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DESIGNING KOKOTAP – HELPING PLAYERS TO KEEP TRACK OF GAME STATE IN BOARD GAMES

M. Sc. Thesis
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ABSTRACT

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The activity of playing a board game is often a complex one, where a player must keep track of not only their own actions, but also the actions of other players. Strategy board games often only add to this complexity by utilizing a complex game structure, where different actions are available at different times. Though various digital tools and helper applications have been developed for countless board games, their purpose tends to be restricted to the automatization of game tasks traditionally done with physical game components. This thesis presents the design and implementation of a board game helper application that provides users a visual representation of active player turns, the ongoing phase of the game round, and the available game actions. By providing players a digital tool they can use to keep track of the game state, the application aims to make the task easier to accomplish, thus lowering the barrier of entry into board gaming for those who may struggle with the task. A user study with eight participants was conducted to evaluate the effectiveness of the application and its effect on the playing experience. Based on the results of the evaluation, the application helped players to feel more confident playing the game despite its complexity and lessened the amount of mental effort needed to keep track of the game state. An appealing and calm design of the application helped it to blend in the context of a board game play, where it did not cause perceivable negative effect to the experience of playing. The results of this thesis demonstrated a use for a digital tool in board games that did not automate any physical tasks but instead helped players with the mental tasks required to play the game.

Keywords: Board games, Tabletop games, Strategy board games, Digital tools, Mobile application, Divided attention, User Experience Design, Calm Technology, Calm Design

USE OF AI IN THESIS

I have utilised AI tools in my thesis:

☒ No
☐ Yes

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1. INTRODUCTION

It is no wonder that in the current digital age, digital tools have found their way into board gaming, providing both convenience and new possibilities. They can be used to randomize and calculate turn order and enemy actions [1–3], automate game setup or card shuffling [4], track player health points and scores [5], keep track of information between games [6,7], or provide immersion into the world and theme of the game with dynamic background music and narration [8–11]. In tabletop role-playing games (TTRPG), digital character sheets are used for automating the process of creating new characters for the game, and to keep track of character statistics during gameplay [12–18]. In addition to supporting existing board games, digital tools are a core part of hybrid board games, where they are used to generate randomized content for the game, or to guide players through the adventure [19–23]. Looking at the landscape of digital tools in board games, a common element shared between the tools is the automation of tasks, be it randomization, calculation, note keeping, or narration. What has so far remained unexplored are digital tools that focus on supporting players in the activity of playing the game. Instead of automating tasks that are done manually with physical game components, the focus of this thesis is on tasks that are typically done mentally – keeping track of whose turn it is to act, remembering what actions can be taken at different times, or what actions have already been completed. The goal of the thesis is therefore to develop and evaluate such a digital tool, while answering the following research questions:

1. **How does a digital tool keeping track of the game state in a complex board game affect the players' experience?**
2. **Can a digital tool help players with mental tasks in board games?**
3. **What design considerations are impactful for a digital tool helping players with mental tasks in board games?**

Strategy board games often employ a complex game structure, where every round of gameplay consists of several different phases and each turn has players complete a set of different actions. The functionality of the KOKOtap application was designed to help with the mental task of keeping track of the game state by allowing players to always see the current state of the game and keep track of their completed actions.

The effects of the application to the playing experience were evaluated with a user study, where eight participants were divided into pairs and taught to play the strategy board game Spirit Island. After the participants had played the game both with and without the application, they found the application had made keeping track of the game state more effortless, were able to be more confident in their ability to play the game, and in some cases found it easier to divide their focus between different gameplay tasks.

The contents of this thesis are focused on interaction with technology in the context of playing a complex board game, especially focusing on the attentional demands of both activities. The second chapter of this thesis introduces strategy board games as a category of board games and defines what it means to keep track of game state, while the third chapter looks at the theoretical background for attention and its limitations. The fourth chapter takes the knowledge uncovered in the earlier chapters and discusses the design considerations for a digital tool used in the context of playing a strategy board game. The research and analysis finally culminate in the fifth chapter, which details the design and functionality of the KOKOtap application. The latter part of the thesis consists of evaluating the effects of using the application while learning and playing a strategy board game, beginning with details of the evaluation described in the sixth chapter. The results of the evaluation are then detailed in the seventh chapter and discussed in the eighth. Finally, the ninth chapter provides a conclusion to the thesis.

2. STRATEGY BOARD GAMES

A central topic in this thesis is the activity of playing a strategy board game. This chapter therefore begins with exploring the categorization of board games, followed by defining the used terminology and structure of strategy board games, before briefly covering how the strategy board game Spirit Island, used in the user study of this thesis, is played.

Board games, also called tabletop games, are defined as games are played on a tabletop that utilize physical components made of cardboard, wood, plastic, or similar materials [24]. Board games can be broadly categorized into traditional games, mass-market games, and hobby games, as shown in Figure 1. Unlike the rest of the categories, traditional games are games without a single producer or designer, consisting of games such as Chess, Mahjong, or Go. The main difference of mass-market and hobby games is their target audience, while mass-market games (such as Monopoly, Clue, or Scrabble) are targeted to a wider audience and are often sold alongside toys in markets, hobby board games can mainly be found in dedicated board game stores, and are targeted towards board game hobbyists - people who consider board gaming a dedicated hobby. [25–27] One category of hobby games are strategy games, complex board games that focus on players' decision-making skills [28]. Examples of strategy games include co-operative games like Spirit Island [29,30] and Slay the Spire: the Board Game [31,32], and competitive games like Wingspan [33,34] and Scythe [35]. As the application developed as part of this thesis is focused on supporting strategy games, they will be the category of focus going forward.

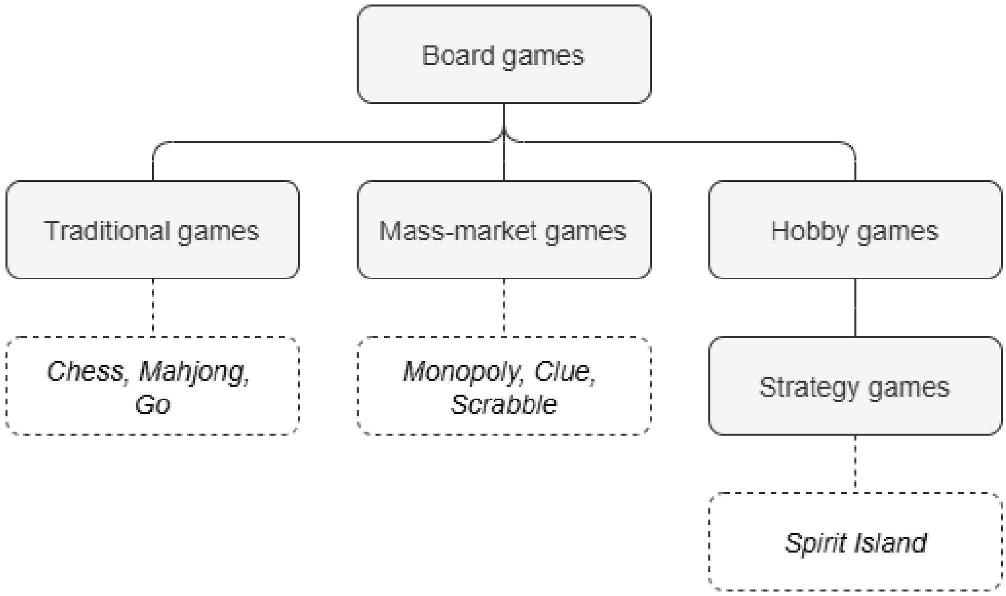


Figure 1. *Categorization of board games with example games in each featured category.*

2.1 Structure of strategy board games

While not all strategy board games are structured exactly alike, a game structure that is utilized by many games [36–48], as well as used as the basis of the developed application, will be defined in this section. The structure, depicted in Figure 2, divides a single game into rounds, during which players take turns to complete actions. Rounds can be even further divided into different phases, functioning as rounds inside rounds, during which different actions are available to players. The rounds are then repeated until an end condition is reached.

