Tampere University

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A MATCH MADE IN THE MIND

Player Strategies in Mahjong Solitaire

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ABSTRACT

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Mahjong Solitaire, also known as *Shanghai* by Activision (1986), is a classical tile matching game that was popular in the early 90s. However, there is little previous academic research done on the game. This master's thesis investigates and examines novice players' strategies in Mahjong Solitaire and its relation to game design. To understand the relationship between players' strategies and game design, visual search behaviors are examined. The aim of this thesis is to investigate the potential contributions of Mahjong Solitaire to game design literature by building up on previous study of Stam (2007) that focuses on the Mahjong Solitaire solving position strategies.

We collected data from eight participants through initial survey, game sessions with think aloud protocol and post-interview survey. Thematic analysis was then utilized in order to analyze the gathered data. The results showed that participants used five strategies to solve the game board. We found a new strategy, the so-called investment strategy that is utilized by participants. Players specifically keep the matching tiles on the game board for a while, until they find another third or more matching tiles to those specific matching pairs. Investment strategy was used in order to increase the chance (profits) of clearing as many as possible tiles from the game board as a long-term strategy. Moreover, during the game sessions, participants had difficulty solving the boards where the tiles were placed condensed compared to less condensed, placed too far away from each other. Furthermore, the process of matching semantically similar pairs perceived more challenging compared to matching visually similar tiles. Besides, participants who are not Chinese speaker developed strategy to distinguish similar tile from each by assigning names to them. During the gameplay sessions, some participants changed the means to play Mahjong Solitaire by creating different ways for engaging the game such as racing against the time. Lastly, we observed similar learning processes among novice players, 1) feeling hectic and trying to survive 2) getting familiar with the rules and tile types 3) forming strategy.

Keywords: mahjong solitaire, player strategies, visual search

Preface

First and foremost, I would like to express my deepest gratitude to my supervisor Simo Järvelä for supporting me during this important process. Thank you for being an inspiring mentor, for which I am truly grateful.

I would like to thank my husband, who is my blessing, my soulmate and my best friend, Niilo Kajala. I am grateful for having you in my life and for always being there to soothe my heart and my mind with your gentle hugs and words whenever I need. Thank you for your endless support and being my cheerleader.

Lasty, I want to thank my dearest friend Vuslat who has never stopped believing in me and supporting me for over a decade.

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1 INTRODUCTION

Tile-matching games are a subgenre of puzzle games that people of all ages are familiar with. Their easy-to-play and easy-to-learn mechanisms make them accessible, entertaining and addictive. Chen and their colleagues (2018) describe the regular tile-matching gameplay as follows:

> During the games, players should identify a specific number of game elements, such as fruit, jewels, animal heads, building blocks, and Mah-Jongg cards, from a seemingly chaotic array of game elements, and then eliminate them by placing them next to each other. Players win when a required number of game elements are matched and deleted. (Chen et. al, 2018, p. 642)

Although some tile-matching games are among the most played mobile games (Chen et al, 2018, p. 642), they have not been the focus of many studies, for instance, Mahjong Solitaire is one of them.

Mahjong Solitaire (also knowns as *Shanghai* or *Mah-Jongg*) is a single-player tile-matching puzzle game which is the main aim of players is to match traditional *Mahjong* tiles with each other to remove them from the gameboard. The game also known as *Shanghai* which is Activision trademarked in 1986 (Dear, 2017, pp. 479-480). Hence, both names, Mahjong Solitaire and *Shanghai*, will be used interchangeably in this master's thesis when referring to the game.

Shanghai became sensational immediately after it was published in 1986 by Activision (Dear, 2017, p. 480). According to Dear (2017, p. 480), the end of the 80s, specifically the years 1986 and 1987 are the peak years of the game's sales. The game has been enjoying great popularity since then, and now Mahjong Solitaire, what Brodie Lockard [the creator of Mahjong Solitaire] calls, 'an entire genre of computer games' (Brodie Lockard). However, despite its enduring popularity, little research has been done on Mahjong Solitaire (Stam, 2007; Rijn 2012). Most of the studies on the game have been conducted by the computer scientists according to the available literature written in English. Moreover, Mahjong Solitaire has not yet been researched by any game scholar to the best of the author's knowledge. Therefore, to fill the gap in the literature, the subject of this master's thesis is Mahjong Solitaire.

One of the notable studies on Mahjong Solitaire was conducted by Stam (2007). The author investigated how well various solving strategies handle the solving of Mahjong

Solitaire positions by comparing four strategies and two heuristics (Stam, 2007). According to Stam (2007), the further research is required to investigate how well human players can play the game, Mahjong Solitaire, to find out if human players' strategies can be used as a winning strategy by a computer player. (Stam, 2007, p.9). The suggestion for future studies by Stam (2007) highlights the importance of understanding of player behaviour and strategies in the context of Mahjong Solitaire gameplay. Therefore, this master's thesis will be built on the study of Stam (2007) and will investigate whether similar strategies exist when actual (novice) humans play Mahjong Solitaire, or what kind of other strategies will be emerged from players' descriptions of their processes through thematic analysis.

Mahjong Solitaire as a tile matching game requires memory, strategy, and concentrated effort (Dear, 2017, p. 473). Moreover, the design of Mahjong Solitaire allows us to observe player behaviour.

As Dear (2017) explains this very eloquently:

> The game monitored your every move, with enough Self-Pacing and Immediate Feedback that Skinner himself would have been proud (Dear, 2017, p.473)

Chesman and their colleagues claimed that puzzle games can be utilized as a visual search task (Chesman et al., 2019). Moreover, in the past, Mahjong Solitaire game utilized as an educational game for teaching introductory chemistry knowledge to students (Cossairt & Grubbs, 2011).

Therefore, utilizing Mahjong Solitaire as an experimental task can provide an ideal setting to study player behaviour, herewith providing insight into the players' decision-making processes, strategies and its relation to the game design. Hence, in order to understand the relationship between player strategies and game design, players' visual search behaviours will be examined. The data will be collected through, initial survey, think-aloud protocol, post-interview survey then the collected data will be analysed using thematic analysis method.

Overall, the ultimate aim of this master thesis is to investigate potential contributions of Mahjong Solitaire to game design literature by building up on previous research of Stam (2007).

Research Questions

1) What are human (novice) player strategies for solving Mahjong Solitaire?
2) How tile layouts and tile types affect visual search behaviours of players?
3) What is the experience of novice players while playing Mahjong Solitaire?

1.1. Structure

First chapter starts with literature review of Mahjong Solitaire which introduces the game mechanics and rules of Mahjong Solitaire, and the second sub-chapter gives insight into theoretical background of visual search behaviours in games.

Second chapter is the methodology chapter where the research design and the selection of data analysis method were introduced as well as the demographic information of participants.

Third chapter highlights the findings of our research, where the themes are introduced and explained. Lastly, the conclusion sub-chapter summarizes findings and gives recommendations for the future studies.

2 THEORETICAL BACKGROUND

2.1. Introduction

This chapter begins with introduction of Mahjong Solitaire in order to gives insights into gameplay of Mahjong Solitaire from the game tiles to game terminology. Sub-chapter 2.2 dives into *Mahjong* tile set, layout, terminology and rules as well as other variants of Mahjong Solitaire. Sub-chapter 2.3 focuses on players strategies in Mahjong Solitaire and introduces four different strategies for solving the gameboard. The third sub-chapter which is the last sub-chapter of theoretical background focuses on the influence of different tile types and layout on visual search behaviour of video game players. Lastly, the objective and hypothesis of this master's thesis will be presented.

2.2. Mahjong Solitaire

Mahjong Solitaire is a tile-matching/removal game. In his book, Dear (2017) described the gameplay of Mahjong Solitaire game as follows:

> The goal is to match one tile with another identical one, and remove them from the formation. To win, remove all the pairs. But it's not easy. Many tiles are placed on top of others, in layers, and there are tricky rules about which tiles you can remove and which ones you can't until others have been removed first. (Dear, 2017, p. 472)

The process of pairing tiles requires careful consideration and planning ahead, as the player must identify matching tiles and determine the most effective way to remove as many of them as possible from the game board under the certain rules. The game ends when there are no available matching pairs left on the game board.

2.2.1. Mahjong Tiles

The original of Mahjong Solitaire game is played with a standard set of *Mahjong* tiles (see *Figure 1*). There are one hundred forty-four tiles in thirty-six quadruplets in the set. As Dear (2007) pointed out in his book, "[…] each tile having a certain symbol or number signifying which class or group it belonged to" (p. 472). However, there are variations of Mahjong Solitaire that are played with different tile sets.

