**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**
Level Information	Level picture										
Layout	Open or closed?	Open	Closed	Closed	Open	Open	Open	Open	Open	Closed	Closed
	Puzzly or freeform?	Freeform	Puzzly	Puzzly	Freeform	Freeform	Freeform	Puzzly	Freeform	Puzzly	Pizzly
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	9	7	9	9	9	9	9	9	7
	Maximum board height	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	63	81	63	81	81	81	81	81	81	63
Statics	Static blocks (not interractible) in level	0	9	9	0	2	0	4	12	20	0
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	9	9	0	2	0	4	12	20	0
	Total matchable tiles	63	72	54	81	79	81	77	69	61	63
Spawners	Number of spawners in level	0	0	1	5	0	0	0	0	9	2
Breakables	Preplaced breakable blocks in level	16	21	4	26	21	10	42	0	11	18
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	4	5	5	4	4	4	4	4	4
Overlays	Tiles that contain an overlay	0	0	6	6	13	9	8	13	2	18
Underlays	Tiles that contain an underlay	0	0	33	18	24	16	8	69	8	0
Special Tiles	Special tiles in Level	2	3	4	5	2	4	5	2	4	1
	Unique (not encountered before in research) special tiles in level	2	1	2	1	0	0	0	0	0	1
Cascade	Level cascade is manipulated	0	yes	yes	0	0	0	yes	0	yes	0
	Tiles affected at start of level	0	18	2	0	0	0	8	0	16	0
Moves	Moves in Level	19	29	36	35	28	19	28	23	23	23
Objectives	Number of objectives in level	2	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	Hard	0	0	0	0	0	0

Table B3 - Candy Crush Saga, Late Game Data

Candy Crush Saga		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Open	Open	Closed	Closed	Closed	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Puzzly	Puzzly	Freeform	Puzzly	Freeform	Puzzly	Puzzly	Puzzly	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	8	9	9	8	9	9	9	9	9
	Maximum board height	9	8	9	9	9	9	9	9	9	9
	Max playable tiles	81	64	81	81	72	81	81	81	81	81
Statics	Static blocks (not interractible) in level	8	8	4	0	10	0	12	22	20	0
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	8	8	4	0	10	0	12	22	20	0
	Total matchable tiles	73	56	77	81	62	81	69	59	61	81
Spawners	Number of spawners in level	9	4	0	0	6	0	0	6	0	0
Breakables	Preplaced breakable blocks in level	37	16	29	32	16	24	37	38	10	36
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	4	5	5	5	5	4	4	5	5
Overlays	Tiles that contain an overlay	16	0	14	12	0	24	9	0	10	0
Underlays	Tiles that contain an underlay	0	28	31	0	10	0	69	0	16	0
Special Tiles	Special tiles in Level	8	6	5	5	6	2	4	3	3	3
	Unique (not encountered before in research) special tiles in level	3	3	1	1	0	0	0	0	0	0
Cascade	Level cascade is manipulated	0	yes	yes	0	yes	0	0	0	yes	0
	Tiles affected at start of level	0	18	32	0	10	0	0	0	16	0
Moves	Moves in Level	35	20	35	25	60	24	27	28	30	22
Objectives	Number of objectives in level	2	1	1	1	2	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	Hard	0	0	0	0

Table B4 - Toon Blast, Early Game Data

Toon Blast		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Closed	Closed	Closed	Open	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Puzzly	Puzzly	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	9	9	9	9	9	9	9	9	9
	Maximum board height	7	7	9	9	9	9	8	9	9	9
	Max playable tiles	49	63	81	81	81	81	72	81	81	81
Statics	Static blocks (not interractible) in level	0	0	24	12	16	0	12	9	10	14
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	0	24	12	16	0	12	9	10	14
	Total matchable tiles	49	63	57	69	65	81	60	72	71	67
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	36	48	36	3	6
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	6	6	5	5	5	4	4	4	6	4
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	0	1	1	1	1	1	1	1	1	1
	Unique (not encountered before in research) special tiles in level	0	1	1	0	1	1	0	0	1	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	99	18	22	27	26	40	45	42	25	35
Objectives	Number of objectives in level	2	2	2	3	3	1	1	2	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B5 - Toon Blast, Mid Game Data

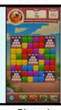
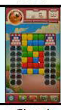
Toon Blast		Mid Game									
Categories	Level Number	101	102	103	104	105	106	107	108	109	110
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Puzzly	Freeform	Puzzly	Puzzly	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	8	8	8	8	8	9	9	9	9	9
	Maximum board height	8	8	8	9	9	9	9	9	9	8
	Max playable tiles	64	64	64	72	72	81	81	81	81	72
Statics	Static blocks (not interractible) in level	0	0	0	8	6	24	14	15	10	0
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	4	0	0
	Total non-matchable tiles	0	0	0	8	6	24	14	19	10	0
	Total matchable tiles	64	64	64	64	66	57	67	62	71	72
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	16	20	40	36	42	45	35	53	24	30
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	5	4	4	4	4	4	4	4	4
Overlays	Tiles that contain an overlay	0	0	0	28	0	36	0	24	0	23
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	1	1	2	2	3	2	2	4	2	3
	Unique (not encountered before in research) special tiles in level	1	0	1	1	1	0	1	1	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	40	50	40	26	38	32	45	36	35	34
Objectives	Number of objectives in level	1	1	2	2	3	2	2	3	2	3
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B6 - Toon Blast, Late Game Data