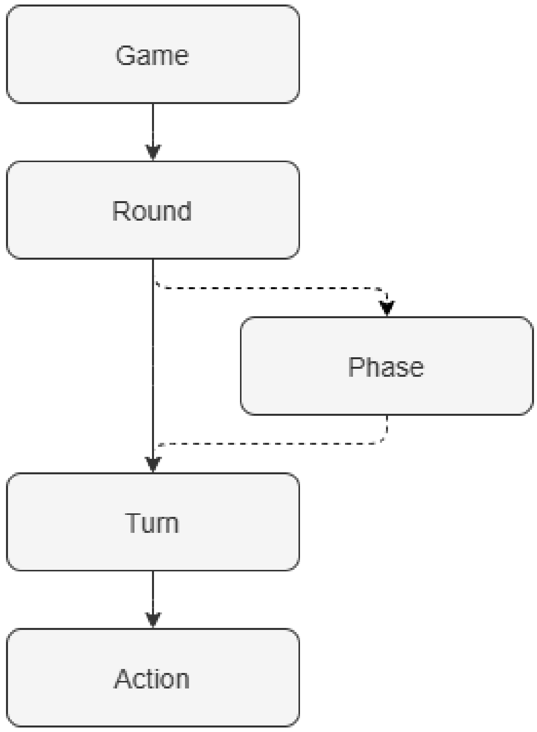


Figure 2. *The game structure that is used in this thesis.*

A **round** usually consists of all players taking their turn, either simultaneously or in consecutive order. The number of rounds can be limited, or they can repeat indefinitely until a certain end condition is reached. Many strategy board games further divide each round into separate phases, each with a different purpose and set of available actions. Phases can also be structured differently from each other, where in one phase players may need to complete a set of actions collaboratively, while in another phase players take individual turns to act – either simultaneously or consecutively. When a player has an active **turn**, they are allowed to perform **actions** in the game. Examples of different actions could be taking a new card from a deck, playing a card from hand, or placing a game component on the game board. The choice of actions that can be performed at any given time is usually limited, often varying between phases or playable characters. The length of a turn can be limited by time, or by the number of actions that can be completed, before the turn is passed onto the next player in turn order. Unless players are allowed to take turns simultaneously, turns progress in a predetermined turn order. [36–48]

The term **game state** is used in this thesis to describe the current state of the game's progress, consisting of two types of information:

1. static information about the game structure that is currently relevant, and
2. dynamic information about the progress of the game.

Static information does not change during a game, but different parts of it are relevant at different times. This includes the name and turn structure of each phase, and the actions that are available during them. Unlike static information, dynamic information is updated as the game progresses, consisting of the current round and phase, currently active player turns, and the completion status of each player's actions.

While many board games provide a reminder list of the game's structure, often printed on the game board [45], on the back of a rulebook [49], on each player's individual game board [40,41], or on separate reminder cards [39], the information can not be filtered to show only the parts that are currently relevant to players. Some aspects of dynamic information can be visualized via physical markers, such as an active player token [49], a round tracker board that marks the progression of game rounds [47,48], or action tokens that can be used to mark which actions have been taken [37,47,48]. Despite the existence of these visualization methods, in most games, keeping track of various aspects of the game state is reliant on the players' memory. The board game used in the user study of this thesis, Spirit Island, is one example of a game that offers no physical tools to help players keep track of the game state. To better understand the task used in the user study, the following section will further explain the structure and terminology of the game.

2.2 The board game Spirit Island

In the user study conducted as a part of this thesis, participants were asked to play a game of a co-operative strategy board game called Spirit Island, where one to four players play as nature-themed Spirits, defending an island against Invaders [30]. A visualization of the game can be seen in Figure 3, showing the game components in a three-player game. At the center of the image is the island board, surrounded by game components for each player: a Spirit board, Presence markers, and a set of four Power cards matching the Spirit depicted on the board. Next to the island board is the Invader board, used for tracking Invader actions and players' progress towards either a victory or defeat. [45]

Figure 3. *Components of the board game Spirit Island [30].*

The structure of the game follows the structure defined in the previous section. A game of Spirit Island consists of limited number of game rounds, each divided into five distinct phases: Spirit phase, Fast power phase, Invader phase, Slow power phase, and Time Passes. In Spirit phase, players add their Spirit's presence to the game board, expanding their reach and power, and choose the power cards to play that round. The chosen power cards and each Spirit's unique Innate powers are either fast or slow acting powers, with fast powers taking effect immediately after the Spirit phase in the Fast power phase, while slow powers are used later in the round in the Slow power phase. In Invader phase, Invaders act according to a randomized and predetermined logic, exploring new areas of the island, expanding their settlements, and causing destruction to the land. Finally each round ends in Time Passes, during which players discard the Power cards played that round. [45] In addition to being a co-operative game, where players work towards a common goal, its central game mechanics include:

- Card driven: actions are performed by playing Power cards, each causing a combination of effects from destroying Invaders to gaining new Power cards.
- Hand management: players have a hand of Power cards, from which they select a limited number of cards to play each round, the optimal combination of cards depending on the situation.
- Action retrieval: played Power cards are discarded at the end of a round, becoming unavailable until retrieved back to hand by choosing the option to reclaim cards during Spirit phase.
- Variable player powers: each player plays as a different Spirit, each with unique special abilities and different play styles.

- Area influence: players need to consider the location of their Presence markers on the game board, being only able to target areas close enough to their Presence. [29,45]

3. ATTENTION AND CALM TECHNOLOGY

Playing a strategy board game is a complex activity, where the majority of a player's attention is directed towards playing the game, making it essential to first understand the limitations of attention before designing an application to be used with such activity. This chapter therefore begins with an overview of the attentional process, before diving deeper into the theory of divided attention and the concepts of central and peripheral attention. The chapter then wraps up with a connection to interaction with technology, exploring calm technology as a way to allow technology to work with the limitations of attention, instead of fighting for it.

Interaction with the physical world is conducted via different senses from eyesight and hearing to sense of hearing and smell. As all the available sensory information, along with all other ongoing mental processes, can not be processed simultaneously with limited mental resources, a process that allocates the resources to a selection of the possible stimuli and processes is needed to make sense of the world. This resource allocation process is called attention. The attentional process begins with salience filters enhancing signals that are either infrequent or have learned biological importance, and top-down sensitivity control regulating the relative signal strengths of different information channels. After the signal strengths have been weighted, the process of competitive selection determines which signals will be actively processed, and allows related information to be temporarily stored in the working memory. [50]

3.1 Divided attention

Out of the various models describing different aspects of the attentional process, the theory of divided attention explains how multiple activities that require sensorial or intellectual attention can be performed simultaneously [51], and is therefore crucial for understanding the concepts of central and peripheral attention. The theory describes attention as a finite amount of mental resources that can be divided between different activities, consisting of both sensorial and intellectual processes [51]. The limitations of performing multiple activities simultaneously depend on the amount and type of mental resources each activity requires. [52]

Activities are divided into controlled and automatic processes depending on whether or not performing the activity needs to be consciously controlled. The characteristics of controlled and automatic processes are summarized in Table 1. As can be seen from the table, automatic processes can be performed without conscious control, often even without conscious awareness of the process. They require little to no effort or cognitive processing and can be performed in parallel to each other. In contrast, controlled processes must be performed sequentially, requiring intentional effort, conscious control, and a considerable amount of resources.