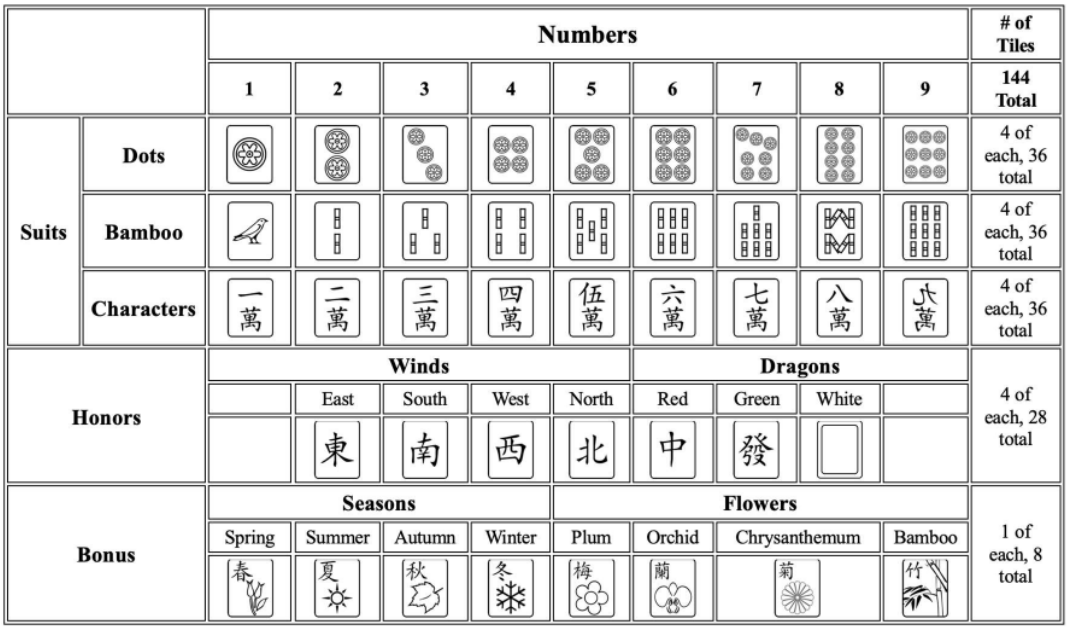

Figure 1 Standard set of Mahjong Tiles

2.2.2. Layout

There are various ways to stack the 144 tiles in Mahjong Solitaire (Stam, 2007, p.2). Bondt (2012) defined the tile layout as follows:

> In the beginning of the game, the tiles are stacked randomly on a predefined pattern, called the *layout*. The so-called *turtle layout* is used the most and therefore called the default layout as well. (p.1)

In the Turtle layout, the 144 tiles are arranged in a five-layer pattern with their faces upwards, as shown in *Figure 2* and *Figure 3*. The position of every tile is always random which is making each Turtle layout unique (Polley, 1986).

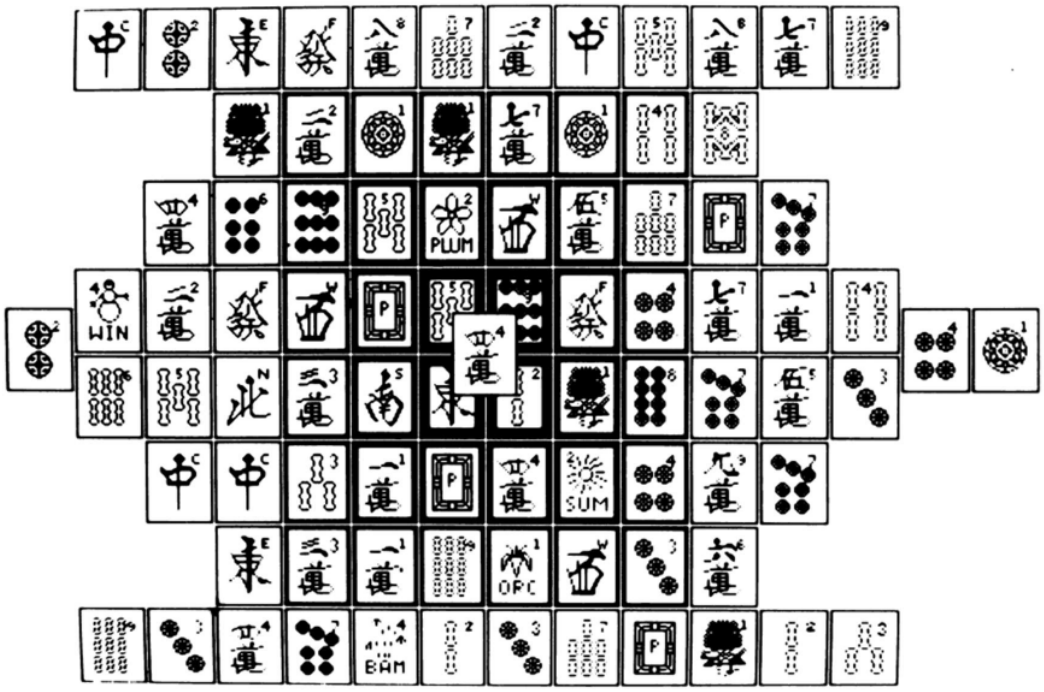

Figure 2 Top view of the Turtle layout. Taken from Shanghai™ Player's Guide (Polley, 1986. p.7)

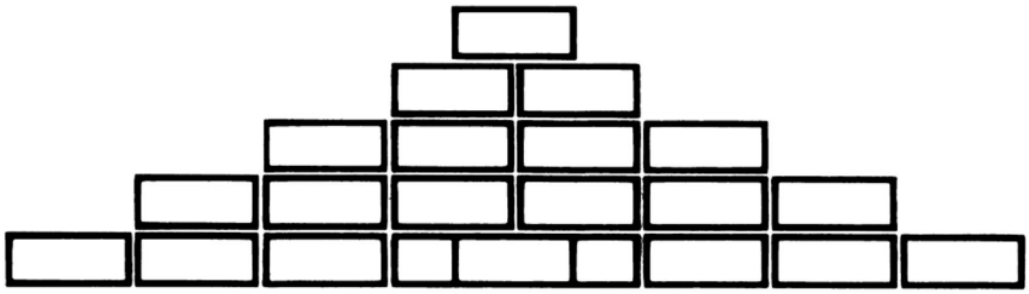

Figure 3 Left and right-side view if the turtle layout. Taken from Shanghai™ Player's Guide (Polley, 1986. p.7)

2.2.3. Terminology and Rules

Terminology

For the sake of consistency, the defined terminology for the game of Mahjong Solitaire stated by Stam (2007, p.3) will be utilized in this master's thesis. The terms along with their definitions are listed in Table 1. Terms and definitions are retrieved from Stam and stated in Table 1 (2007, p.3).

Table 1

Term	Definition
blocked	A stone is blocked when there are stones touching it to the left and to the right, or when there are stones (partially) covering it from above.
free	A stone is free when it is not blocked.
pair	A pair is two stones [tiles] with the same face.
pick	To pick a stone is to remove the stone from the pile. A picked stone plays no further role in the game position.
position	A position is one instance of the Mahjong game [*mahjong solitaire*] with a particular permutation of the faces over the available stones.
obstructor	An obstructor is a stone blocking another stone either directly, or indirectly by blocking other blocking stones. A stone that has obstructors can still be free, as long as it *only* has obstructor either to the left or to the right, and none above.
solved	A solved game position (or simply position) is a position where all stones are picked.

Rules

According to Shanghai™ Player's Guide (Polley, 1987, pp. 8-9), the rules of Mahjong Solitaire as follows:

> You can remove only "free" tiles, two tiles at a time.
>
> **"Free" Tiles.** Any tile is considered "free" if there's nothing on top of it and if can slide out to the left or right. If the tiles on both sides of it are stacked to the same height, that tile is not free.
>
> **Matching Pairs.** You can remove a pair of tiles only if they're identical.
>
> That is, an East Wind can only be paired with another East Wind, a Three of Dots can only be paired with another Three of Dots, and so on.
>
> But there *are* exceptions…

> **The Exceptions.** There are two sets of four tile that need not match. These are the Seasons and the Flowers.
>
> Any two Seasons may be removed as a pair, and two Flowers may be removed as a pair. For example, Winter matched Autumn, and Orchis matches Plum. Seasons and Flowers do not match. (pp. 8-9)

The demonstration of terminology and rules of Mahjong Solitaire are illustrated in *Figure 4*.

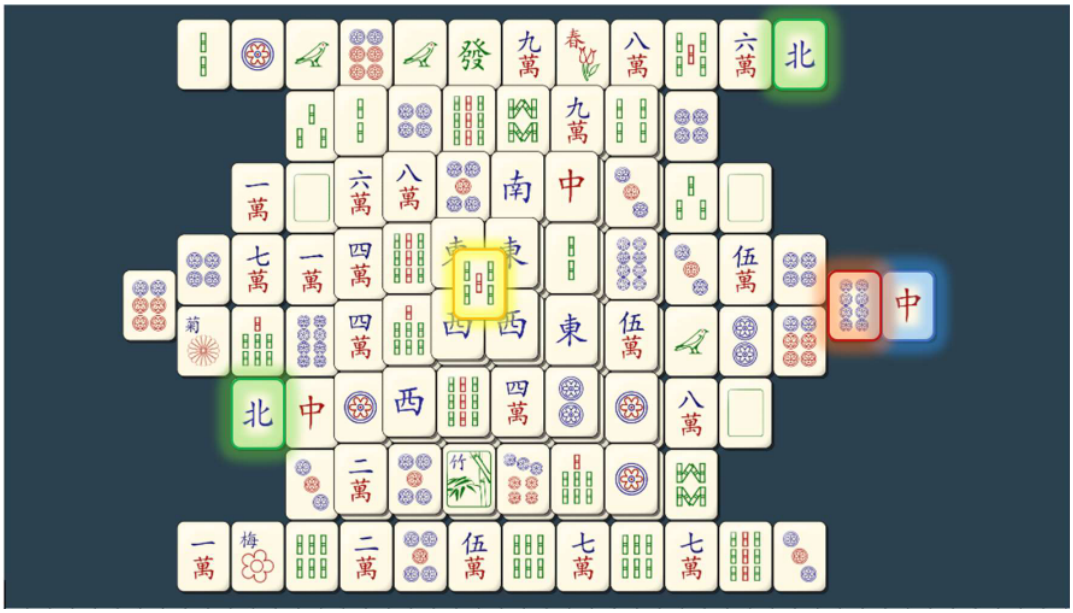

Figure 4 Screenshot of the game. Taken from the https://ffalt.github.io/mah/

In *Figure 4*, the blue highlighted tile is a free tile since it is not blocked by any other tile or tiles. However, the blue tile is an obstructor and is blocking the red tile. Therefore, the red tile is blocked. To be able to pick the red tile, the player must remove the blue tile by finding its other pair. Each green tile represents one of the pairs of matching tiles. The yellow tile is an obstructor. Although the picture is taken from the game, the author did highlight the tiles.