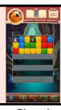
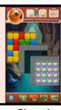
Toon Blast		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed	Closed	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Puzzly	Puzzly	Puzzly	Puzzly	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	9	9	9	9	9	9	9	9	9
	Maximum board height	8	9	9	9	9	9	9	8	9	9
	Max playable tiles	56	81	81	81	81	81	81	72	81	81
Statics	Static blocks (not interractible) in level	0	12	0	24	12	9	13	24	9	16
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	9	0	0	0
	Total non-matchable tiles	0	12	0	24	12	9	22	24	9	16
	Total matchable tiles	56	69	81	57	69	72	59	48	72	65
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	21	54	45	34	42	50	45	40	56	38
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	4	4	4	4	4	4	4	4	4
Overlays	Tiles that contain an overlay	0	0	0	16	0	20	0	12	0	9
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	1	2	2	3	3	3	3	3	3	3
	Unique (not encountered before in research) special tiles in level	1	0	0	1	1	1	1	0	1	1
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	30	30	25	30	26	40	27	34	42	27
Objectives	Number of objectives in level	1	2	2	3	3	3	3	3	3	3
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B7 - Homescapes, Early Game Data

Homescapes		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Open	Open	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	8	11	10	9	9	11	9	11	11
	Maximum board height	6	8	8	9	9	9	7	9	7	8
	Max playable tiles	42	64	88	90	81	81	77	81	77	88
Statics	Static blocks (not interractible) in level	0	12	25	38	20	8	4	13	8	30
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	12	25	38	20	8	4	13	8	30
	Total matchable tiles	42	52	63	52	61	73	73	68	69	58
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	0	0	0	0
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	5	5	5	5	5	5	5
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	20	30	30
Underlays	Tiles that contain an underlay	0	0	0	0	0	24	17	8	4	0
Special Tiles	Special tiles in Level	1	1	1	1	1	1	1	2	2	1
	Unique (not encountered before in research) special tiles in level	1	1	1	1	1	1	0	1	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	26	27	20	30	20	23	22	34	27	22
Objectives	Number of objectives in level	1	2	2	1	2	1	1	1	1	2
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B8 - Homescapes, Mid Game Data

Homescapes		Mid Game													
Categories	Level Number	101	102	103	104	105	106a	106b	106	107a	107b	107	108	109	110
Level Information	Level picture								2			2			
Layout	Open or closed?	Open	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Open	Open	Open	Closed	Open
	Puzzly or freeform?	Closed	Freeform	Freeform	Puzzly	Puzzly	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	2	2	2	2	2	2	1	1	1
	Maximum board width	11	11	11	11	11	11	11	22	11	11	22	11	11	11
	Maximum board height	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	99	99	99	99	99	99	99	198	99	99	198	99	99	99
Statics	Static blocks (not interractible) in level	8	10	5	10	14	8	18	26	19	32	19	21	18	9
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	8	10	5	10	14	8	18	26	19	32	19	21	18	9
	Total matchable tiles	91	89	94	89	85	91	81	172	80	67	179	78	81	90
Spawners	Number of spawners in level	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	45	18	40	39	47	43	57	100	3	1	4	29	0	51
Fences	Number of fences in level	0	0	0	0	7	0	0	0	0	0	0	0	0	16
Matchables	Unique matchable tiles in level	5	5	5	5	4	5	5	5	4	4	4	5	40	4
Overlays	Tiles that contain an overlay	34	47	60	0	46	0	0	0	13	13	26	9	0	0
Underlays	Tiles that contain an underlay	0	8	0	22	0	0	0	0	24	27	51	0	0	0
Special Tiles	Special tiles in Level	3	5	4	3	6	2	2	2	3	3	3	4	1	4
	Unique (not encountered before in research) special tiles in level	3	0	0	1	2	1	1	1	0	0	0	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0	0	yes	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0	0	8	0	0
Moves	Moves in Level	32	38	30	31	26	31	31	31	28	28	28	23	26	25
Objectives	Number of objectives in level	1	2	1	2	2	1	1	1	2	2	2	1	2	2
Difficulty	Has difficulty indication	0	0	0	0	0	Hard	Hard	Hard	0	0	0	0	0	Hard

Table B9 - Homescapes, Late Game Data

Homescapes		Late Game													
Categories	Level Number	1001a	1001b	1001	1002	1003	1004	1005	1006	1007	1008	1009a	1009b	1009	1010
Level Information	Level picture			2										2	
Layout	Open or closed?	Open	Open	Open	Closed	Closed	Open	Closed	Closed	Open	Closed	Open	Open	Open	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Puzzly	Puzzly	Puzzly	Freeform	Freeform	Puzzly	Freeform	Freeform	Freeform	Puzzly
Board	Multiple boards	2	2	2	1	1	1	1	1	1	1	2	2	2	1
	Maximum board width	11	11	22	11	11	11	10	11	9	11	9	9	18	11
	Maximum board height	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	99	99	198	99	99	99	90	99	81	99	81	81	162	99
Statics	Static blocks (not interractible) in level	15	28	43	22	10	6	22	17	4	19	13	5	18	28
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	15	28	43	22	10	6	22	17	4	19	13	5	18	28
	Total matchable tiles	84	71	155	77	89	93	68	82	77	80	68	76	144	71
Spawners	Number of spawners in level	0	0	0	0	0	0	0	3	0	2	0	0	0	0
Breakables	Preplaced breakable blocks in level	28	21	49	29	46	14	24	44	49	38	18	24	42	34
Fences	Number of fences in level	0	0	0	0	0	30	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	4	4	5	5	5	4	5	5	5	4	4	4	5
Overlays	Tiles that contain an overlay	28	24	52	37	0	6	9	0	16	40	8	22	30	0
Underlays	Tiles that contain an underlay	0	0	0	37	20	0	0	0	0	0	14	14	28	44
Special Tiles	Special tiles in Level	4	4	4	5	3	5	4	3	4	4	3	3	3	4
	Unique (not encountered before in research) special tiles in level	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Cascade	Level cascade is manipulated	yes	yes	0	0	0	0	yes	0	0	0	0	0	0	yes
	Tiles affected at start of level	20	15	0	0	0	0	12	0	0	0	0	0	0	8
Moves	Moves in Level	32	32	32	30	36	23	24	24	29	27	42	42	42	31
Objectives	Number of objectives in level	2	2	2	2	2	1	2	1	2	1	1	1	1	2
Difficulty	Has difficulty indication	0	0	0	0	Hard	0	0	0	Hard	0	0	0	0	Hard