An activity must be familiar and extensively practiced before it can become an automatic process, and many activities start as controlled processes before becoming automatized. Though activities that become automatic are usually relatively easy to perform and have only few changing variables, with sufficient practice, even complex and difficult activities can eventually become automatic. As an example, driving a car is initially a complex task that requires conscious control and full undivided attention, but after enough practice, it becomes automatic and can be performed in parallel with other activities such as talking with a passenger or operating a radio. An activity often is not strictly an automatic or a controlled process. Driving a car can change from being an automatic process to a controlled one when the conditions become unfamiliar or difficult, such as driving on an icy road or in busy traffic, where normally automatic actions, such as speed control, must be done with conscious control. [52]

Table 1. *Differences of controlled and automatic processes [Adapted from 52].*

Characteristics	Controlled processes	Automatic processes
Intentional effort	Required	Little to none
Conscious awareness	Required	Usually none
Use of attentional resources	Considerable	Negligible
Type of processing	Sequential	Parallel
Speed of processing	Time-consuming	Fast
Level of cognitive processing	High	Low
Relative novelty of activities	Novel and unpracticed	Familiar and practiced
Difficulty of activities	Usually difficult	Usually relatively easy

Another limitation on the division of mental resources concerns the types of resources each activity requires. The theory of threaded multitasking explains this limitation by describing activities as cognitive threads, each of which uses a variety of mental resources, such as motoric, visual, or memory resources. Multiple threads can be active concurrently only when the mental resources they require do not overlap, otherwise a bottleneck occurs and one of the activities must wait for the occupied resource to become available. [53]

Therefore, dividing attention to multiple activities is limited by (1) the amount of mental resources required by each activity, and (2) the type of mental resources an activity uses. Only activities that (1) do not both require a considerable amount of mental resources and (2) do not require the use of the same mental resource can be performed concurrently. As an example, the activities of driving a car on a familiar route and listening to an audio book can be performed simultaneously, as listening to an audio book requires the auditory resource to hear the narration and conscious control to follow the narrative, neither of which are required by the other activity of driving a familiar route. However, if the route were unfamiliar, navigation would no longer be an automatic process and therefore could not be performed simultaneously with another activity requiring conscious control. Alternatively, if listening to an audio book was substituted with reading a book, multiple activities would require the use of visual resources, causing a bottleneck and forcing the activities to be performed consecutively.

3.2 Center and periphery of attention

The terms center and periphery are often used when describing the field of vision. The term center of vision refers to its focal point, where the vision is detailed, but only able to focus on a single point in space, while everything else in the field is described as being in its periphery. [54,55] When used to describe attention, the terms center and periphery of attention are used in a comparable way – only broadened to cover not only the sense of vision, but all sensory information and mental processes.

As attention in divided attention theory is described as the division of mental resources over different activities, the concepts of central and peripheral attention can be explained in the same context. The activity that has the most resources allocated to it is described as being in the center of attention, and all other activities in its periphery. [56] How the resources are divided between the activity in the center of attention and activities in the periphery varies depending on the demands of the activities. The activity at the center of attention can require the vast majority of resources, while barely any are left for peripheral activities. An example of this could be being highly engaged in reading a book, to a point where the rest of the world seems to almost disappear. In an alternate scenario, resources can be more equally divided, where the activity in the center of attention takes up only slightly more resources than another activity in the periphery. In such a scenario, the center of attention can easily switch between different activities, whereas a change is more unlikely to happen when the allocation of resources is uneven. [56] These switches in an activity being in the center and periphery of attention are a key component of peripheral interaction [51], discussed in the following sections.

3.3 Calm technology

Interaction with technology usually relies heavily on being in the center of attention [56]. The concept of taking advantage of peripheral attention in the interaction with technology was first envisioned by Weiser and Brown [57], who coined the term calm technology, a design approach that takes inspiration from the physical world where many interactions happen in the periphery of attention. The first example of calm technology was the Dangling String [58], a motorized string hanging from a ceiling, programmed to spin based on the amount of data going trough a connected ethernet cable. The Dangling String visualized information about the network traffic similarly to how a window to outside provides information about the current weather, readily available at a glance, while otherwise fading to the background of attention.

However, not every system should be designed for calmness. A fire alarm should immediately pull attention to itself regardless of the situation, and a video game likely should be engaging enough to be played in the center of attention rather than in the periphery. On the other hand, systems that help keep track of specific information or remember upcoming tasks can be quite suitable for calm technology. [51] Unlike the previous examples where the activity was either important to perform immediately (escaping from a potential fire), or highly engaging (playing a video game), an activity such as checking the weather for the day is not time-critical and only needs to be in the center of attention briefly.

3.4 Design for peripheral attention

The goal of peripheral interaction is to allow a system to be interacted with when it is either fully in peripheral attention or only briefly occupying of the center of attention. This section will discuss a set of design recommendations for facilitating peripheral interaction, proposed by Bakker et al. [51]. The design recommendations are broadly divided into two areas of interest: supporting the user’s attention to the system shifting between its center and periphery and supporting personal differences between users.

As discussed previously, an activity can rapidly shift between being in the center of attention and in its periphery, especially in situations where there are multiple activities being performed concurrently or in quick succession to one another. This leads to a possibility that interaction with the system can be initiated at a moment’s notice when it shifts to the center of attention and be discarded just as quickly when another activity is shifted to the center mid-interaction. The following design recommendations were proposed to facilitate the possibly rapid switches in attention: (1) minimizing interaction start-up time, (2) having the device be ‘at hand’ when an interaction is likely to happen, and (3) making sure the interaction remains in a stable state even if it is discarded suddenly. [51]

As the activities that can be performed in the periphery as automatic processes need to first be practiced extensively, it follows that interaction with the system also needs repetitions before it can be performed with peripheral attention. This process of familiarization can be considered in the design of the system in two ways: supporting habituation of the interaction and the personal preferences of users. To support interaction with the system becoming habitual, the suggested methods were to utilize multiple modalities to convey information, and to layer the information with multiple levels of detail. When the same information was conveyed via multiple different modalities, where one modality offered more context to the information (such as visually displaying a time frame on an analogue clock) and the other was more abstract (playing a specific audio track), users could first learn to use the system by utilizing the visual modality, before learning to additionally extract meaning from the audio and being able to interact with the system only based on the auditory information. In addition to offering the same information through multiple different modalities, overlaying multiple levels of detail in the information seemed helpful to the learning process. Instead of being required to learn and understand a multitude of details at the start, users can start using the system while only utilizing the overall level of information, and after getting accustomed to interacting with the system, begin picking up more of the underlying details. As all users will have different routines and habits surrounding the ongoing activities, interaction with the system should be flexible enough to adjust to different preferences. An open-ended design where users can decide how to best utilize the system allows interaction with the system to adjust to user’s routines, instead of forcing the user to alter their routines around the system. [51]

In conclusion, the design considerations examined in this section can be summarized with the following three points:

- Supporting shifts between central and peripheral attention by considering what mental resources are available in the use context and by enabling interaction to be started and discarded easily.

- Supporting the process of habituation by utilizing multiple different modalities and levels of detail to communicate information.
- Supporting personal preferences by allowing users to decide how to use the system to best suit their habits and routines.

4. DESIGN CONSIDERATIONS

As the goal of the KOKOtap application is to help players keep track of the game state in a complex board game, in order for it to not instead negatively affect the playing experience, its design needs to carefully take into account the context of playing a board game and how it affects the design choices to be made. This chapter therefore first defines the target user groups of the application and then analyses the specific use context of playing a board game.

4.1 User groups

The target user group of the application are people who are interested in learning and playing board games but may find keeping track of the game difficult or taxing. The reason could be the high complexity of the game, having a cognitive disability that makes playing more difficult, or any temporary factors that affect everyone occasionally. The target user group can be further divided into two, where the first group consists of users who play high-complexity board games, where the complexity of the game causes the need for assistance in keeping track of the game state, while the second group consists of users who find it difficult to partake in board games due to either cognitive disabilities or environmental factors. For example, disability such as attention-deficit/hyperactivity disorder (ADHD) could make it difficult for a user to stay focused on the game during periods of inactivity, or a hearing impairment could make communication about the game state more difficult, as information could only be relied visually without the help of speech or other auditory cues. Temporary factors can also make playing a board game difficult for anyone, such as having difficulty hearing in a noisy environment, or having a lowered cognitive function after a long day [60]. Even though the second user group functioned as one of the main inspirations for the development of the application, the scope of the research and evaluation would not have been not able to adequately cover both groups, limiting the focus of this thesis to only the first user group.

4.2 Analysis of use context

It is widely understood that understanding the context of use is important for design of any interactive systems, but especially important for systems that utilize peripheral interaction [51,59]. Though there are many views on what aspects make up a context of use [59,67,68], many of the studies suggest that a context not only consists of the physical location in which a system is used in, but also the social setting and other activities that are part of the situation. An aspect that is especially relevant for peripheral interaction, is consideration of the other ongoing activities and the types of mental resources they occupy [51]. As explained in chapter 3, if the system were to utilize the same mental resource as another ongoing activity, a bottleneck would occur, and the interaction would have to wait for the resources to become available. This section will therefore consist of analysis of a few different aspects of the use context, beginning with an examination of the activities performed while using the application, followed by looking at the physical context of board game play.