2.2.4. Mahjong Solitaire Variants

There are many different versions of Mahjong Solitaire, with different tiles, features and tools which some call “legal” cheat options such as back up a move so-called undo and show all moves as known as hint (Forman, 1986).

The undo option helps players to reverse their last move that they have made. On the other hand, hint option shows the players an available move (a possible matching pair) that they might not have spotted (Forman, 1986, pp. 113-114).

Some variants of Mahjong Solitaire have also a shuffle feature which will be included in our research.

Mahjong Solitaire does not have a scoring system, as the primary objective is to clear the board. Nevertheless, some variants of the game score the players based on the time taken to find a single-match or solve the entire game board. While players are scored based on how quickly they clear the board, utilizing the "back up a move" or the "show all moves" features may result in penalties, such as additional time added to their overall spend time on the game which in turn leads to reduction in their overall score.

2.3. Player Strategies

Stam (2007) demonstrates four strategies that were implemented to solve Mahjong Solitaire game positions (p.4). These strategies are Random, MultipleFirst, Greedy, and Obstruction-Tree Strategy.

2.3.1. Random Strategy

According to Stam (2007), random strategy happens when the player decided to pick a random pair from the board because these two tiles are basically free. It is random because there are other free pairs are available on the board beside the chosen one (p.4).

2.3.2. MultipleFirst Strategy

In this strategy, the player focuses on removing the sets of quadruplets, triplets and pairs. The player starts removing pairs from quadruplets then pairs from triplets and then from pairs (Stam, 2007, p.4).

2.3.3. Greedy Strategy

This is a strategy that the player's aim is to maximize the number of free stones by picking free pairs first that increase the number of free tiles (Stam, 2007, p. 4)

2.3.4. Obstruction-Tree Strategy

This strategy is little bit complex than the others since it contains two-steps. The player decides to remove a specific tile as it blocks many other tiles. So, they will find that specific tile's pair first in order to remove it that obstructor (Stam, 2007, p.5).

2.4. Visual Search Behaviour in Games

Mahjong Solitaire is a tile-matching game where the attention and pattern recognition are required to matching tiles under the certain rules and circumstances. Although we will not collect any physiological data regarding visual search behaviour of players, we will investigate whether visual elements of the game design of Mahjong Solitaire, such as tile types and tile layouts, affect the strategy formation of players and player experiences. Hence, in order to investigate the influence of tile layouts and tile types on player strategies and gameplay experiences, we need to understand visual search behaviour in games. Therefore, this sub-chapter will focus on visual search behaviour in games.

There are several studies on the influence of game design in action video games on visual search behaviour (Delmas, Caroux & Lemercier. 2022, Azizi, Abel, Stain, 2016, Montolio-Vila, Argiles, Sunyer-Grau & Quevedo, 2024, Caroux, Mouginé, 2022). However, there is not much research addressing the question of how game design in puzzle games affects player strategies. Moreover, there is limited amount of research on visual search behaviours of players in games. Therefore, the literature review is limited to give diverse examples regarding the relation of game design and visual search behaviours of puzzle game players.

2.4.1. Visual Search Behaviour on Different Tile Layouts

During the interview, we will utilize different types of tile layouts. Depends on the tile layouts, tile arrangements change. For instance, some tile layouts consist of tiles where the tiles are uncluttered which means they are too close to each other that there are barely any gaps between them. However, on the other hand, in some layout, tiles are placed cluttered and more disorganized compared to uncluttered ones (See *Figure 5*).

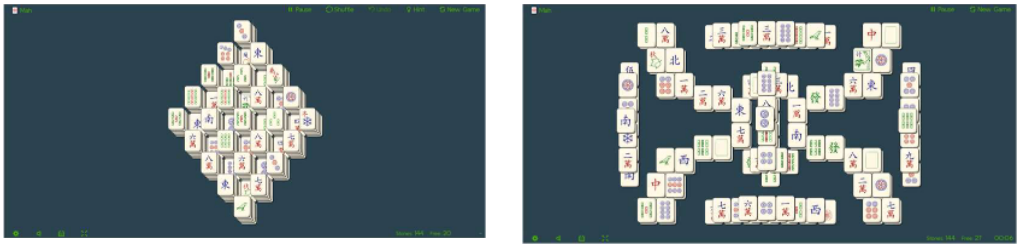

Figure 5 Cluttered versus less cluttered tile layout

Delmas, Caroux and Lemercier (2022) investigated the effect of visual clutter on performance and visual search behavior in action video games. Furthermore, they also

explored the relation between video game expertise and visual clutter, however the influence of game expertise is beyond the scope of this study. They divided fifty-eight participants into two groups: action video game players and non-action video game players then made participants search for a target object in high clutter and uncluttered visual scenes. They measured the performance by reaction times and accuracy, and their results showed that reaction time and performance is affected negatively by visual clutter.

Although Mahjong Solitaire is not an action video game, it represents complex stimuli as the positions and arrangements of tiles create object occlusion which means tiles are positioned on top of each other or covers each other from different angles in some extent. Therefore, we can compare types of tile layout by cluttered and uncluttered depends on the arrangements (adjoining and separating) of tiles on the board.

Lohrenz and Beck (2010) stated that people tend to avoid conduct searching in highly cluttered scenes and tend to start conducting search first on lower cluttered scene and then moving onto searching to highly cluttered scene. Similarly, according to Rosenholtz, Li and Nakano (2007) visual perception adversely affected by disorganized complex and crowded displays. Similar results occured in the research conducted by Beck, Trenchard, van Lamsweerde, Goldstein and Lohrenz (2012) where the visual search performance is negatively affected by clutter which results in slower visual search performance.

Hence, the first two hypothesis as follows:

H1: The players will start solving the game board from less complicated areas where tiles are easy to be seen and detected.

H2: The players will be challenged when the tile layout is more uncluttered and condensed compared to ones where tiles are placed far away from each other.

2.4.2. Visual Search Behaviour on Different Tile Types

Mahjong tile set consists of tiles that have different patterns such as numbers, letters and pictures on them. While some tiles are semantically similar, some are visually similar to each other. For example, tiles in the seasons tile group are semantically similar to each other which means they are not identical, however they belong to same tile group, and they can be paired/matched with each other, same as with tiles from flowers tile group (See *Figure 6*). On the other hand, the rest of the tiles in the tile set are visually similar to

each other, in other words, they are identical, so players match them without go through any other thinking processes like they do in matching semantically similar tiles.

Understanding how visual search influenced by the degree of visual similarity and semantic similarity of tile type to the target object, in this case it is a tile, is important for understanding player strategies and its relation to game design.

Figure 6 Semantically similar tiles

Chesman et al. (2019) manipulated the task difficulty of puzzle game by the set size and distractor heterogeneity. They found that the larger set (the number of items on the game board) increased the task difficulty. Moreover, according to the results of their study, the numbers of heterogeneous set of distractors affects the game play performance negatively (Chesman et al., 2019).

Although we will keep the set size same in all tile layouts, the level of heterogeneity among the game sessions cannot be controlled. However, *Mahjong* tile set itself presents heterogenous tiles group, so perhaps the number of distractors may cognitively challenge for players during the game sessions.

According to the study conducted by Schwarz and Eiselt (2012) revealed that people spend more time on examining distractors that are semantically similar to the target object and spend less time on examining distractors when they are semantically less similar to the target object.

Similarly, Godwin, Hout and Menneer (2013) investigated the influence of visual and semantic information on behaviour. They collected data of eye movements of twenty-one participants as participants where they were asked to search for a target within numbers from zero to nine. The authors examined the visual similarity between the target and each distractor, and the semantic similarity, for instance, the numeric distance between the target and each distractor. They found that when participants looking for a number the visually similar number to the target distract them which result in spending more time on looking at those visually similar objects. On the other, when participants were asked to find semantically similar number to the target object (number), they are distracted by numbers that numerically close to the target number. However, they found that visual

similarity has stronger effect on eye movements than semantic similarity. Participants spent more time on looking at visually similar distractors than looking at semantically similar distractors.

Hence, player may comment on how tile types affect their gameplay experience and verbalize that visually or semantically similar tiles to the target tile distract them when they are matching pairs.

Therefore, the third hypothesis is:

H3: Participants will be challenged when matching tiles from tile groups, seasons and flower.