Table B10 - Gardenscapes, Early Game Data

Gardenscapes		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Open	Open	Open	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	9	12	12	11	11	11	12	11	11
	Maximum board height	7	9	9	9	9	8	9	8	9	9
	Max playable tiles	49	81	108	108	99	88	99	96	99	99
Statics	Static blocks (not interractible) in level	4	12	14	20	0	14	10	24	2	24
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	4	0	0
	Total non-matchable tiles	4	12	14	20	0	14	10	28	2	24
	Total matchable tiles	45	69	94	88	99	74	89	68	97	75
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	0	0	19	69
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	5	5	5	4	4	6	4
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	0	38	40	89	0	67	75
Special Tiles	Special tiles in Level	0	0	0	0	2	2	2	1	3	3
	Unique (not encountered before in research) special tiles in level	0	1	1	1	2	0	0	1	1	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	23	27	28	25	23	26	25	29	38	30
Objectives	Number of objectives in level	1	1	2	2	1	1	1	2	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B11 - Gardenscapes, Mid Game Data

Gardenscapes		Mid Game									
Categories	Level Number	101	102	103	104	105	106	107	108	109	110
Level Information	Level picture										
Layout	Open or closed?	Open	Closed	Closed	Closed	Open	Closed	Closed	Closed	Open	Closed
	Puzzly or freeform?	Freeform	Puzzly	Puzzly	Freeform	Puzzly	Puzzly	Puzzly	Puzzly	Puzzly	Puzzly
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	11	12	12	11	11	9	9	10	12
	Maximum board height	9	9	8	8	9	9	9	9	9	9
	Max playable tiles	81	99	96	96	99	99	81	81	90	108
Statics	Static blocks (not interractible) in level	6	0	16	0	0	0	0	13	0	16
	Special tile static blocks (interractible) in level	0	3	0	0	36	14	0	0	14	6
	Total non-matchable tiles	6	3	16	0	36	14	0	13	14	22
	Total matchable tiles	75	96	80	96	63	85	81	68	76	86
Spawners	Number of spawners in level	0	3	0	0	0	2	0	0	6	0
Breakables	Preplaced breakable blocks in level	9	40	40	52	6	60	24	10	18	32
Fences	Number of fences in level	0	0	0	0	0	10	0	0	0	0
Matchables	Unique matchable tiles in level	4	5	5	5	6	5	5	5	5	5
Overlays	Tiles that contain an overlay	0	0	8	20	24	0	30	0	8	40
Underlays	Tiles that contain an underlay	36	0	0	32	63	0	48	0	0	42
Special Tiles	Special tiles in Level	3	2	5	5	6	4	4	3	5	6
	Unique (not encountered before in research) special tiles in level	1	1	4	0	2	1	0	1	0	0
Cascade	Level cascade is manipulated	0	0	yes	0	yes	0	0	yes	0	yes
	Tiles affected at start of level	0	0	4	0	36	0	0	16	0	28
Moves	Moves in Level	30	30	36	30	17	30	33	24	29	30
Objectives	Number of objectives in level	1	1	2	1	1	2	2	1	2	2
Difficulty	Has difficulty indication	0	0	0	Hard	0	0	0	0	0	Super Hard

Table B12 - Gardenscapes, Late Game Data

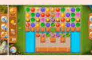
Gardenscapes		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Closed	Open
	Puzzly or freeform?	Freeform	Puzzly	Freeform	Puzzly	Puzzly	Puzzly	Freeform	Puzzly	Puzzly	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	12	12	12	12	12	11	12	12	11	12
	Maximum board height	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	108	108	108	108	108	99	108	108	99	108
Statics	Static blocks (not interractible) in level	0	0	16	38	12	0	0	24	1	18
	Special tile static blocks (interractible) in level	20	12	14	0	12	10	16	0	26	4
	Total non-matchable tiles	20	12	30	38	24	10	16	24	27	22
	Total matchable tiles	88	96	78	70	84	89	92	84	72	86
Spawners	Number of spawners in level	3	2	6	0	4	0	2	0	0	3
Breakables	Preplaced breakable blocks in level	36	69	52	54	28	66	74	8	27	48
Fences	Number of fences in level	0	0	0	0	0	0	0	10	0	0
Matchables	Unique matchable tiles in level	5	4	5	4	5	5	5	5	5	4
Overlays	Tiles that contain an overlay	8	21	18	22	24	28	0	30	17	0
Underlays	Tiles that contain an underlay	0	0	0	0	12	0	0	0	10	0
Special Tiles	Special tiles in Level	5	6	5	8	6	6	6	4	6	5
	Unique (not encountered before in research) special tiles in level	1	0	2	1	0	1	0	1	2	0
Cascade	Level cascade is manipulated	0	0	0	yes	yes	0	0	yes	yes	0
	Tiles affected at start of level	0	0	0	14	12	0	0	12	10	0
Moves	Moves in Level	28	28	24	30	26	26	31	29	24	31
Objectives	Number of objectives in level	1	2	2	2	0	2	2	1	2	2
Difficulty	Has difficulty indication	0	0	0	0	Hard Level	0	0	0	Hard Level	0