4.2.1 Activities part of the context

The use context consists of two main activities: playing the board game and social interaction with other players, where usually playing the board game is the primary activity and social interaction a secondary one. Playing a strategy board game is a complex activity that requires conscious control for many of its tasks. Although it is possible to learn even difficult tasks well enough for them to become automatic processes and be performed in the periphery of attention, usually such tasks require high level of cognitive processing and are performed in the center of attention [52]. In addition to requiring a considerable amount of attentional resources, playing a board game also requires the use of visual resources. Though some modern board games may additionally utilize an accompanying application to communicate information with sound effects or audio narration, the vast majority of games lack any digital integration and can therefore only rely on the visual modality to communicate information. As explored in Chapter 2, learning a new strategy board game requires the person to learn and remember a significant amount of information, such as the overall structure of the game and what actions can and must be taken in different situations. In addition to these, the game rules and tactical knowledge of how to succeed in the game need to be learned and often partly memorized. The secondary activity, social interaction with other players, can often be just as important as the activity of playing the game, as face-to-face interaction between players and the opportunity to spend time with friends and family are among the important reasons players enjoy the experience of playing board games [24].

4.2.2 Physical context

The examination of the physical surroundings around board game play focuses on three characteristics: lighting conditions, player positioning, and the visual design of strategy board games. As standard working hours in modern society are from morning to afternoon, a common time of day for many free-time activities, board gaming included, is during the evening hours. Therefore, usual lighting conditions for board game play can be assumed to be indoors in artificial lighting. As residential indoor lighting in the evening rarely matches the brightness of sunlight, user interfaces with dark themes can be more favorable [61,62]. The arrangement of players can similarly be assumed to be positioned around a table, as board games are by definition centered around a game board that all players need to have access to, necessitating that shared physical and digital components are readable from multiple viewing angles. The final aspect of the physical context to be examined is the visual styles of strategy board games. Exploring a variety of strategy board games, two contrasting visual themes can be singled out: (1) a natural theme, utilizing warm colors and wood-like graphics, and (2) a futuristic theme, consisting of gray and dark blue colors with metallic or futuristic graphics. Examples of board games utilizing a natural theme with a warm color palette can be seen in Figure 4, where each game has a combination of a brown or tan color with contrasting accent colors of greens, blues, reds, and oranges.

Figure 4. *Examples of strategy board games with natural themes [34,63,64].*

A more futuristic theme can be seen in the examples presented in Figure 5, where the games utilize a cold color palette consisting of a blue or gray base color, with different contrasting accent colors. Textures representing metallic surfaces can also be seen in the second example in Figure 5.

Figure 5. *Examples of strategy board games with a futuristic themes [65,66].*

5. IMPLEMENTATION

This chapter introduces the design and implementation of the KOKOtap application. The application was developed with the Flutter framework and will become available for Android devices through Google Play Store in fall 2025. The user interface of the application is optimized for mobile devices with touch screens, with flexibility to adjust to different screen sizes. The functionality is based on the assumption that a board game follows a structure defined in Chapter 2. Though the application can be used with a variety of different board games, this chapter will focus on covering only the functionality that is relevant when the application is used with Spirit Island.

The functional goals of the application are to keep track of the game state and to provide information about the game structure relevant in the current game state. In addition to these goals, the design of the application aims to minimize negative effects caused by the presence of a digital tool to the experience of playing a board game. The chapter begins with an overview of the application, followed by a discussion of how the aforementioned goals were implemented.

5.1 Overview

The KOKOtap application consists of a main view and a game view. The application launches into the main view, where a user selects a board game from a list of compatible games. After confirming the selection, the application transitions into game view, and is ready to be used with the selected board game.

The user interface of the game view is divided horizontally from the middle, and each side is rotated away from the center of the screen. These two sections, called player sections, consist of four main elements: name of the current phase, round number, a ready button, and a row of action buttons. The default user interface layout for a player section is displayed in Figure 6, and variations of the layout based on turn structure can be seen in Figure 7. Though the application is designed to function with different types of turn structures, due to consecutive player turns not being present in the user study task, this section will focus on covering the functionality of phases with simultaneous player turns or shared player actions. The application can currently be used with either one or two players, displaying the corresponding number of player sections on the device. The rest of this chapter will assume usage with two players.

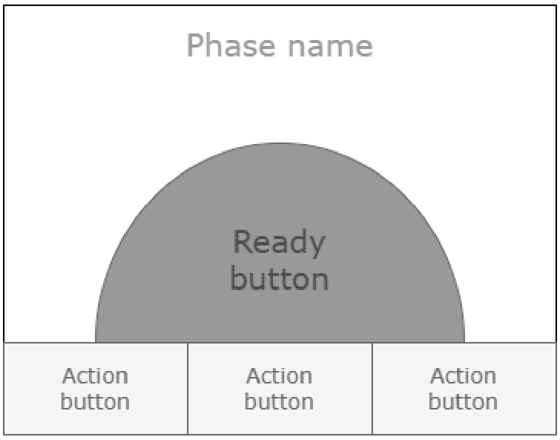
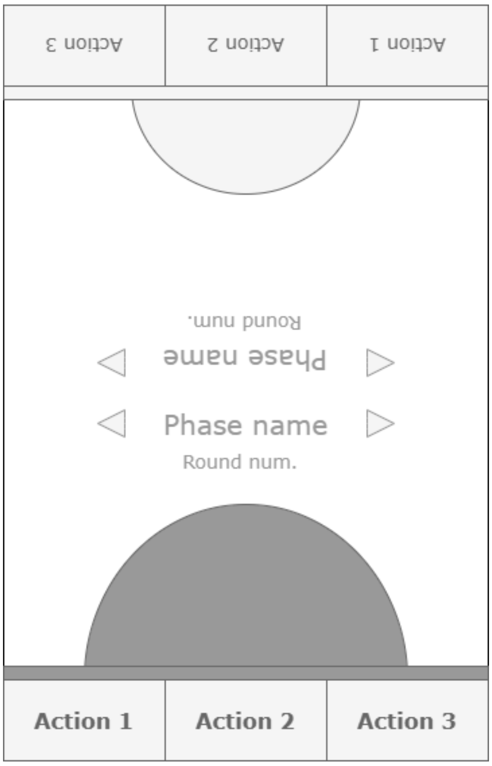


Figure 6. *User interface diagram of a player section.*

The game view launches into the first phase of the first game round, populating the phase name, round number, and action labels with data from the selected board game. At the start of each phase, all players are given an active player status, and transition to the next phase is triggered when no active players remain. The phases loop in both directions, where navigating forward from the last phase transitions to the first phase and navigating backwards from the first phase transitions to the last phase. Though round numbers are counted, the rounds can be looped indefinitely in either direction.

When a player turn is activated, the Ready button and all Action buttons in the player section (Figure 6) are automatically toggled to their active states. Action buttons have no functionality aside a visual indication of being active or inactive, whereas the Ready button controls the player turn state it is associated with, and always causes all Action buttons in its section to switch to the same state it is in. Unless a phase transition is triggered, all buttons can be freely toggled between their active and inactive states. In addition to triggering a phase change automatically by ending all active player turns, arrow buttons on both sides of the phase name (visible in Figure 7) can be used to navigate between phases and rounds.

(a) both player turns active



(b) one player turn active

Figure 7. *User interface diagrams for phases with individual player turns.*

The default user interface for the game view is displayed in Figure 7, where the view consists of two separate player sections. The diagram (a) displays a situation where both players have an active turn, and diagram (b) a situation where only one player has an active turn. During phases where actions are shared between all players, the game view is reorganized to highlight the collaborative nature of the phase. As displayed in Figure 8, the player sections no longer have individual Ready buttons, and instead a shared Ready button is displayed in the middle of the view. The decorative borders above the Action button rows extend all around the middle of the view to further enhance the difference. Functionally, all players are considered to have an active player turn, with all button states synchronized between players.