Overall, the objective of this research is to contribute to Mahjong Solitaire literature by building this research on the study of Stam (2007). In order to accomplish that we will investigate whether above-mentioned strategies used by actual (novice) human players and explore further strategies that will emerge be from gameplay sessions that can be adapted to computer player strategies by conducting thematic analysis.

3 METHOD AND DATA

This chapter starts with the pilot study. The sub-chapter 3.1. gives insight into data collection methods, data collection process, and demographic information of participants. 3.3. introduces thematic analysis and explains why thematic analysis was chosen as a data analysis method for our study. 3.4. introduces the chosen instrumentations for collecting data. 3.5. includes ethical considerations. The sub-chapter 3.5. explains the how the data analysis process was held. Lastly, 3.6. explains the limitations of the thematic analysis and think-aloud protocol.

3.1. Pilot Study

Before conducting interviews, the pilot study was conducted in order to make sure if the research plan along with instrumentation selections for the interviews work well as intended. The participant is twenty-six years old female. She described her experience with puzzle game as fun. She likes playing puzzle games but not that often. She also thinks that puzzle games are good for brain development and improve vocabulary skills. During the pilot study, the participant played three levels of difficulty (easy, standard, expert) in two different game modes; solvable and random (this can be unsolvable game mode this is why it is random). The participant's familiarity with Mahjong Solitaire was strong, in other words, she used to play the game when she was a kid, and she came to the study prepared with at least twenty-five minutes gameplay experience prior to interview.

During the interview, two different tile types were compared to each other, Riichi and Uni tile sets. The tiles in the Riichi tile set were not easy to differentiate from each other as the patters on them very detailed and has overlapping design, so we decided to use tile set from Riichi to the Uni tile set (See *Figure 7*) during the interviews. Moreover, the participant stated that tiles that contain only one colour were easy to find and easy to differentiate from others.

The first strategy the participant mentioned was starting to match tiles from the corners as the tiles located in that area of the game board are mostly free to be selected. The second main strategy that she used was during the interview was Greedy Strategy (See in *Figure 7*).

In the *Figure 7*, there is a selected tile which look like faded orange colour in the middle of yellow circled tiles. These tiles that inside of the yellow circles are the possible matching pairs to that orange faded colour tile. The participant stated that if she chooses the tile that located on the right side of the gameboard, she will not get more tiles from out of that, so she decided to select the tile on the left side of the gameboard in order to open the tile underneath and make the bamboo tile free to be selected.

Figure 7 The illustration of Greedy Strategy

There was another game state (See *Figure 8*) that she verbalized her another strategy very precisely:

> I want to remove that stone, but in order to reach its pair, I have to get rid of these two tiles which blocking its pair.

This strategy is similar to Obstruction-Tree-Strategy.

Figure 8 The illustration of Obstruction-Tree-Strategy

This pilot study also provides insight into influence of layer type on the difficulty level. It was not easy for the participant if the tiles are not cluttered, close to each other or there is little distance between them as it was hard for her to differentiate the tiles from each other.

As we change the gameboard mode from Solvable to Random, the participant said that she became more cautious and started to think further, two or three steps ahead.

The participant also mentioned that the more she plays the game, the more she gets familiar with it. Moreover, she stated that the in-game decision-making processes are similar to the real-life decision-making processes and choices. As the participant removed the tiles, she said she feels more satisfied.

After the pilot study, she was given post-experiment survey. The participants stated that her main goal was to being faster as much as possible. When we asked her overall opinion on Mahjong Solitaire she said:

> It is a game that really requires attention, relaxing and entertains. It doesn't make me feel like I am wasting my time when I am playing this game

In light of the pilot study, we recommend participants to play Mahjong Solitaire at least twenty-five minutes before coming to the interview, until they get familiar with Mahjong Solitaire. Furthermore, we realized one hour gameplay session is enough to understand player strategies, so we decided to reduce the number of gameplays in the interview and make participants play the game at least in one Solvable mode and one Random mode.

Overall, the pilot study was successful, and it gives insight into how to conduct subsequent interviews.

3.2. Data Collection

This subchapter gives insight into participants recruitment process as well as introduces participants by giving information regarding their demographic background,

3.2.1. Participant Recruitment

Before initiating the participant recruitment process, the recommended sample size for a master's thesis by Braun and Clarke (2013), which is six to fifteen, is taken into account (Terry, Hayfield, Clarke & Braun, 2017, p. 22).

A total of eight participants (7 male and 1 female) were recruited for our study. Participants were recruited through Game Studies social media platforms such as Discord and Telegram groups. Participants were asked to sign the informed consent form and play Mahjong Solitaire game on https://ffalt.github.io/mah/ for at least 25 minutes, until they get familiar with the game, Mahjong Solitaire, before coming to the interview.

The data collected from the combination of playing Mahjong Solitaire with think aloud protocol and two surveys. Each interview sessions were conducted online, lasting no more than an hour.

We utilized think aloud protocol as a data collection method in order to record verbalized thoughts of participants during the gameplay sessions (Eccles & Arsal, 2017, Ericsson & Simon, 1980). Toh (2021) used think-aloud protocol in order to investigate the players' decision-making processes. Therefore, to understand players strategies and its relation to game design, we did used think aloud protocol as a data gathering method.

Participants are chosen based on their degree of familiarity with Mahjong Solitaire. None of the participants is expert of the game. Therefore, there will be no expert versus novice comparison in our research. The reason behind the decision of selecting novice players is that control the variables that would affect player strategies as much as we can.

Ten participants, including the participant from the pilot study signed up for the study. However, one of the participants came to the interview unprepared as she did not know the basic rules of the game and during the game session she tried to trial and error technique to solve the gameboard. Therefore, that participant's data will be excluded from the date set. Overall, eight participants were used for the study. Information regarding demographic backgrounds of participants as follows:

3.2.2. Participants

Participant 1

Participant 1 mainly plays basketball, billiards and video games, mainly ARPG games. They stated that they occasionally play different types of board games and cards games such as *The Settlers of Catan, Dixit, Taboo and Tichu*. They have been playing games since they were a three-year-old kid. They mentioned that playing games make them excited and at ease at the same time. The devices they use for gaming PS5 and PC. When

we asked them to describe their experiences with puzzle games, Participant 1 stated that they are not into puzzle games however they have experience playing puzzle games. They were not familiar with Mahjong Solitaire as they never played it before.

Participant 2

Participant 2 plays all kinds of games, from sports to boardgames, videogames and theatre games. They said that they have been playing games since they were a kid. As a gaming platform, they use PC. They stated that they are not a frequent player of puzzle games, however they are familiar with *Sudoku* and *Candy Crush saga*. When we asked how familiar they were with Mahjong Solitaire, they said they remember playing the game on PC with their mother when they were a kid.

Participant 3

Participant 3 plays a lot of video games and board games. The games they play are usually action, adventure, RPG and strategy games. They have been playing games since they were around six-years old. They use PC, PS4 and Android phone for playing games. Participant 3 stated that they rarely play puzzle games however they used to play puzzle games when they were a teenager. Participant 3 familiar with Mahjong Solitaire, however it has been 5 years since the last time they played the game.

Participant 4

Participant 4 describes their experience with gaming as extensive. They usually play JRPGs, puzzle games, Horror games and card games. They state that they have been playing games for twenty years. Participant 4 plays such as puzzles in adventure games, simple puzzles in RPGs, puzzle games such as Baba Is You, Return of the Obra Dinn, Outer Wilds. They stated they are not familiar with Mahjong Solitaire at all.

Participant 5

Participant 5 plays all sorts of games. They said they have played a wide range of both video and board game. They particularly like strategy game and they have been playing them since they were a child. They use several devices for gaming, such as PlayStation 5, Mac and NVIDIA GeForce Now streaming service. Participants 5 describes their experience with puzzle games as somewhat limited. They stated puzzle game is not a genre they like that much. They have not played Mahjong Solitaire before.

Participant 6

Participant 6 mostly plays card games, some online strategy games such as *Sudoku*. They also play boardgames such as Life and Scrabble. They use iPad and iPhone to play games. They have experience with puzzle games, however they stated they never played Mahjong Solitaire before.

Participant 7

Participant 7 describes themselves as 'God gamer'. They use PC and phone for playing games. They are an experienced puzzle gamer; however, they played Mahjong Solitaire few times, fifteen years ago.

Participant 8

Participant 8 usually plays mind games and war games online, beside *Mario* and *Hollow Night*. They been playing games since they were ten years old. They usually use iPhone or iPad for playing games. Participant 8 describes themselves as someone experienced with puzzle games positive as they like puzzle games however do not play puzzle games online. They stated that they are familiar with Mahjong Solitaire.

Overall, there are a total of eight participants with different background, nationalities and age ranges who agreed to participate in our study.

3.3. Thematic Analysis Framework

Since the main research questions aim to address what kind of strategies will be used by players for solving Mahjong Solitaire gameboard, for our qualitative research as a methodology approach, theoretical thematic analysis will be utilized for addressing research questions and hypothesis.