Table B13 - Candy Crush Soda Saga, Early Game Data

Candy Crush Soda Saga		Early Game												
Categories	Level Number	1	2	3	4	5	6	7	8	9a	9b	9c	9	10
Level Information	Level picture												3	
Layout	Open or closed?	Open	Open	Open	Open	Closed	Open	Open	Closed	Closed	Closed	Closed	Closed	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Puzzly
Board	Multiple boards	1	1	1	1	1	1	1	1	3	3	3	3	1
	Maximum board width	5	9	9	9	9	8	9	9	5	3	7	21	9
	Maximum board height	7	9	9	9	9	9	9	9	4	6	8	8	9
	Max playable tiles	35	81	81	81	81	72	81	81	20	18	56	168	81
Statics	Static blocks (not interractible) in level	0	0	18	7	0	4	0	0	0	0	0	74	11
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	0	18	7	0	4	0	0	0	0	0	74	11
	Total matchable tiles	35	81	63	74	81	68	81	81	20	18	56	94	70
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	0	66	1	1	1	3	3
Fences	Number of fences in level	0	0	0	0	0	0	0	0	5	3	7	15	0
Matchables	Unique matchable tiles in level	6	5	5	5	7	6	6	4	5	5	5	5	6
Overlays	Tiles that contain an overlay	0	8	4	9	26	0	5	0	0	0	0	0	5
Underlays	Tiles that contain an underlay	0	9	9	9	9	26	48	81	20	18	56	94	81
Special Tiles	Special tiles in Level	2	3	4	3	2	2	3	3	3	3	3	3	5
	Unique (not encountered before in research) special tiles in level	2	2	1	1	0	2	0	1	2	2	2	2	0
Cascade	Level cascade is manipulated	yes	yes	yes	yes	yes	0	0	0	yes	yes	yes	yes	yes
	Tiles affected at start of level	0	9	9	9	9	0	0	0	20	18	56	94	81
Moves	Moves in Level	16	25	20	20	35	20	20	25	20	20	20	20	15
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0	0	0	Hard Level

Table B14 - Candy Crush Soda Saga, Mid Game Data

Candy Crush Soda Saga		Mid Game																			
Categories	Level Number	101	102a	102b	102c	102d	102e	102	103	104a	104b	104c	104	105	106	107	108	109	110a	110b	110
Level Information	Level picture							5					3								2
Layout	Open or closed?	Closed	Open	Open	Open	Open	Open	Open	Closed	open	open	open	Open	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed
	Puzzly or freeform?	Puzzly	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Puzzly	Puzzly	Puzzly	Puzzly	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	0	5	5	5	5	5	5	1	3	3	3	3	1	1	1	1	1	2	2	2
	Maximum board width	9	9	9	9	9	9	45	9	9	9	9	9	9	9	9	9	9	7	7	7
	Maximum board height	9	9	9	9	9	9	9	9	9	9	9	27	9	9	9	9	9	9	3	12
	Max playable tiles	81	81	81	81	81	81	405	81	81	81	81	243	81	81	81	81	81	63	21	84
Statics	Static blocks (not interractible) in level	17	0	0	0	0	0	0	4	10	11	0	21	18	0	0	0	0	6	2	8
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	17	0	0	0	0	0	0	4	10	11	0	21	18	0	0	0	0	6	2	8
	Total matchable tiles	64	81	81	81	81	81	405	77	71	70	81	222	63	81	81	81	81	57	19	76
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	0	25	0	0	0	0	0	0	3	0	3	0	0	0
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	9	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5
Overlays	Tiles that contain an overlay	40	22	39	36	43	21	161	39	22	22	37	81	26	62	30	42	40	30	18	48
Underlays	Tiles that contain an underlay	32	1	2	3	4	1	11	0	3	6	5	14	35	20	0	18	0	13	5	18
Special Tiles	Special tiles in Level	2	2	2	2	2	2	2	3	2	2	2	2	3	2	4	3	4	2	2	2
	Unique (not encountered before in research) special tiles in level	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	yes	0	yes	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	18	0	0	0
Moves	Moves in Level	20	49	49	49	49	49	49	20	50	50	50	50	25	25	24	35	35	36	36	36
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	Hard	Hard	Hard	Hard	Hard	Hard	0	0	0	0	0	0	0	0	0	0	Hard	Hard	Hard

Table B15 - Candy Crush Soda Saga, Late Game Data

Candy Crush Soda Saga		Late Game													
Categories	Level Number	1001	1002a	1002b	1002	1003	1004a	1004b	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture				2				2						
Layout	Open or closed?	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Open	Closed	Closed	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Puzzly	Puzzly	Puzzly	Puzzly	Freeform	Freeform	Freeform	Freeform	Puzzly	Puzzly	Freeform	Puzzly	Puzzly
Board	Multiple boards	1	2	2	2	1	2	2	2	1	1	1	1	1	1
	Maximum board width	9	9	9	18	9	9	9	9	9	9	9	9	9	9
	Maximum board height	9	9	9	9	9	9	9	18	9	9	9	9	9	9
	Max playable tiles	81	81	81	162	81	81	81	162	81	81	81	81	81	81
Statics	Static blocks (not interractible) in level	0	27	28	55	18	8	4	12	0	5	16	18	15	13
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	27	28	55	18	8	4	12	0	5	16	18	15	13
	Total matchable tiles	81	54	53	107	63	73	77	150	81	76	65	63	66	68
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	2	0	5	0	3
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	11	8	19	29	49	13	8	4	0
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	5	4	5	5	5	5	5	5	4	5	5
Overlays	Tiles that contain an overlay	53	5	11	16	37	15	23	38	36	0	23	31	17	16
Underlays	Tiles that contain an underlay	53	5	11	16	74	6	14	20	81	0	1	31	1	14
Special Tiles	Special tiles in Level	1	2	2	2	3	4	4	4	5	3	6	6	4	3
	Unique (not encountered before in research) special tiles in level	1	0	0	0	0	1	1	1	1	3	0	0	1	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0	yes	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Moves	Moves in Level	23	35	35	35	40	43	43	43	30	30	28	30	30	30
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B16 - Toy Blast, Early Game Data