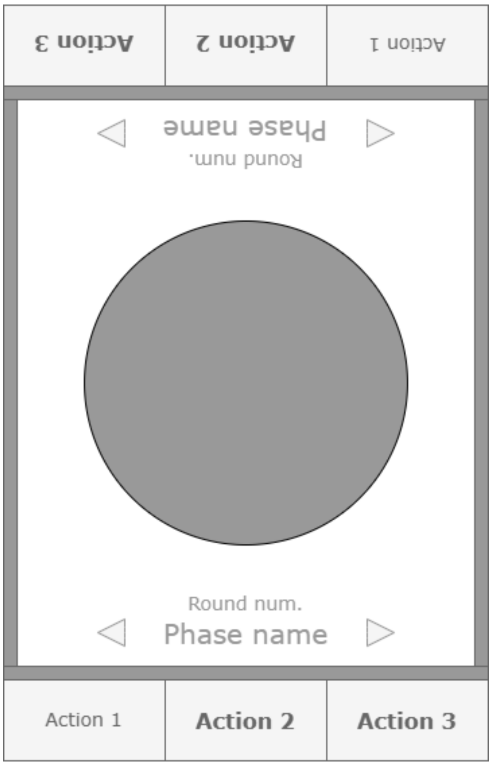


Figure 8. *User interface diagram for phases with shared actions.*

5.2 Functionality

The main functionality of the application consists of users updating the application’s internal game state via Ready and Action buttons, and the application displaying the current game state via the visual user interface. The application’s internal functionality of keeping track of the game state is controlled with the Ready buttons, leaving all other interactive elements optional to use. Utilizing a single-button control scheme means that controlling the application in the middle of a game requires minimal interaction, while more manual control via triggering phase transitions with arrow keys and individually toggling action completion states is still allowed whenever a player chooses to do so.

To provide equal access to all relevant knowledge, the application displays the same information to all players, regardless of their turn state. Only information that is relevant in the current game state is displayed, lessening the amount of information visible at a time, thus making it easier to read at a glance compared to a full list of all round phases and actions in each phase. The goal of providing access to knowledge about current game state is accomplished by displaying information about the current game state, consisting of:

- **Name of the current phase**, displayed at the top of the player section (Figure 6).

- **Turn structure of the current phase**, visualized by the layout of the game view (as seen in the difference between Figure 7 and Figure 8).
- **A list of currently available actions**, displayed at the bottom of the player section (Figure 6).

Using a game of Spirit Island as an example, at the start of the game, the application informs players that they are currently in the Spirit phase where all players can act simultaneously, and have three actions they are allowed to take: Growth, Gain energy, and Play cards [45]. Displaying the name of the phase, its turn structure, and actions available in the phase ensure that all players share the same knowledge of what is currently happening, regardless of how well any given player has learned and memorized the structure of the game. Listing only the currently available actions additionally functions as a to-do list of the next actions to complete, offering players an immediate goal to work towards.

In addition to displaying information about the game structure, the application keeps track of and visualizes dynamic information about the game state. Unlike the previous set of information that is itself unchanging, dynamic information is constantly updated as the game progresses. This consists of the following information:

- **Current round number** tracks the amount of completed rounds.
- **Current round phase** keeps track of the currently active phase, providing data about the phase to the rest of the view, including the phase name display, view layout based on turn structure, and the list of currently available actions. Current phase is updated through phase transitions, triggered either manually with the arrow keys, or automatically when no player turns are active.
- **Player turn status** is visualized by the color and size of all elements in the player section and is controlled with the corresponding Ready button.
- **Action completion statuses** are controlled by the corresponding Action buttons and visualized by the color and size of the Action button label. States of all Action buttons are additionally automatically activated and deactivated to match changes in turn status.

Using Spirit Island again as an example, in Spirit phase when play is simultaneous and all players have their individual actions to take, while at the same time needing to collaborate on a common strategy for the round, there can simultaneously be different tasks fighting for a player’s attention. The focus of a player’s attention can therefore be subject to rapid switches between the concurrent tasks, making it difficult to keep track of each task’s state of completion. The goal of the Action buttons is to function as a checklist that players can utilize to remind themselves what actions they have already completed. While the Action buttons are individual to each player, the visualization of each player’s turn status aims to increase awareness of each player’s turn status to all players via audio cues and persistent visual indicators.

5.3 Design

The first priority in the design of the application is to allow users to always be in control of when and how much attention is directed towards it. To achieve this, immediate action is never demanded from the user, and the amount of interaction required to upkeep the application during a game is kept as low as possible.

The implemented design of the application can be seen in Figure 9, where the application is displayed during (a) simultaneous turns while both turns are active, (b) simultaneous turns while only one player turn is active, and (c) phase with shared actions. As seen from the images, a color scheme of a dark, blue-toned gray contrasted with orange was chosen. The background colors are #1B2630 for the middle section, and #0D1319 for the Action buttons. Highlighted elements use color #CC7636, and other elements color #536571. The chosen colors were based on the analysis done in the previous chapter, where it was observed that many board games use either a color palette consisting of bright and warm colors or a palette of dark and cold color. Utilizing a color from both ends of the spectrum should allow the visual design of the application to blend in with many board games.

(a) (b) (c)

Figure 9. *Final design of the application.*

The visual indicators for active and inactive player turns can be seen Figure 9 (b), where all interactive elements in the active player section are highlighted in orange and are larger in size, whereas the same elements are de-emphasized in the bottom section. The font size for an active Action button is 11 pt, while the inactive button uses 7 pt font size. Changes in active player state are communicated via animation and sound. The Ready button's size changes with a dynamic and bouncy animation, lasting for 1.5 seconds when animating from an active state to inactive, and 0.9 seconds when reactivated. The sound effect for state change from active to inactive is 26 milliseconds long and sounds similar to a water bubble popping. Reactivating the state is communicated via a similar sound, though shorter and lower in pitch.

The name of the current phase is displayed in light gray font against a dark gray background in 14 pt font size. Transition to the next phase is communicated via animation and sound. All labels and buttons in the view simultaneously shrink in size in 0.5 seconds until they have disappeared from view, before reappearing again with reverse animations. The visual changes in the view are accompanied by a short sound effect, again similar to a water bubble popping, though sharper in tone and louder in volume when compared to other sound effects.

To support interaction with the application shifting between the center and periphery of attention, the following features were implemented:

- Minimizing interaction start-up time by forcing the device's display to be always on while the application is running, preventing the device from sleeping or dimming the display.
- Having the device 'at hand' by splitting the user interface into two halves facing opposite directions, allowing the device to be placed right next to other game components in a location that is easy to reach.
- Allowing imprecise interaction to lessen the precision needed to successfully complete an interaction, lessening the time the interaction requires central attention.
- Using sound to communicate information in addition to visuals, taking advantage of sound being a less utilized modality in board gaming context, allowing information to potentially be perceived in the periphery of attention.
- Using simple design language with enough empty space between elements to help the interface be perceivable at a glance or in peripheral vision.

In order to lessen the amount of central attention needed to operate the application, interaction is designed to be simple to execute, requiring as little time and thought as possible. One of the methods to achieve this is designing the user interface around allowing imprecise interaction. The most important interactive element during gameplay, the ready button, takes up a significant portion of the interface and has a large hitbox extending beyond its visual size. Though smaller in size, the action buttons also utilize as much space as possible, with no dead space in between the buttons. These choices were made to increase the likelihood that even an imprecise touch event results in a successful interaction, allowing elements to be tapped in a quick succession.

To support personal differences and the habituation process, the following points were considered:

- Allowing flexibility in how the application is used.
- Using multiple different modalities to communicate the same information; allowing users to simultaneously see the visual animation of completing a turn and hear the associated sound effect.

- Having an appealing look and blending in with the board game context to distance possible negative associations to technology in board gaming context, and to motivate adaptation by appearing as an appealing part of a board game.

Allowing flexibility the usage of the application was an important principle guiding its design. Requiring the user to change their pre-existing habits and routines in board game play would require conscious effort, making the usage of the application more difficult to adopt. Instead, the usage was designed to be flexible, so that it can mold to fit different preferences and habits. What this means in practice, is that when and how the application is used is decided by the user. Looking at an example situation where a phase transition has just been triggered by another player. After hearing the sound effect indicating a phase transition, a user might (1) look at the application to see what the new phase is and what actions are now available, (2) continue concentrating on some other matter in the board game, and check the application at a later time as needed, or (3) recall from memory what the next phase and actions are and start executing them immediately without looking at the application. The optional usage of Action buttons allows for similar flexibility, where a user might check the available actions each time before deciding what to do next, and check the action completed immediately afterwards, or they might only check the actions occasionally for confirmation, and mark an action completed only when it feels useful in the situation. The third and final way this flexibility is visible in the design, is by allowing any of the interactive elements to be used at any time. Phases can be navigated manually with arrow buttons, both forwards and backwards, without any restrictions to either direction, and all Ready and Action buttons can be freely toggled on and off until the condition for a phase transition is triggered. This freedom should be useful both for demonstrating the usage of the application and to allow users to correct mistakes while playing.