Thematic analysis method allows us flexibility for interpretating the data and identifying themes (Braun & Clarke, 2006). In other words, thematic analysis is a way to interpret data and making sense of it (Maguire & Delahunt, 2017). According to Braun and Clarke (2006), thematic analysis method is a way to handling big and rich data set by identifying, analysing and reporting patterns (p.79). Patterns are important because they are the footprints that lead us to themes which provide important information to address research questions. There are two different approaches in coding processes in thematic analysis to

identify themes or patterns within data such as inductive approach/analysis (bottom up) and deductive approach/analysis (top down). In the inductive approach researcher doesn't try to find a codes that fit in pre-existing framework rather the researcher develops their own framework based on the data itself, in other words codes are data-driven, on the other hand in the deductive approach researcher has idea of what to expect from the data based on pre-existing frameworks, so codes are driven by researcher's interest (Braun & Clarke, 2006). In our research, we will use deductive approach as we interested into find out if human players use the same strategies as computer player.

According to Braun and Clarke (2006), themes are identified at two levels, semantic (explicit) level and latent (interpretive) level. Latent approach was selected as it interests in underlying meanings of the data whereas semantic approach interests the surface and explicit content of the data (Caulfield, 2023). We will use semantic approach in our research.

The authors, Braun and Clarke (2006) proposed that thematic analysis consists of six steps. In the first step researcher should get familiar with data. Familiarizing with data means going through the materials such as listening, reading, watching or transcribing data. Next, after getting familiar with data, researchers should code the data. Codes are generated by labelling or highlighting anything relevant to research questions. After codes are generated, researcher should generate the themes. Then researcher should review the themes. In the fifth step, researcher should define and name the themes before the last step which is producing the report. In this master thesis, those six steps mentioned above will be followed in the analysis process.

In our research data will be thematically coded by using aforementioned player strategies in Chapter 2, under the section 2.5.5. Those strategies, which were adopted by a computer player in Stam's (2007) study, will be used in order to investigate if those strategies can be applied to understand human (novice) player strategies.

3.4. Instrumentation

First of all, in order to reach as many as participants as possible, introductory message regarding the study was shared on Game Studies social media groups such as Telegram. After that required amount of participant agreed to participate in our study. Before coming

to interview participants play the game until they get familiar with the concept of Mahjong Solitaire.

Participants were asked to sign the informed consent formed and fill the questionnaire regarding their demographic backgrounds such as gender, age and nationality and their prior game experiences (See Appendix A).

In order to conduct interviews, the software, Microsoft Teams were utilized to record participants' gameplay sessions and verbalized thoughts of their yours.

During the interview participants played Mahjong Solitaire on https://ffalt.github.io/mah/ and verbalized their decisions, strategies and emotions regarding to Mahjong Solitaire gameplay. During the game sessions, two different games modes (Solvable and Random) were used in order to select game boards randomly and unbiased. After the interview sessions, participants were asked to fill post-experiment survey (See Appendix B) which contains questions about their interview and gameplay experiences.

3.5. Ethical Considerations

In the formed consent form participants were informed about the aim of the research, their rights and how their data will be used and stored. Participants were informed that they can leave the study whenever they want without given any explanation to the researcher. Moreover, participants were informed that being participating to the research is voluntary which means they will not be provided any compensation or rewards in exchange their participation to the study. As a data protection policy, GDPR and Tampere University guidelines are followed.

3.6. Data Analysis Process

As we mentioned earlier under the 3.1., recommended six steps for analysing data by Braun and Clarke (2006) was followed. After conducting initial surveys, recording sessions and post-interview survey, we did get familiar with the data by watching recordings and reading the survey answers. After getting familiar with data, we started to generating data. The generated codes lead us to themes. After generating themes, we review the themes and names for themes were created. Finally, as a last step we did write the report.

We did report that four themes emerged from our data analysis regarding player strategies and player visual search behaviours (See Chapter 4).

3.7. Limitations

There are several limitations in our research. For example, we utilized thematic analysis which means thematic analysis can be subjective as the researcher is the one interpreting the data. On the other hand, we had only one female participant beside the one participant from the pilot study. Although the gender differences are beyond the scope of this research, they may be worth examining in relation to player strategies. Overall, the shortcoming of thematic analysis can be seen as limitations for this study.

The scope of this master's thesis is does not cover the cognitive processes and cognitive performances of players. We are interested in player strategies which are easily observed through recordings and think-aloud protocol. If further researchers intend to investigate visual search behaviour and its relation to any cognitive processes of players, we recommend them to combine think-aloud method with eye tracking method (Nisbett &Wilson, 1977, Oh, Almarode, Tai, 2013).

4 RESULTS

This chapter explains generated themes from the data codes. Result chapter starts with introduction of first theme which is novice player strategies for solving Mahjong Solitaire. There are four sub-themes emerged from the data analysis related to player strategies beside the new strategy. These four sub-themes are Random Strategy, MultipleFirst Strategy, Greedy Strategy and Obstruction-Tree Strategy which are from the study of Stam (2007). On the other hand, Investment Strategy will be introduced as a fifth strategy.

The second sub-chapter related to role of tile types and tiles layouts on visual search behaviours of novice human players.

The third theme gives insight into novice player experience as well as game engagement patterns that emerged from the data.

Fourth theme which learning, and progression describes the learning and strategy formation processes of players.

The sub second-chapter explains the role of player demographics in player strategies.

Before presents the themes, we would like to remind the aim our research, research questions and hypothesis.

The aim of the research: Contributing the literature gap by investigating the player strategies in the context of Mahjong Solitaire in order to build a study on Stam's (2007) research.

Research Questions

1) What are human (novice) player strategies for solving Mahjong Solitaire?
2) How tile layouts and tile types affect visual search behaviours of players?
3) What is the experience of novice players while playing Mahjong Solitaire?

Hypothesis:

H1: The players will start solving the game board from less complicated areas where tiles are easy to be seen and detected.

H2: The players will be challenged when the tile layout is more uncluttered and condensed compared to ones where tiles are placed far away from each other.

H3: Participants will be challenged when matching tiles from tile groups, seasons and flower.

4.1. Theme 1: Novice Player Strategies for Solving Mahjong Solitaire

Theme 1 explains what kind of strategies that players used when they are playing Mahjong Solitaire. Five strategies that were used by participants are presented and explained under this sub-chapter.

4.1.1. Random Strategy

Random Strategy (Stam, 2007) is a strategy that the player uses when matching the free tiles randomly among other free tiles. When we asked the participants if they had developed any gameboard solving strategy, Participant 1 and Participant 8 answered as follows:

> Participant 1: Yes, it's a very simple, short-term strategy: Try to combine the blocks that free as many other immediately combinable blocks as possible.
>
> Participant 8: Yes, if there are pieces that do not open yet, I look up for the ones which are open first. Then generally I find the pairs.

During the game sessions participants tend to adopt Random Strategy when they faced with the game board for the first time.

Other occasion where Random Strategy was used by players was at the end of the game when there were several tiles left on the gameboard. This may be due to their choices for the tile selection of the game does not affect the outcome of the game as all the tiles are free to be matched at that point. Participants were confident, because they know that they will successfully clear the board, eventually.

On the other hand, Random Strategy was also chosen by participants who are not feel confident enough to develop strategy. They were aware of the rules, however due to being novice players they decided to make choices and decisions somewhat intuitively.

The interesting thing is that Participant 4 used Random Strategy constantly during the game sessions, however when they were playing solvable game board, they could not manage the clear gameboard. However, they cleaned the gameboard with Random Strategy when playing Random gameboard. Perhaps, the level of effectiveness of the strategy depends on the tile arrangements.

Overall, Random Strategy was preferred by novice human players for solving Mahjong Solitaire.

4.1.2. MultipleFirst Strategy

MultipleFirst strategy was the one of the most used strategies that players utilized during the game sessions.

MultipleFirst Strategy (Stam, 2007) is a strategy that the player focuses on removing sets of same tiles, tiles that are quadruplets, triplets, or pairs. When we asked participants whether they had developed any strategies to solve the gameboard, Participant 2 responded:

> Participant 2: Prioritize getting rid of the highest layers. I you can see only two matches; it is generally fine to take those out. Especially if you can reveal or free up tiles by doing so. If you see four matching tiles which are all free, just take them out right away. If you see three or four matching tiles, but all are not accessible yet, try to prolong the decision on which ones to take out. Prioritise taking out tiles that will reveal or unlock new tiles on their own or enable that with further moves.

Although, other participants also used this strategy quite often, Participant 2 utilized this strategy during throughout of the gameplay sessions (See *Figure 9*).

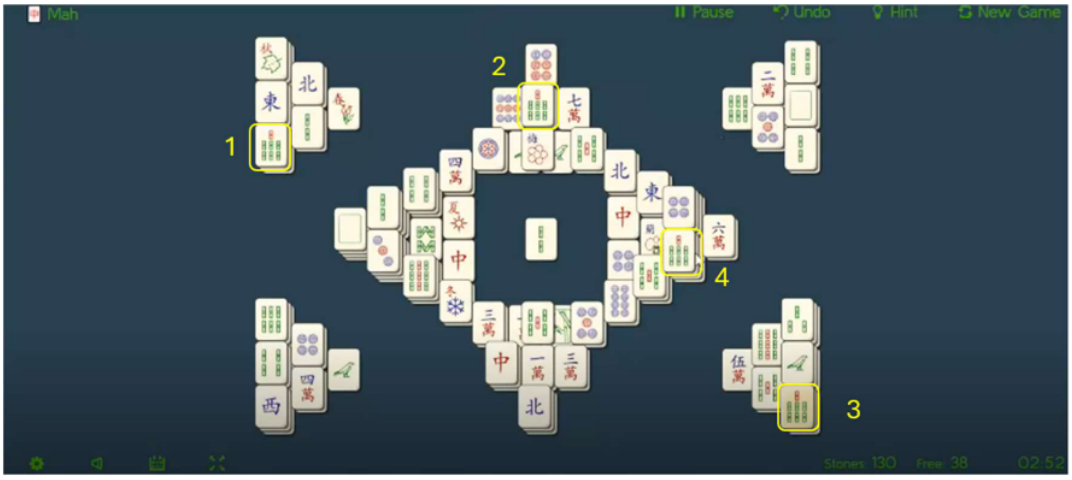

Figure 9 Screenshot from the game session of Participant 2

At this game state Participant 2 verbalized the strategy they used:

> Participant 2: There's three of those, four of those I can get off without. And I remember that there is the maximum amount of similar tiles is like 4. So, there should not be anything that's more than 4. And sometimes there is two of them. There is four, and sometimes you only have [pair].