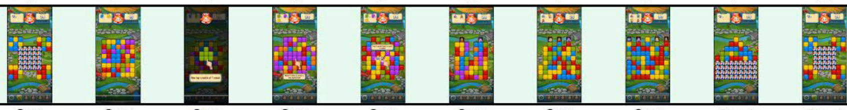
Toy Blast		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Open	Open	Open	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	2
	Maximum board width	9	7	7	9	9	7	9	9	9	9
	Maximum board height	6	8	8	9	9	9	9	9	9	9
	Max playable tiles	54	56	56	81	81	63	81	81	81	81
Statics	Static blocks (not interractible) in level	0	0	4	16	16	9	23	10	20	24
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	0	4	16	16	9	23	10	20	24
	Total matchable tiles	54	56	52	65	65	54	58	71	61	57
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	2	3	4	36	25
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	6	6	5	6	5	6	4	4	4	4
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	1	1	1	1	1	1	1	1	1	1
	Unique (not encountered before in research) special tiles in level	1	1	1	1	1	1	0	0	1	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	15	15	20	30	30	20	25	30	35	28
Objectives	Number of objectives in level	2	2	2	3	3	2	3	4	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B17 - Toy Blast, Mid Game Data

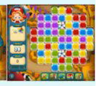
Toy Blast		Mid Game									
Categories	Level Number	101	102	103	104	105	106	107	108	109	110
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Closed	Closed	Closed	Open	Open	Open	Closed	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Puzzly	Freeform	Freeform	Freeform	Freeform	Puzzly	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	9	9	9	9	9	9	9	7	9
	Maximum board height	9	9	9	9	9	9	9	8	9	9
	Max playable tiles	81	81	81	81	81	81	81	72	63	81
Statics	Static blocks (not interractible) in level	25	5	0	9	0	4	20	0	3	15
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	25	5	0	9	0	4	20	0	3	15
	Total matchable tiles	56	76	81	72	81	77	61	72	60	66
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	47	16	75	66	36	2	2	10	20	2
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	4	4	4	4	5	5	4	4	6
Overlays	Tiles that contain an overlay	20	76	0	56	45	0	0	0	18	59
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	3	2	2	3	3	1	1	2	3	2
	Unique (not encountered before in research) special tiles in level	2	2	1	0	1	1	0	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	35	40	40	44	40	40	42	30	30	36
Objectives	Number of objectives in level	2	2	2	3	1	1	1	2	2	2
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B18 - Toy Blast, Late Game Data

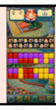
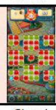
Toy Blast		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed	Open
	Puzzly or freeform?	Puzzly	Puzzly	Freeform	Freeform	Puzzly	Puzzly	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	4	9	9	9	9	7	9	8	7
	Maximum board height	9	8	8	9	9	6	9	9	8	9
	Max playable tiles	81	32	72	81	81	54	63	81	64	63
Statics	Static blocks (not interractible) in level	9	0	18	40	28	8	5	32	16	0
	Special tile static blocks (interractible) in level	0	8	0	0	2	0	4	1	0	0
	Total non-matchable tiles	9	8	18	40	30	8	9	33	16	0
	Total matchable tiles	72	24	54	41	51	46	54	48	48	63
Spawners	Number of spawners in level	0	8	0	0	2	0	4	1	0	0
Breakables	Preplaced breakable blocks in level	56	12	18	19	0	29	36	12	44	21
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	4	3	4	2	4	3	4	3	4
Overlays	Tiles that contain an overlay	0	0	0	0	51	46	0	0	0	63
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	2	2	2	2	2	3	3	3	1	2
	Unique (not encountered before in research) special tiles in level	0	2	0	1	1	1	1	1	1	1
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	50	46	33	40	55	51	50	52	60	50
Objectives	Number of objectives in level	2	2	2	2	2	3	3	2	1	2
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B19 - Matchington Mansion, Early Game Data

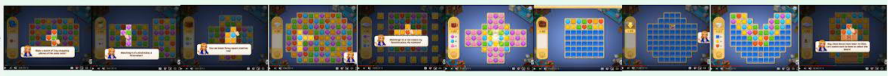
Matchington Mansion		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Closed	Open	Closed	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	12	8	12	11	11	8	8	11	7
	Maximum board height	7	7	8	9	9	9	8	9	9	9
	Max playable tiles	63	84	64	108	99	99	64	72	99	63
Statics	Static blocks (not interractible) in level	4	28	12	12	36	44	0	20	22	4
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	4	28	12	12	36	44	0	20	22	4
	Total matchable tiles	59	56	52	96	63	55	64	52	77	59
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	35	51	40	15
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	6	4	5	5	5	5	5
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	7
Special Tiles	Special tiles in Level	1	1	1	1	1	1	1	1	1	1
	Unique (not encountered before in research) special tiles in level	1	1	1	1	1	1	1	0	0	1
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	25	26	25	30	30	26	30	30	21	22
Objectives	Number of objectives in level	1	2	2	2	3	3	1	2	3	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B20 - Matchington Mansion, Mid Game Data

Matchington Mansion		Mid Game									
Categories	Level Number	101	102	103	104	105	106	107	108	109	110
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Open	Closed	Closed	Closed	Closed	Open	Open	Open
	Puzzly or freeform?	Freeform	Puzzly	Freeform	Puzzly	Puzzly	Freeform	Puzzly	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	9	12	11	11	9	12	12	11	12
	Maximum board height	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	81	81	108	99	99	81	108	108	99	108
Statics	Static blocks (not interractible) in level	4	21	14	15	11	4	32	16	13	10
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	9	0
	Total non-matchable tiles	4	21	14	15	11	4	32	16	22	10
	Total matchable tiles	77	60	94	84	88	77	76	92	77	98
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	43	30	38	72	16	18	48	52	24	35
Fences	Number of fences in level	0	0	0	0	0	40	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	4	5	5	5	5	5	6
Overlays	Tiles that contain an overlay	0	0	0	0	5	0	0	10	12	0
Underlays	Tiles that contain an underlay	0	0	64	0	0	81	0	0	36	0
Special Tiles	Special tiles in Level	3	3	4	3	4	4	4	4	4	3
	Unique (not encountered before in research) special tiles in level	1	2	2	0	1	2	1	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	yes	0	yes	0	0	yes
	Tiles affected at start of level	0	0	0	0	10	0	16	0	0	6
Moves	Moves in Level	25	22	25	26	25	22	16	29	25	22
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	2
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B21 - Matchington Mansion, Late Game Data