6. EVALUATION

To evaluate the effects of the KOKOtap application on the experience of playing a complex board game, participants in the user study played two games of Spirit Island, one while utilizing the application, and another without. Both games were observed to examine usage of the application, and the participants were then interviewed about their experience. This chapter will give a detailed account of how the evaluation was conducted, including what modifications were made to the game setup to facilitate testing.

6.1 Participants

Eight participants were recruited from local board gaming groups in Tampere University utilizing convenience and snowball sampling, where the criterium for participation was having an interest in learning and playing a strategy board game. Participants' ages ranged from 21 to 26, with a mean of 24.5 years. Six of the participants reported their gender as male, two as female, and none as other or wished to not disclose.

As the criteria for participation did not require a participant to have prior experience in strategy board games, their general experience with board games, card games, or tabletop role-playing games was queried both at sign-up and at the start of the evaluation session. The results are summarized in Table 2, which lists the categories of the games participants reported playing frequently, game mechanics shared by the frequently played games and Spirit Island, and if the participant had prior experience of playing Spirit Island specifically. Participants L1 and L2 had the lowest relative experience level, their prior experience being limited to family games like Carcassonne. Participant H8 reported playing a complex collectible card game (CCG) Magic: The Gathering weekly and regularly playing other complex strategy board games like Eclipse: Second Dawn for the Galaxy, resulting in relatively high level of experience. The rest of the participants had frequent experience with either strategy games or TTRPGs but were less familiar with the game mechanics present in Spirit Island or the complexity of the games was lower.

Table 2. *Board gaming experience of participants [72–77].*

ID	Frequently played game categories	Familiar game mechanics	Spirit Island experience	Experience level
L1	Family	None	None	Low
L2	Family	None	None	Low
M3	TTRPG	Variable player powers	None	Medium
M4	TTRPG	Variable player powers	None	Medium
M5	TTRPG	Variable player powers	1-2 games	Medium
M6	TTRPG, Family	Variable player powers	1-2 games	Medium
M7	Strategy	Variable player powers, Hand management	None	Medium
H8	Strategy, CCG	Variable player powers, Hand management, Card driven, Area influence	None	High

Table 3 presents how the participants were paired for the sessions. When signing up for the evaluation, participants were given a choice of either recruiting a friend they wished to participate with or be assigned a pair later on in the process. When participants who had not signed up with a friend were paired for the sessions, they were primarily paired with a participant they already had some familiarity with, with a secondary criterion of having similar levels of experience. The goal of the process was to enable a testing environment resembling a real-life situation, where participants could feel socially comfortable and be able to participate in the game in equal capacity.

Table 3. *Participants were paired together based on their familiarity with each other and their experience in complex board games.*

Session	Participants	Experience levels
1	L1, L2	Low
2	M3, M4	Medium
3	M5, M6	Medium
4	M7, H8	Medium - High

Participants were additionally asked whether or not they had used any kind of digital tools with board games. Two of the participants had not used any tools, one participant

(H8) had used multiple different applications for tracking player life points in Magic: The Gathering, four participants (M3, M4, M5, M6) had used a web application D&D Beyond for character creation and tracking character information and statuses in Dungeons & Dragons, and one participant (M7) had used a mobile application for counting points in Darts. Similarly to the observation expressed in chapter 1, the digital tools participants had used were all designed to keep track of game variables, such as life- or victory points, or to make game setup easier with character creation tools.

6.2 Evaluation setup

The following explanation of the evaluation setup covers two areas of interest: test environment and task setup. The first section detailing the test environment covers the location where the testing was conducted and equipment used in each task, while the section about the task setup explains the setup of the game in detail, including what changes were made to better facilitate testing and how the setup was adapted to participants with different levels of experience.

6.2.1 Test environment

The evaluation sessions were concluded at Tampere University campus during evening hours, where a suitable classroom was used for the evaluation. The room was set up as seen in Figure 10, where the board game has been prepared on a four-person classroom table, with chairs for the participants on opposite sides of it.

Figure 10. *A game of Spirit Island prepared for the evaluation session.*

During the tasks, information about the game’s structure was available to participants via the “Spirit Island phase order” section in the center of the Invader board (Figure 11). The section has a horizontal list of all five phases, with Fast Power and Slow Power phases illustrated with their corresponding icons, and the rest of the phases listed by name, printed in approximately 11 pt font size. Two of the phases, Spirit phase and Invader phase, additionally list all the actions available in that phase, printed in approximately 10 pt font size. The section can be used as a reminder of the phase order and actions, with no functionality to track the current place in it. As seen in Figure 10, the Invader board was positioned next to the island boards, rotated at a 90° angle from the direction each participant was facing, and was not moved between tasks.

Figure 11. *The structure of the game visualized on the Invader board.*

During one of the tasks, the setup additionally included a mobile phone running the KOKOtap application. As seen in Figure 12, the phone was positioned at the center of the table, in between the island boards and the Invader board. This positioned the application in the middle of the areas where the majority of physical interactions with the game happens, where it could easily be seen and interacted with. The position of the Invader board or other game components was not altered, as the mobile device was able to fit in the existing space between the boards.

Figure 12. *Phone with the KOKOtap application placed between the island boards and the Invader board.*

6.2.2 Task setup

The board game used in the tasks was the base game of Spirit Island, with additional Spirits from expansions Branch and Claw and Nature Incarnate. The game utilizes a variety of options to tune its difficulty and complexity, of which the lowest difficulty options were used. In addition to the official difficulty modifiers, the following modifications were used to make testing with the game feasible:

- a premade Invader card deck,
- smaller amount Fear needed to earn a Fear card,
- a premade Fear card deck, and
- a limited selection of available Spirits.

Out of the official difficulty modifiers, the choices for lowest difficulty were chosen. Playing without a Blight card or an Adversary is a recommended option for first-time players, and therefore neither was used. The balanced sides of island boards are also recommended by the rulebook for better game balance between games compared to the thematic sides. [45] The selection of island boards is usually randomized, but boards A and B (visible in Figure 10) were used in all tasks for consistency and ease of setup.

The Invader cards, used for determining the Invader actions, consist of cards in three phases. The first and second phases have four cards matching the land types on the island boards, with an additional "Coastal lands" -card in the second phase. The third phase consists of cards with two land types each, one for each combination of lands. The Invader deck is usually constructed by removing a certain number of cards from each phase, after which the cards in each phase are shuffled. During the evaluation, instead of removing one card from each phase, only the second phase Coastal lands -card was removed. The number of cards in the Invader deck determines the game's round limit, and therefore not removing cards added additional rounds before a game would result in a loss, without otherwise affecting game difficulty. The Coastal lands -card was still removed, as it causes Invaders to act in higher number of lands compared to other cards in the same phase, increasing the game difficulty during the round when it is drawn. Changes made to the Invader deck were not disclosed to the participants in order to keep the playing experience similar to using a randomized Invader deck.

The amount of Fear needed to earn a Fear card determines the ease of achieving the game's victory condition. To help participants achieve victory within the time allocated for each game, this amount was halved. In addition to lowering the victory condition, earning a Fear card causes a random beneficial effect, the effectiveness of which can highly depend on the current situation of the game. An example of a situational Fear card could be a card providing defense to all lands meeting a specific condition, the usefulness of which entirely depends on such lands existing, the Invaders attacking those lands that round, and the players' strategy not already covering the lands' defense. To limit the variance caused by situational Fear cards, cards listed in Table 4 were used to construct the Fear deck in all games. The cards were selected based on their effect not relying on a specific event specific happening during that game round, and instead either eliminating or relocating existing Invaders. To prevent participants from anticipating the effects of upcoming Fear cards, the order of the cards was randomized for each game, and the participants were not informed about the changes to the Fear deck.