Figure 9 illustrates how MultipleFirst Strategy works. Both in game sessions and the post-interview survey, Participant 2 emphasized on this strategy so many times.

Utilizing MultipleFirst Strategy by the participants indicates that most of the players did get familiar enough with Mahjong Solitaire before coming to gameplay sessions that they know that some tiles can be appeared on the board several times. This means the majority of the participants came to interview well prepared.

There may be a reason why some participants were looking for more than two identical tiles and prefer to using this strategy. According to Participant 3, their strategy was:

> Participant 3: Start from the top, but always try to see how many options you have for each piece. If I am about to remove a piece, I first see if there is another one of the same kind I can do instead. If so, I look at the pieces either move would free up and try to see which I might need next. I try not to remove pieces that are not blocking anything important (bottom floor pieces usually).

Ultimately, MultipleFirst strategy one of the strategies that utilized by computer player (Stam 2007) as well as novice human players.

4.1.3. Greedy Strategy

Several participants developed Greedy Strategy (Stam, 2007) during the game sessions where they aim to maximize the number of free tiles by picking free pairs that increase the number of free tiles.

Greedy Strategy requires more calculations than the Random Strategy as players are focusing in maximize the number of free tiles.

> Participant 1: My goal was to clear the board, and my strategy was to open up as many blocks as I could with each move I made.

> Participant 1: I am always trying to more of those open pairs instead of reducing the number of the tiles.

During game sessions, Participant 5 prioritized using Greedy strategy to solve the game boards.

> Participant 5: At first, I just match at random and then as it goes on, I try to leave myself as many options as possible.

Their main strategy was:

> Participant 5: To try and leave as many potential plays open as I can and to look for tiles that will open up more options.

Participant 2 also describes their main strategy as follows:

> Participant 2: Prioritizing tiles that will lead to greater accessibility and visibility, saving the tiles with lesser unlocking potential, when reasonable, to later help with those more important tiles.

During sessions, Participant 6 said that they were looking for a specific pair.

> Participant 6: For pairs, and ideally kind of, you know, uncovering one that will give me more options in the future.

Meanwhile Participant 4 describes their strategy as follows:

> Prioritize matching pairs that unlock other tiles over pairs that can be accessed at any time, identify problematic tiles that halt a lot of progress and deal with them as soon as possible.

During the gameplay sessions, participants implement Greedy Strategy by focusing specific areas of the tile layout.

> Participant 6: So, my only real strategy for this one is just kind of to remove the top layer as fast as I can.

> Participant 6: My strategy was to: 1 - work to open as many tiles on the top layer as possible, while 2 - trying to solve the long horizontal arrays first, as only the two edge pieces were usable, by using as many as the usable vertical arrays or open tiles as possible, and 3 - checking to see if a tile can be uncovered in multiple positions and choosing the best option that removed the most layers

> Participant 7: Get rid of the big piles first and prioritize unlocking paths to hard-to-reach areas (generally middle of the board). [M7 is talking about his strategy]

Participant 7: Start from side and work towards middle.

In conclusion, participants move toward the areas where the tile layers were higher in order to get rid of them to reveal tiles underneath.

All in all, Greedy strategy was a popular one among participants.

4.1.4. Obstruction-Tree Strategy

Obstruction-Tree Strategy focuses a getting rid of a tile which is preventing matching a particular pair.

This strategy adopted by several participants however, not as much as other strategies. Participants who used this strategy have solid background in playing different kinds of game for a long time, such as Participant 2 and Participant 7. Although some participants were aware of the presence of obstructor and noticed that it was preventing them to make a match, they did give up so fast and tried to find easy to match free pairs.

Participant 7 was one of the participants who used Obstruction-Tree Strategy quite often (See *Figure 10*)

Figure 10 Screenshot from the game session of Participant 7

In *Figure 10*, Participant 7 combined two strategies: MultipleFirst Strategy and Obstruction-Tree Strategy. First, they did find four identical bamboo tiles however one obstructed by the three circles tile (B1). In order to match four bamboo tiles, they had to reach tile A1. They way make A1 free, they decided to get rid of B1 by finding its matching pair.

Another example of Obstruction-Tree Strategy from Participant 7's gameplay sessions can be found in *Figure 11*.

Figure 11 Screenshot from the game session of Participant 7

Here, in *Figure 11* Participant 7 tries to match four identical tiles, however the tile that is highlighted with red colour is an obstructer which means prevents the yellow highlighted tile to be selected. Therefore, Participant 7 did match the two tiles connected with arrow first. By doing this, they picked up all of the four identical tiles in the end.

Figure 10 and *Figure 11* are examples of Obstruction-Tree Strategy. Although the same strategy adopted by the other participants as well, these two examples are chosen to explain the way of how players used Obstruction-Tree Strategy in Mahjong Solitaire.

4.1.5. Investment Strategy

Investment Strategy is a strategy that was not mentioned in the study of Stam (2007) but found in our research.

Investment Strategy is different from other strategies as it is a long-term strategy, not a short-term strategy.

In the game sessions, so many participants did not to pick up some of the free tiles for a while. They wanted to keep them until they found out another matching pair of those specific tiles which help them to increase the chance of clearing the gameboard. In other words, rather than investing in short-term matching, they kept certain tiles on the game

board, did not take them off from the gameboard and waited them to become more valuable profitable later.

However, we don't know if they would use this strategy when the game scoring based on the game completing time. We also don't know if this strategy is a time saving strategy or not because participants did spend time during the game sessions in order to find alternative matching pairs.

By not taking the particular pairs from the game board, participants save the tiles from getting wasted.

For instance, Participant 6 did not want to take the free tiles, as they decided to save them for later, for more profitable matching in the future.

> Participant 6: Try not to like waste pieces that I could save for something else.

Participant 7 described their investment strategy as follows:

> Participant 7: Start from side and work towards middle. Leave "guaranteed" tiles alone as they can match with anything easily. Their removal value is less than ones in piles as there is nothing under them.

Almost all of the participants implement this strategy during the game sessions. They calculated the value of tiles and make moves according to that. By using investment strategy, participants showed that the orders of matching tiles are important factor for clearing the board.

In conclusion, this theme answers our research questions by providing strategies that novice human players prefer use to solving Mahjong Solitaire gameboard.

4.2. Theme 2: Influence of Tile Types and Tile Layouts on Visual Search Behaviours

The second theme focuses on tile types and tile layout, how different tile types and tile layout affect visual search behaviours of players, and the way players approach Mahjong Solitaire.

4.2.1. Challenge related to tile identification.

As we mentioned on literature review, identification tiles from the *Mahjong* tile set would be challenging as the number of heterogeneity of tiles.

During the gameplay many of the participants spent a significant amount of time matching tiles that were semantically similar. Several participants find this process difficult and challenging. For instance, when we asked participants what they found difficult when they are playing Mahjong Solitaire, Participant 8 and Participant 2 explicitly point out the tile types.

> Participant 8: Some of the pieces were different but matching!
>
> Participant 2: Distinguishing between certain tiles and understanding which non-visually matching tiles actually go together.

Furthermore, Participant 3 described processes of matching tiles as follows:

> Participant 3: But overall, it is a bit straining and exhausting to look at the pieces.

During the interview Participant 3 tried to matching Fall tile with the Chrysanthemum tiles and Fall tile with Orchid tile several times (See *Figure 12*). As we know, while Fall belongs to the Seasons tile group, Chrysanthemum and Orchid belong to the Flowers tile group.

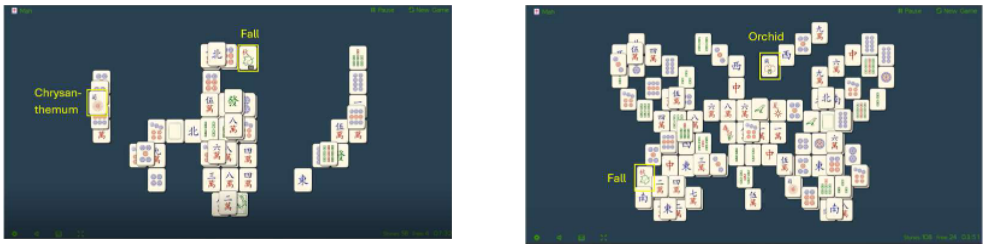

Figure 12 Screenshots from the gameplay sessions of Participant 3, two different occasions where they tried to match tiles from different tile groups.