Matchington Mansion		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Open	Closed	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Puzzly	Freeform	Puzzly	Puzzly	Freeform	Puzzly	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	9	10	9	9	9	12	10	11	12	9
	Maximum board height	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	81	90	81	81	81	108	90	99	108	81
Statics	Static blocks (not interractible) in level	12	24	9	0	20	39	22	3	28	11
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	12	24	9	0	20	39	22	3	28	11
	Total matchable tiles	69	66	72	81	61	69	68	96	80	70
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	10	50	32	64	45	45	48	58	42	42
Fences	Number of fences in level	0	0	0	0	0	0	20	0	18	0
Matchables	Unique matchable tiles in level	5	4	4	4	4	4	5	4	6	4
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	17	57	69	54	0	48	0
Special Tiles	Special tiles in Level	2	1	2	5	4	3	5	6	6	3
	Unique (not encountered before in research) special tiles in level	1	0	0	1	1	1	0	2	0	0
Cascade	Level cascade is manipulated	0	0	0	yes	0	0	0	0	yes	0
	Tiles affected at start of level	0	0	0	48	0	0	0	0	12	0
Moves	Moves in Level	25	27	26	20	24	27	25	25	25	25
Objectives	Number of objectives in level	1	1	2	3	2	2	1	3	2	3
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B22 - Fishdom, Early Game Data

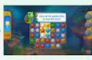
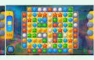
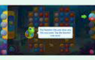
Fishdom		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Open	Closed	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	10	12	11	9	11	9	12	11	9
	Maximum board height	7	8	9	9	9	8	9	9	9	9
	Max playable tiles	49	80	108	99	81	88	81	108	99	81
Statics	Static blocks (not interractible) in level	4	12	28	4	12	0	10	22	6	4
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	4	12	28	4	12	0	10	22	6	4
	Total matchable tiles	45	68	80	95	69	88	71	86	93	77
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	1	0	0	15	31	34	63	0
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	5	5	5	4	5	4	5
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	9
Underlays	Tiles that contain an underlay	6	20	37	51	49	0	0	0	31	34
Special Tiles	Special tiles in Level	1	2	2	1	1	2	2	2	3	2
	Unique (not encountered before in research) special tiles in level	1	1	1	1	0	2	0	0	1	1
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	24	20	24	28	26	27	22	20	22	23
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	2	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B23 - Fishdom, Mid Game Data

Fishdom		Mid Game									
Categories	Level Number	101	102	103	104	105	106	107	108	109	110
Level Information	Level picture										
Layout	Open or closed?	Closed	Closed	Closed	Closed	Open	Closed	Open	Open	Open	Open
	Puzzly or freeform?	Freeform	Puzly	Puzly	Freeform	Freeform	Puzzly	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	12	12	12	12	12	12	9	11	12	11
	Maximum board height	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	108	108	108	108	108	108	81	99	108	99
Statics	Static blocks (not interractible) in level	30	23	26	18	11	28	12	8	20	16
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	30	23	26	18	11	28	12	8	20	16
	Total matchable tiles	78	85	82	90	97	80	69	91	88	83
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	58	3	26	44	15	42	42	40	38	15
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	6	5	4	5	4	5	4	5	5
Overlays	Tiles that contain an overlay	0	6	10	12	10	0	0	14	0	12
Underlays	Tiles that contain an underlay	0	49	18	0	63	42	42	48	50	37
Special Tiles	Special tiles in Level	1	5	5	5	5	6	2	3	4	3
	Unique (not encountered before in research) special tiles in level	0	2	2	1	0	0	1	0	0	0
Cascade	Level cascade is manipulated	0	yes	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	12	0	0	0	0	0	0	0	0
Moves	Moves in Level	34	34	33	25	27	26	24	25	22	37
Objectives	Number of objectives in level	1	1	1	1	1	2	1	1	2	1
Difficulty	Has difficulty indication	0	0	0	0	0	Super Hard	0	0	Hard Level	0

Table B24 - Fishdom, Late Game Data

Fishdom		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Closed	Closed	Closed	Closed	Closed	Open	Closed	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	12	12	12	12	10	11	12	12	12	12
	Maximum board height	9	9	9	9	9	9	9	9	9	9
	Max playable tiles	108	108	108	108	90	99	108	108	108	108
Statics	Static blocks (not interractible) in level	12	22	12	16	24	17	28	8	0	14
	Special tile static blocks (interractible) in level	0	0	0	8	0	0	0	0	0	2
	Total non-matchable tiles	12	22	12	24	24	17	28	8	0	16
	Total matchable tiles	96	86	96	84	66	82	80	100	108	92
Spawners	Number of spawners in level	0	0	2	2	0	0	0	0	0	2
Breakables	Preplaced breakable blocks in level	60	26	32	15	8	30	16	48	81	50
Fences	Number of fences in level	0	0	0	0	12	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	4	5	5	4	5	5	4	4
Overlays	Tiles that contain an overlay	6	0	0	21	30	12	30	18	0	6
Underlays	Tiles that contain an underlay	0	44	36	0	48	82	70	0	0	0
Special Tiles	Special tiles in Level	4	3	6	4	5	5	4	4	3	6
	Unique (not encountered before in research) special tiles in level	2	1	1	1	3	2	1	0	1	1
Cascade	Level cascade is manipulated	0	0	0	0	0	yes	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	8	0	0	0	0
Moves	Moves in Level	38	35	40	44	Timed: 2:05	23	34	25	30	30
Objectives	Number of objectives in level	1	2	2	2	2	2	2	2	2	2
Difficulty	Has difficulty indication	0	0	0	Super Hard	0	0	0	Hard	0	0