Table 4. *The fear cards in the Fear deck [78].*

Card title	Effect
Isolation	Remove Invaders from lands where it is the only Invader.
Scapegoats	Destroy Invaders in lands with Towns or Cities.
Tall Tales of Savagery	Remove Invaders from lands with Dahan.
Wary of the Interior	Remove Invaders from Inland lands.
Depopulation	Downgrade Invaders.
Emigration Accelerates	Remove Invaders from a Coastal lands.
Fear of the Unseen	Remove Invaders from lands with Spirit Presence.
Plan for Departure	Gather Invaders into Coastal lands.
Retreat!	Push Invaders from Inland lands.

The available selection of Spirits (Table 5) consisted of two low-complexity Spirits recommended for first-time players and three moderate complexity Spirits for participants who wanted more challenge. The three moderate complexity Spirits were chosen based on their play styles synergizing with the rest of the chosen Spirits, while minimizing the amount of new game concepts. All three of the moderate difficulty Spirits have both defensive and offensive abilities, which meant that choosing any combination of the available Spirits would result in a well-rounded combination of both defense and offense, and the playing experience would not be drastically different regardless of the chosen Spirits.

Table 5. The selection of Spirits used in the tasks [78].

Complexity	Name of the Spirit	Play style
Low	Lightning's Swift Strike	Extremely offensive, destroying buildings in big bursts of damage.
Low	Vital Strength of the Earth	Acts slowly, but the lands with its Presence are reliably defended.
Moderate	A Spread of Rampant Green	Expands its Presence rapidly and prevents Invaders from building.
Moderate	Keeper of the Forbidden Wilds	Expands slowly, but the areas with its Presence are well defended.
Moderate	Hearth-Vigil	Protects the Dahan, using them to attack the Invaders.

The selection of Spirits given to each participant depended on their experience with the game. If a participant had never played Spirit Island before, they were assigned either one of the low complexity Spirits for the first task and were given the option to choose any other Spirit for the second. Participants who had prior experience with the game had the option to choose a Spirit also for the first task, or they could use the assigned low complexity Spirit. Providing participants with an opportunity to increase the game complexity by choosing a higher complexity Spirit aimed to level out the experienced complexity between participants of different experience levels, and to provide participants with an opportunity for an additional challenge for the second task. Regardless of their choice for the first task, participants had to choose a new Spirit for the second, either from low or moderate complexity Spirits.

6.3 Procedure

All testing sessions followed the same procedure, starting with an introduction to the session and the game used in the tasks, followed by the first task and an interview, a short break while the second task was set up, before continuing with the second task and a final interview.

6.3.1 Introduction

Each testing session began with welcoming the participants and having a short informal chat to create a relaxed atmosphere. After the participants had settled down, they were informed about the schedule of the session and were then given a more detailed description of the contents of the session, its purpose, data gathering methods, and how the collected data would be stored and used. After an opportunity to ask any questions about participation in the user study, participants were asked to read and sign the user experience test consent form (Appendix A), and to fill in a background information questionnaire (Appendix B). The session then continued with introducing the participants to the Spirit Island board game and explaining the game rules. In addition to the initial explanation, specific game rules were explained again as a reminder as they came up the first time in-game. As the aim for the evaluation was to be similar to a real-life game night where one player might be teaching a new game to the rest of the group, help with understanding game concepts, and clarifications or reminders to game rules were offered to participants at any point as needed.

6.3.2 Tasks

After the participants were introduced to the testing session and taught how to play the game, participants would complete two tasks. Each task consisted of participants playing a game of Spirit Island, which was set up according to specifications detailed in Section 6.2.2. In task A, participants were instructed to utilize the KOKOtap application while playing, while in task B the game was played without any additional tools. Table 6 shows the task order in each session, first half of the sessions starting with task B, and latter half with task A.

Table 6. *Task order in each session.*

Session	First task	Second task
1	B	A
2	B	A
3	A	B
4	A	B

Usage of the application was demonstrated before task A. The demonstration began with the application already in game view and the device placed on the table as described in Section 6.2.1. The participants were first given an overview of the user interface, pointing out where the game state information could be seen in the application, and where the same information was located on the physical Invader board. The usage of action buttons and the ready button were demonstrated next, emphasizing how the usage of action buttons was an independent choice for each participant that they could freely adapt to suit their preferences. Re-activating a turn by tapping the ready button again, and manual navigation between phases were also demonstrated to give assurance to participants that all actions with the application could easily be reversed.

The estimated duration of one game of Spirit Island is from one and a half hours to two hours [45]. To keep the duration of the whole session reasonable, modifications to the game setup (detailed in Section 6.2.2) were made to shorten the duration to an hour. As the goal of the evaluation was to compare participants' playing experience, rather than measuring the results of the game, shortening the game duration was seen as suitable way to speed up the game without it affecting the results. Participants were informed about each game having a soft time limit of one hour, which they were free to extend at their digression, for example to conclude a game that was close to a victory.

6.3.3 Interviews

After each task, the participants were interviewed together in a semi-structured manner. The interviews were conducted in Finnish, with quotations from the interviews later translated into English. Preplanned questions (Appendix C) were used to structure the interview, but participants were additionally encouraged to share any other thoughts and opinions they had about the experience, which were then used to guide the direction of the interview. The interviews started with an informal starter question about the participants' general feelings and thoughts about playing the game, aimed at setting up a relaxed tone for the interview. The first part of the interview then focused on exploring the participants' experience of playing the game, while the second part focused on participants' experience of using the application and its effect on the playing experience. The first part of the interview was used after both tasks, and the second part only when task A had been completed.

7. RESULTS

This chapter covers the results of the evaluation, gathered from observations made during the tasks and the interviews that followed them. Since the interviews were partly guided by the answers and observations made by the participants, not all interviews consisted of exactly the same set of questions. The results are therefore grouped by subject. Quotations from the interviews are translated from Finnish.

7.1 Usage of the application

In neither task did participants express feeling overwhelmed about the amount of information that they needed to know and remember. During task B, participants relied on their memory to keep track of the current game state. The phase order section on the Invader board (Figure 11) was used as a memory aid to remember the order of the phases, the layout of the Spirit board to remember the actions in Spirit phase, and the labels above Invader cards on the Invader board to remember the order of Invader actions in Invader phase. Most participants (L1, L2, M3, M4, M7, H8) took shared responsibility of keeping track of the current phase, while some (M5, M6) relied more on one participant audibly narrating the progress of the game. In task A, all participants used the KOKOtap application to keep track of the game state. All participants felt that using the application made playing the game easier and helped to offload some of the mental load of remembering the game structure and their current turn progress. When playing without the application, participants felt that they had to exert more effort into learning and memorizing the game structure. For some (L1, L2), this resulted in feeling like they learned the structure better than when relying on the application, while others (M3, M4) felt that the visual presentation of three actions in each phase helped them to better visualize and understand the structure. Most participants (M3, M4, M5, M6, M7, H8) showed an increase in how confident they felt about either having remembered to complete all actions or not skipping any phases, some (M7, H8) after having expressed feeling unsure about it during task B. Participant H8 explained how following the application helped to prevent mistakes, *“When we didn’t have the app to follow along, it was easier to mess up what is happening when, and we easily took shortcuts.”*

During task B, all participants developed similar strategies to help in keeping track of the game state. When attempting to recall the current game state, participants used a strategy where they backtracked through recent game actions to logically arrive at a conclusion of what the game state must be. This often happened collaboratively, where positions of game components were used as evidence in solving the mystery of what must have happened. After participants had completed their actions in the current phase and needed to progress to the next one, the common strategies to help memory recall were to look at the phase order list to see the name of the next phase, or to wait for the other participant to take the lead. Asking for help was often only used as a last resort when neither participant was confident of the next step. None of these strategies were used in task A, where participants expressed that they did not need to use backtracking to figure out the current game state (M3, M4, M7, H8), nor read through the phase order list to see what happens next (L1, L2, M3, M5, M6). As participant M3 explained when comparing the experience in both tasks, *"When we had to use the phase list [on the game board] to check what happens next, we had to read though it step by step every time, since we weren't yet that familiar with it to know where exactly find the information. And if some of the actions took a lot of thinking, we'd forget where we left off in the list and had to read through it again.",* expressing how referring back to the phase order list felt more labor intensive. As explained by participant M4, *"We didn't have to do any backtracking [to figure out the current game phase or next actions in a phase], because the app always showed us where we are, we just had to glance at the app instead of thinking back to things we've done."*, while the knowledge of the current game state was able to be quickly recovered by glancing at the application in task A, during task B participants often needed to pause for a moment to retrace their steps until they could recall the information. The lessened effort needed to constantly stay on track of the game state was also expressed by participant M7, *"It felt more carefree to play when we had the application. We didn't need to always start recalling what things we have done – didn't need to constantly be on track of the situation - it was easy to check where we are."*. Playing the game required a considerable amount of focused attention from participants, where many participants [L1, M4] found the application helpful in directing their attention towards the things that were currently relevant, as explained by participant L1 *"We only had to focus on the thing that was next in the agenda, and that [the application] showed what it was. We were better able to focus on the ongoing phase, while the app showed automatically what to do next."* A similar sentiment was shared by participant M4, *"Since there were many different things to focus on, outsourcing keeping track of the game phase and actions to the app was helpful."*.