Likewise, during the gameplay sessions Participant 8 tried to match the Fall tile to Bamboo (See *Figure 13*).

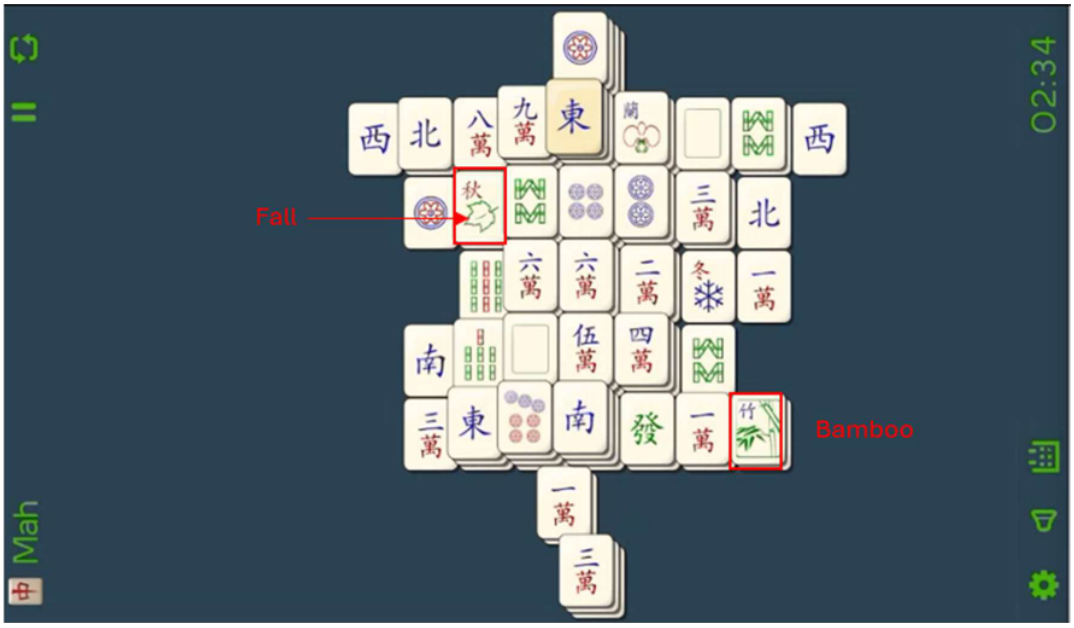

Figure 13 Screenshot from Participant 8's gaming sessions, where they tried to match the Fall tile with the Bamboo tile

During the interview, Participant 2 mentioned their experience with semantically similar tiles as follows:

> Participant 2: In the testing rounds before today, I had issues because there are a few tiles that you don't have the exact match for, but you have to kind of recognize that there are different types of seasons, for example. So, I was able to figure out those, but they puzzled me for a while when I tried to understand how things were going.

These results in line with our third hypothesis and with previous studies (Schwarz & Eiselt, 2012; Godwin, Hout & Menneer, 2013) mentioned in the theoretical background chapter by proving that matching semantically similar tiles in the cluttered environment was challenging for participants.

Overall, matching semantically similar tiles was not easy compared to visually similar tiles, and physically and cognitively challenging according to participants.

The theme of influence of tile types is related to our research questions as it addresses to question of how tile layouts and tile types affect players' visual search behaviours.

4.2.2. Challenge related to cluttered versus condensed layout

The influence of tile layout theme focuses on the effect of different tile layouts on visual search behaviours of players and players' experiences.

Several participants expressed their experience with playing different types of layouts. For instance, when we asked participants what they found difficult while they were playing Mahjong Solitaire Participant 5 responded as follows:

> Participant 5: I've only played on the turtle shape and using the random ones made the game much more interesting and also more challenging.

Meanwhile, Participant 3 did give more general answer to this question

> Participant 3: Keeping your eyes focused, as the tile layout can be confusing.

During the game sessions participants played different randomly selected tile layouts. So, the player more likely not familiar with the layouts that is presented to them. During the data analysis similar codes was generating regarding playing with unfamiliar tile layout. For instance, Participant 5 mentioned the difficulty of playing with unfamiliar tile layouts during the recordings and in their survey answers.

> Participant 5: I haven't played this shape before, so I'm not kind of quite familiar with where they can slide it out from. This is definitely more difficult shape than the turtle one. I have been playing in the turtle one. This is a more, this is a bit more challenging. (See *Figure 14*)

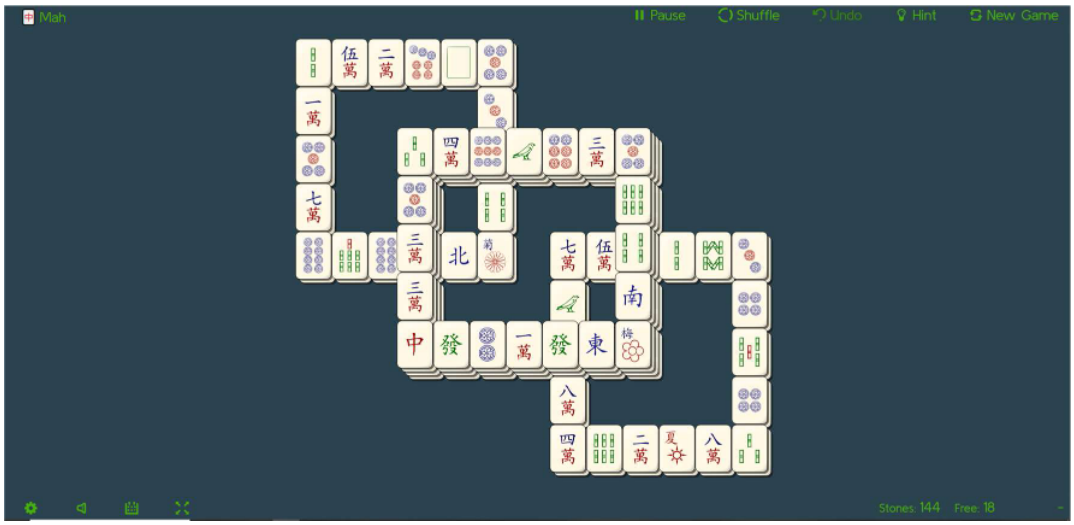

Figure 14 The layer called Boxed

Participant 7 stated that the more condensed tile arrangements were more difficult.

> Participant 7: The ones that are full blocks, it is really, it is a lot more difficult for me at least. Also, I guess it was hard for me to see the layers and make comparisons or adjustments to which was the better choice between removing card.

Furthermore, several participants decided to solve the gameboard from outside of the layout the inside of the layout. For instance, one of the participants who tried to solve the gameboard this way was P1 (pilot study).

> P1: Generally, I preferred to start from the edge stones. I tried to progress from the edge to the middle. It comforts me to think that I am progressing in an orderly manner.

Participant 6 was a participant who can speak Chinese fluently. Unlike other participants they refer to tiles by their actual name. While other participants tried to memorize tiles by naming them with different names such as, star looking etc.

Participant 6 describes their overall experience with tiles and tile layouts:

> Participant 6: I realize that I am not very good at identifying/finding matching pieces quickly, so it was more difficult to create a winning strategy. (I am very bad at the find a needle in a haystack books or games) I did enjoy some of the simpler game arrangements, as I actually felt like I was accomplishing something. Other than that, I do recognize Chinese characters, so I guess I had some advantage, in that I knew what the characters meant, and could quickly do comparisons.

Understanding the game from the perspective of Chinese speaker was important because English speakers were not familiar with Chinese letter which makes the game little bit harder for them as similarity between letters was high enough to makes distract players to differentiate tiles from each other.

Ultimately, our findings in line with our first hypothesis and previous works of other scholars (Lohrenz & Beck, 2010; Rosenholtz et al., 2007; Goldstein & Loren, 2016).

4.3. Theme 3: Novice Player Experiences and Game Engagement

This theme gives insight into player experience and engagement in relation to Mahjong Solitaire.

4.3.1. Emotional responses

Most of the players described their gameplay experience as ‘fun’, however also cognitively and emotionally challenging due to several reasons. For instance, Participant

1 describes their gameplay experience and opinions about the game respectively as follows,

> Participant 1: I enjoyed myself, probably because I love playing games. Also, I felt cognitively challenged and intrigued because I had never played a game like this this before.

> Participant 1: It is quite fun the first few times you play, I guess, but I don't think it could keep me hooked for days. I prefer games that are about action and emotion. Then again, the core loop is rather elegant as all you do is combine blocks of the same type.

We got similar answer from Participant 5 and Participant 6 regarding preferring other games over Mahjong Solitaire. In the first survey, both participants stated that they are not into playing puzzle games, so it makes sense that why they think they are not likely to going to play the game after the interview.

> Participant 5: It's pretty fun. I could see myself playing it every now and then, but I'm not sure if I actually will as there are other games I find more interesting.

> Participant 6: It was interesting, but I wouldn't say that I would play the game much in the future. I appreciate being "forced" to try a new game for at least a 30 minute period, as it allowed me to truly see if I clicked with the game and could form strategies as well as form an appreciation or like for it. But, overall, I prefer games that involve math skills, or more complex problem solving skills, like light bot(coding), cut the rope, or stack. So, I found myself losing concentration, and just hoping to get to the end of the pile of tiles rather than enjoying the actual play. Thank you for the opportunity to try something new, but Mahjong Solitaire is not my cup of tea.