Table B25 - Best Fiends, Early Game Data

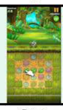
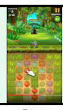
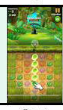
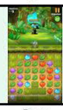
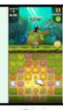
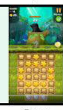
Best Fiends		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Open	Open	Open	Open	Open	Open	Open	Open	Open	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	7	7	7	7	7	7	7	7	7
	Maximum board height	7	7	7	7	7	7	7	7	7	7
	Max playable tiles	49	49	49	49	49	49	49	49	49	49
Statics	Static blocks (not interractible) in level	28	26	18	18	15	16	16	8	21	6
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	28	26	18	18	15	16	16	8	21	6
	Total matchable tiles	21	23	31	31	34	33	33	41	28	43
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	2	3	22	30	16	19
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	3	4	4	4	4	4	4	4	4	4
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	0	0	0	0
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	1	1	2	2	2	3	3	2	3	3
	Unique (not encountered before in research) special tiles in level	0	0	1	1	1	1	1	1	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	20	18	15	16	22	22	22	23	22	15
Objectives	Number of objectives in level	1	2	2	2	1	2	2	1	2	2
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B26 - Best Fiends, Mid Game Data

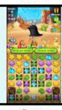
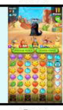
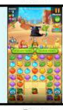
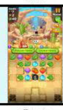
Best Fiends		Mid Game									
Categories	Level Number	101	102	103	104	105	106	107	108	109	110
Level Information	Level picture										
Layout	Open or closed?	Closed	Open	Open	Open	Open	Open	Open	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Puzzly	Puzzly	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	7	7	7	7	7	7	7	7	7
	Maximum board height	7	7	7	7	7	7	7	7	7	7
	Max playable tiles	49	49	49	49	49	49	49	49	49	49
Statics	Static blocks (not interractible) in level	3	0	0	0	0	2	0	0	0	0
	Special tile static blocks (interractible) in level	3	3	1	4	2	2	0	0	0	3
	Total non-matchable tiles	6	3	1	4	2	4	0	0	0	3
	Total matchable tiles	43	46	48	45	47	45	49	49	49	46
Spawners	Number of spawners in level	1	1	1	1	2	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	1	1	6	10	3	1	14	13	4	2
Fences	Number of fences in level	16	10	23	14	17	23	32	17	27	13
Matchables	Unique matchable tiles in level	4	4	4	5	5	4	4	4	4	4
Overlays	Tiles that contain an overlay	2	15	19	3	7	3	0	0	12	19
Underlays	Tiles that contain an underlay	0	0	0	0	0	0	0	0	0	0
Special Tiles	Special tiles in Level	7	8	7	6	4	5	4	4	4	4
	Unique (not encountered before in research) special tiles in level	6	1	1	0	0	0	0	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	40	29	27	28	28	27	31	31	29	24
Objectives	Number of objectives in level	3	3	2	2	3	3	3	2	3	2
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0

Table B27 - Best Fiends, Late Game Data

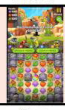
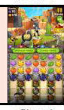
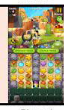
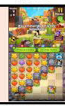
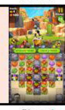
Best Fiends		Late Game									
Categories	Level Number	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture										
Layout	Open or closed?	Open	Closed	Open	Closed	Closed	Closed	Closed	Open	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Puzzly	Freeform	Freeform	Puzzly
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	7	7	7	7	7	7	7	7	7	7
	Maximum board height	7	7	7	7	7	7	7	7	7	7
	Max playable tiles	49	49	49	49	49	49	49	49	49	49
Statics	Static blocks (not interractible) in level	14	12	8	3	12	8	7	9	9	4
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	1	7	0	4
	Total non-matchable tiles	14	12	8	3	12	8	8	16	9	8
	Total matchable tiles	35	37	41	46	37	41	41	33	40	41
Spawners	Number of spawners in level	0	0	0	0	0	0	1	0	0	0
Breakables	Preplaced breakable blocks in level	13	13	15	13	16	9	7	3	18	5
Fences	Number of fences in level	4	12	22	32	19	4	7	12	12	14
Matchables	Unique matchable tiles in level	3	4	4	4	5	4	4	5	3	5
Overlays	Tiles that contain an overlay	0	0	13	13	1	0	0	0	6	9
Underlays	Tiles that contain an underlay	0	12	11	0	0	14	0	0	0	0
Special Tiles	Special tiles in Level	3	5	7	4	5	7	8	5	6	8
	Unique (not encountered before in research) special tiles in level	1	1	0	1	1	0	1	2	0	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	25	22	24	23	28	24	27	22	24	23
Objectives	Number of objectives in level	3	3	2	2	3	2	2	2	2	2
Difficulty	Has difficulty indication	0	0	0	0	Double Rewards	0	0	0	0	Double Rewards

Table B28 - Candy Crush Friends Saga, Early Game Data

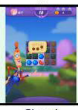
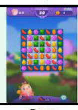
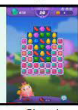
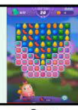
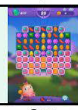
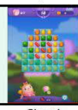
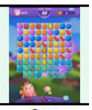
Candy Crush Friends Saga		Early Game									
Categories	Level Number	1	2	3	4	5	6	7	8	9	10
Level Information	Level picture										
Layout	Open or closed?	Closed	Open	Open	Open	Closed	Open	Open	Closed	Closed	Open
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	1	1	1	1	1	1	1
	Maximum board width	5	7	7	7	7	9	9	9	7	9
	Maximum board height	4	6	7	7	8	9	8	8	7	9
	Max playable tiles	20	42	49	49	56	81	72	72	49	81
Statics	Static blocks (not interractible) in level	0	0	0	0	6	6	5	0	6	3
	Special tile static blocks (interractible) in level	0	0	0	0	0	0	0	0	0	0
	Total non-matchable tiles	0	0	0	0	6	6	5	0	6	3
	Total matchable tiles	20	42	49	49	50	75	67	72	43	78
Spawners	Number of spawners in level	0	0	0	0	0	0	0	0	0	0
Breakables	Preplaced breakable blocks in level	0	0	0	0	0	0	0	0	0	0
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	5	5	5	5	5	5	5	4	5
Overlays	Tiles that contain an overlay	0	0	0	0	30	32	34	39	20	24
Underlays	Tiles that contain an underlay	20	42	25	49	0	0	0	0	49	81
Special Tiles	Special tiles in Level	3	2	2	2	2	2	2	2	3	3
	Unique (not encountered before in research) special tiles in level	3	0	0	0	2	0	0	0	1	0
Cascade	Level cascade is manipulated	0	0	0	0	0	0	0	0	0	0
	Tiles affected at start of level	0	0	0	0	0	0	0	0	0	0
Moves	Moves in Level	15	25	20	25	20	20	25	20	18	32
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	Normal Level	Normal Level	Normal Level	Normal Level	Normal Level	Normal Level	Normal Level	Normal Level	Normal Level