> Participant 6: But overall, I did not really enjoy playing, and I probably would not play this game in my free time.

When Participant 1 was asked what he found difficult when playing Mahjong Solitaire, they mentioned that the game was emotionally and cognitively challenging.

> Participant 1: Understanding the basic idea behind the game and facing the emotional challenge of not really knowing what I am doing.

Similarly, other participants also talked about cognitive challenges they faced.

> Participant 8: It was mind boggling

> Participant 3: It is straining for the eyes and the brain, but in small doses it's fun

Participant 7 enjoyed the game but also found it ‘unfair’ as clearing tiles are not easy or possible all the time.

> It's a fun but unfair game. You can already see that the game is over dozen+ moves before the game actually ends because some of the piles just can't be emptied.

P1 also conveyed her perception of Mahjong Solitaire in an interesting way:

P1: This game reminds me of decisions that I made in my life that I can’t take it back.

This was an interesting comment, it gives ideas for future studies as motives researchers to investigate the relation between real life related decision-making processes and Mahjong Solitaire gameplay styles.

In conclusion, although Mahjong Solitaire has easy mechanics to be learned and played, this does not mean that it is enough to attract everyone. Participants who like playing games in general did have good time playing Mahjong Solitaire. Perhaps, it is because their game repertoire is wide and they like playing and exploring games for it owns sakes.

4.3.2. Engagement Through Creating Meaningful Challenges

Some players creating ‘imaginary’ rules or goals in order to become ‘successful’. Some raced with times, some approaches the game as a memory game, and others tried to solve the board quickly from top to the bottom.

Even though gameboard completion time was not considered as a factor to rate players’ success, some participants wanted to race against to time. They engage with Mahjong Solitaire by creating challenges and forming strategies based on them.

For example, P1 and Participant 8 describe their main goals and strategies as follow:

> P1: Making matches as fast as I can,
>
> Participant 8: Quickly finishing up from top to the bottom.

Meanwhile, Participant 4 approaches Mahjong Solitaire as a memory game. Their strategy was

> Participant 4: Play it like a game of memory.

During the gameplay sessions, participants did alter the means to play Mahjong Solitaire. In other words, they created unconventional ways for engaging with game.

The reason why they play the game in an unusual way is a matter of question as they did not give any further explanation regarding these matters. However, it is worth to investigate why participants decided to create new means to play the game.

4.4. Theme 4: Learning and Progression

We have observed similar learning processes of novice players and changes in strategies that they adopt overtime.

First phase of the learning processes of players was exploring the gameboard and trying to find a good strategy as soon as possible because participants were of the fact that Mahjong Solitaire was a game with consequence, and every decision they make in game have some consequences.

Usually, first ten minutes of the game was hectic for players. For example, Participant 1 stated that they should have had a strategy, but they did not know what kind of strategy they should form.

Participant 1 described the first phase of learning process of how to play Mahjong Solitaire very precisely.

> Participant 1: I constantly felt like I should have a master plan as to how to approach each constellation of blocks, but I was just trying to survive.

Most of the participants formed strategies after they warmed up.

> Participant 3: I learned a bit about what you need to think about during play.

This same learning curve occurs, the same pattens of getting used to play Mahjong Solitaire did occur among all of the participants.

After that, they started focusing on tile types and layouts, the aspects of the game required attention and focused.

> Participant 2: I have not been playing this for a long time (maybe not at all as an adult), so it was a lot about discovering strategies and reasonings for my actions. And then just studying the interface and trying to recognize the matching tiles.

Participants usually started feeling confident with their decisions and choices when the game board was changed to Solvable to Random although in the Random mode there are no assisting features to help them. Perhaps, at this point of the game participants already did get used to playing Mahjong Solitaire and playing in Random mode made them more careful about their choices

4.5. Player Demographics and Mahjong Solitaire

Although the influence of having background in playing games on gameplay style was not scope of this research, we found some emerging patterns in relation to this matter.

First of all, participants who has experience with playing different kinds of game genres showed faster adaptation to understanding the game rules and mechanics compared to participants who has narrow repertoire in playing games from diverse genres. Even though experienced game players are not into playing puzzle games, they made more tactical and mindful decisions more often than participants who like playing puzzle game-like genres.

Moreover, participants who are not Chinese native speakers, developed different strategies by trying to find any differentiation factors between the tiles (colours, patterns) and assigning new names to tiles as a memorizing strategy.

4.6. Conclusion of Findings

Our first research was: What are human (novice) player strategies for solving Mahjong Solitaire?

There are five strategies that emerged from our data analysis process regarding novice player strategies for solving Mahjong Solitaire gameboard. Four strategies that we found are related strategies that are mentioned in the study of Stam (2007). However, we discovered fifth, the new strategy which is called Investment Strategy that players use it by keeping the free tiles on the board for a while in order to make the more profitable matching later on the game.

Second research question was: How tile how tile layouts and tile types affect visual search behaviours of players?

We hypothesized that 1) players will start solving the game board from less complicated areas where tiles are easy to be seen and detected and 2) players will be challenged when the tile layout is more uncluttered and condensed compared to ones where tiles are placed far away from each other.

The results showed that when the in-game elements positioned too close to each other, participants get exhausted physically and cognitively. In other words, when the layer shape consists of tiles which are located too close to each other (condensed), finding matching pairs become more difficult and exhausting for the eyes.

Furthermore, third hypothesis is 3) participants will be challenged when matching tiles from tile groups, seasons and flower.

Moreover, matching pairs that are semantically similar to each other was challenging compared to matching pairs that are visually similar tiles. Our findings give insight into the influenced of game design on player strategies by investigating the challenges that occurred during the visual search behaviours of players due to the tile types and tile layouts.

In conclusion, the results are in line with our hypothesis and previous studies (Schwarz & Eiselt, 2012; Godwin, Hout & Menneer, 2013) as well as gives insight into to address our research questions.

Players' degree of familiarity to the in-game elements affects their perception of challenge as well as problem-solving strategies. For instance, participants who did not speak Chinese noted that the Chinese letters on the tiles were look so similar to each other, and they assigned new names to them so they can easily distinguish specific tiles among others.

Our third research question was: What is the experience of novice players while playing Mahjong Solitaire?

Some of the themes gives insight into learning curve of novice players in Mahjong Solitaire as well as their way of engaging with the game. For instance, Mahjong Solitaire, due to its nature as a consequential game, created a sense of urgency in participants to

form a strategy in the beginning of the game. However, players start forming strategy after they get familiar with the tile types and the game rules.

We found that some participants created their own in game goals and challenges. For instance, overall game playing time was not considered an indicator of being successful in the game however, some participants stated that they wanted to complete game as fast as possible, or they wanted to match the tiles from top to bottom.

Overall, our research also indicates that Mahjong Solitaire can be used in order to explore player behaviours in relation to game design.

For future studies we suggest that

1) Conducting quantitative research by collecting physiological data from participants in order to get deeper understanding of visual search behaviours of players.

2) Having a bigger and diverse sample size.

3) Investigating the relationship between cognitive styles of players and decision-making strategies in Mahjong Solitaire.

4) Investigating if there is any relation between decision-making processes in Mahjong Solitaire and economic concepts.

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APPENDIX A. INFORMED CONSENT FORM

Hello,

My name is Rana Ince, and I am a Master's Student in Game Studies at Tampere University. The objective of my master's thesis is to investigate player strategies in Mahjong Solitaire. There is little research on Mahjong Solitaire in scientific literature, therefore by conducting experiment I aim to fill this literature gap.

I will be conducting the experiment under the supervision of Simo Järvelä (simo.jarvela@tuni.fi). The data will be collected through this consent form where the demographic information is asked and recordings of gameplay sessions through think-aloud protocol. Before participating in the experiment, you must play Mahjong Solitaire (https://ffalt.github.io/mah/) for at least 25 minutes. The duration of the experiment approximately 1 hour and you will be asked to play the game, Mahjong Solitaire, 6 times. After that there will be post-experiment survey.

Your data will be collected and processed by following GDPR and Tampere University guidelines. The collected data will be accessible only to my supervisor and me. Your data will not be shared to any other third party. The data will be stored in my personal computer. The results of this experiment will be published but your identity will be remain anonymous. After the master's thesis the data will be stored in my personal computer for future studies.

Being participated to this experiment is voluntary and the participants can withdraw from the experiment by contacting to researcher whenever they want without given any explanation, then their data will not be processed. By filling out this form, you confirm that you read and understood the above mentioned information. Moreover, by filling out this form you are agree to participate in this study.

For further information, please contact me (nermin.ince@tuni.com) or Simo Järvelä (simo.jarvela@tuni.fi).

Questions

1) What is you gender?
2) What is your nationality?
3) Could you describe your gaming experience? What types of game do you usually play? How long have you been playing games?
4) What devices do you use for gaming?
5) Could you describe your experience with puzzle games?
6) How familiar are you with Mahjong Solitaire?

APPENDIX B. POST-INTERVIEW SURVEY

1) How many minutes did you play *Mahjong Solitaire* before coming to this experiment?

2) How was your gameplay experience?

3) What did you find difficult when playing Mahjong Solitaire?

4) Have you formed any strategy to solve gameboard? If so, could you explain it.

5) What was your main goal/strategy for solving gameboard?

6) What is your overall opinion on Mahjong Solitaire?