Table B29 - Candy Crush Friends Saga, Mid Game Data

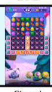
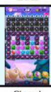
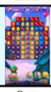
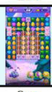
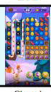
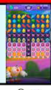
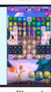
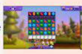
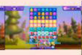
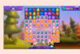
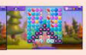
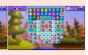
Candy Crush Friends Saga		Mid Game												
Categories	Level Number	101	102	103	104	105	106a	106b	106c	106	107	108	109	110
Level Information	Level picture									3				
Layout	Open or closed?	Closed	Closed	Open	Open	Closed	Open	Open	Open	Open	Closed	Closed	Open	Closed
	Puzzly or freeform?	Freeform	Freeform	Freeform	Freeform	Puzzly	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Puzzly
Board	Multiple boards	1	1	1	1	1	3	3	3	3	1	1	1	1
	Maximum board width	9	9	9	9	9	9	9	9	9	9	9	9	9
	Maximum board height	8	9	9	9	9	9	9	9	27	9	9	9	9
	Max playable tiles	72	81	81	81	81	81	81	81	243	81	81	81	81
Statics	Static blocks (not interractible) in level	8	4	12	0	1	0	0	0	0	0	0	1	13
	Special tile static blocks (interractible) in level	0	0	0	0	20	0	0	8	8	12	4	3	4
	Total non-matchable tiles	8	4	12	0	21	0	0	8	8	12	4	4	17
	Total matchable tiles	64	77	69	81	60	81	81	73	235	69	77	77	64
Spawners	Number of spawners in level	0	9	0	0	0	0	0	0	0	0	0	8	0
Breakables	Preplaced breakable blocks in level	22	59	33	33	26	50	38	45	133	38	28	35	28
Fences	Number of fences in level	0	0	0	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	5	4	4	5	4	5	5	5	5	5	5	5	5
Overlays	Tiles that contain an overlay	0	0	0	0	0	0	8	0	8	0	22	0	2
Underlays	Tiles that contain an underlay	0	77	19	35	0	0	0	0	0	27	77	17	1
Special Tiles	Special tiles in Level	3	5	3	4	4	4	5	4	5	6	5	7	6
	Unique (not encountered before in research) special tiles in level	0	2	1	3	2	0	0	0	0	0	0	0	0
Cascade	Level cascade is manipulated	0	0	0	0	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Tiles affected at start of level	0	0	0	0	4	0	7	7	21	8	6	2	4
Moves	Moves in Level	28	20	25	28	24	35	35	35	35	25	35	28	32
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	Hard	0	Hard	Hard	Hard	Hard	0	0	Hard	0

Table B30 - Candy Crush Friends Saga, Late Game Data

Candy Crush Friends Saga		Late Game											
Categories	Level Number	1001	1002	1003	1004a	1004b	1004	1005	1006	1007	1008	1009	1010
Level Information	Level picture						2						
Layout	Open or closed?	Open	Open	closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
	Puzzly or freeform?	Freeform	Freeform	Puzzly	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform	Freeform
Board	Multiple boards	1	1	1	2	2	2	1	1	1	1	1	1
	Maximum board width	8	9	9	9	9	9	9	9	9	9	9	9
	Maximum board height	9	9	9	9	9	18	9	9	9	9	9	9
	Max playable tiles	72	81	81	81	81	162	81	81	81	81	81	81
Statics	Static blocks (not interractible) in level	0	0	17	18	16	34	5	12	6	12	6	4
	Special tile static blocks (interractible) in level	0	0	0	0	1	1	8	1	4	0	2	0
	Total non-matchable tiles	0	0	17	18	17	35	13	13	10	12	8	4
	Total matchable tiles	72	81	64	63	64	127	68	68	71	69	73	77
Spawners	Number of spawners in level	0	0	0	0	0	0	0	6	0	0	0	0
Breakables	Preplaced breakable blocks in level	24	45	50	21	13	34	44	38	16	46	35	10
Fences	Number of fences in level		0	0	0	0	0	0	0	0	0	0	0
Matchables	Unique matchable tiles in level	4	5	4	5	5	5	5	5	5	5	5	5
Overlays	Tiles that contain an overlay	0	6	0	21	46	67	0	0	21	0	4	45
Underlays	Tiles that contain an underlay	8	5	14	9	24	33	0	5	71	1	1	47
Special Tiles	Special tiles in Level	3	5	4	5	6	6	3	7	5	3	5	5
	Unique (not encountered before in research) special tiles in level	1	0	1	0	0	0	0	0	0	1	0	0
Cascade	Level cascade is manipulated	0	0	yes	0	yes	yes	yes	yes	yes	0	yes	0
	Tiles affected at start of level	0	0	64	0	2	2	8	2	8	0	73	0
Moves	Moves in Level	20	30	30	36	36	36	30	25	25	35	29	32
Objectives	Number of objectives in level	1	1	1	1	1	1	1	1	1	1	1	1
Difficulty	Has difficulty indication	0	0	0	0	0	0	0	0	0	0	0	0