Participants used the Action buttons in two main ways: in the middle of a turn as a checklist to keep track of what actions have been completed, or at the end of the turn to verify that all actions have been completed. Action buttons were used in the middle of a turn situationally by all participants, mostly when actions took a long time to complete, or when a participant had to divert their attention elsewhere during a turn and wanted to "bookmark" their progress. When the Action buttons were used at the end of a turn, participants either tapped each Action button while verifying the action as completed (either by recalling from memory or by looking at the corresponding game components) or read through the Action button labels without interacting with the buttons. One participant (H8) remarked that they would have preferred if marking all actions completed would have automatically ended their turn, as they sometimes forgot to do so. Another participant (L2) on the other hand felt thankful that completing all actions did not automatically cause the turn to end, as they wanted to first make sure that they had indeed completed everything. One participant (M5) additionally expressed feeling more aware of the other participant's actions, explaining that *"Even if I wasn't really consciously following your [the other participant] play in the previous game [in task A], I felt that I had kind of peripheral awareness – like I knew in an unconscious way – of where you are in your turn."* The observation was not noticed immediately after task A, only after comparing the experience in both tasks.

7.2 User interface

Participants found the text displayed on the KOKOtap application easier to read than the phase order list, participants M4 and M5 commenting on the text on the phase order list being difficult to read due to its 90° rotation and small font size. Differences in text readability between the application and the phase order list were:

- The device was positioned between the game board and the Invader board, resulting in its position being slightly closer to the center of the table than the phase order list (Figure 10).
- Text in the application was oriented towards each participant, while text in the phase order list was in a 90° angle to how participants were seated.
- The font size on the phase order list (approximately 11 pt for the phase names and 10 pt for the actions) was small enough to often require participants to lean closer to be able to read the text, while font sizes used in the application were 14 pt for the phase name and 11 pt for actions.

None of the participants felt bothered by the presence of the mobile phone, many expressing that it quickly became a natural part of the game alongside the physical components (L1, L2, M3, M4). Participant M3 explained their thoughts about its presence, *"Especially when it's positioned like that [in the middle of the table] and the style being so satisfying, fitting the colors and themes of this game, it felt like a well* *integrated part of the game."*, highlighting the application's visual design as a key factor in making it feel like a part of the game. Participants L2 and M4 both independently compared the application to a chess timer, likely referring to similarities in placement between players, the mirrored interface, and the functionality of marking the end of a player's turn. None of the participants reported feeling distracted by the application. Participant M4 explained, *"If there had been something blinking, rotating, or some other distracting motion on the background, I feel like then it would have been distracting. Especially since this [playing the board game] is a thing that requires a lot of focusing, so it was good that it had a clean and calm look."*, expressing how the calmness of the design felt fitting to the context of having to focus on a demanding activity.

7.3 Future usage

All participants expressed interest in using a similar application in the future, especially when playing either a new game or a game they had not played in a while. One participant (M7) expressed that they would want to always use the application regardless of the game, but many (L1, M3, H8) felt that they would likely no longer feel the need for the application after becoming familiar enough with a certain game. Participant H8 saw the application as potentially beneficial mainly when learning a new game, *"When learning a new board game, this helps in keeping everything together. Then again, after playing a game enough, I probably would no longer use the app when everything is already clear and memorized. (…) Taking into account, that I play these games quite often."*, while participant M7 was more open to always using the application, *"I don't play board games that often, so I think that if I had the app, I'd use it every time regardless of if I knew the game well or not."*. Comparing the application to prior experiences with mobile applications used with board games, participant H8 noted the differences in purpose *"In this game, this type of app felt really beneficial. (…) It felt really useful that you can outsource your own remembering a little better. With the other games I've played [that utilized a helper application], the remembering is not outsourced in any way, you just have to remember all the things, and the app just tracks some life counters or similar things."*, explaining how the digital tools have provided convenience by replacing physical counters, but have not helped players in other mental tasks such as remembering things.

Two of the participants (M3, H8) felt it was important that the application did not replace any physical game components and was purely additional. Participant M3 saw the physicality of the board game as an important factor, not wishing to replace the physical components with digital variants. To participant H8, the main concern was the potential unreliability of digital tools, where essential game state information could be lost in the middle of a game if the device became unavailable in one way or another. Participants M3 and M4 also expressed concerns about having to dedicate a personal phone to the task, where it could not be easily used for other things, such as controlling music or responding to messages.

7.4 Summary of results

Common sentiments shared between participants are summarized in Table 7, where each participant's positive or negative opinion of the stated effect is listed. Cells are left empty when no opinion was expressed on the effect.

As seen in Table 7, the clearest effect of the application was lessening the effort participants felt they needed to exert into keeping track of the game state. All participants unanimously expressed that while they did not feel that the task of keeping track of the game state to be impossible during task B, it required less effort during task A. Half of the participants additionally mentioned being able to feel more confident in staying on track of the game state. Additional notions that arose in some of the interviews were the application's effect to how well the participants felt they had learned the game structure, where two participants found its effect helpful and two harmful. Three participants expressed that in task A they found their focus easier to divide between their own gameplay and the other participants' gameplay plans. Only one participant expressed an increased awareness of the other participant's game state.

Table 7. *Summary of effects to playing experience.*

Effect	**L1**	**L2**	**M3**	**M4**	**M5**	**M6**	**M7**	**H8**
Less effort required	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
More confidence			Yes	Yes	Yes	Yes	Yes	Yes
Better learning outcome	No	No	Yes	Yes				
Easier to divide focus	Yes		Yes	Yes				
Increased awareness					Yes			

None of the participants expressed negative feelings about the presence of the mobile phone in the playing table, and half of participants additionally expressed positive feelings that they felt the phone and application began feeling like a natural part of the game. All participants expressed an interest in using a similar application in the future, many specifying that they would feel compelled to use the application at least when playing a new game, and one participant could see themselves using it regardless of the game.

8. DISCUSSION

The results of the evaluation indicate that the KOKOtap application had a positive effect on the experience of learning and playing a complex strategy board game. This chapter discusses the results in detail, divided into sections that each cover a distinct observation apparent from the results. The first sections discuss the effectiveness of the application in different areas, and later sections focus on the effect the use of the application had on the playing experience. Finally, the last section of the chapter proposes topics for further research on the subject.

8.1 Keeping track of game state required less effort

The main benefit of the KOKOtap application was lessening the effort required for keeping track of the game state. The evaluation results indicated that participants found playing with the application easier and found it especially lessening the strain on mental load.

During task B, keeping track of the game state required constant effort from the participants. Though the amount of effort was not perceived to be overwhelming, its absence in task A was seen as a relief. At the start of any phase, participants needed to obtain knowledge of what the phase is and what actions should be done next. This knowledge could either be obtained by looking at the phase order list on the Invader board, or by recalling from memory. Then the information needed to be retained in memory while completing the required actions, along with the added information about the completion status of each action. Previous research has shown that keeping information stored in short-term memory becomes more difficult when simultaneously completing a demanding task [80]. This effect was also demonstrated in this evaluation by participants often forgetting the exact state of the game after focusing on a game action that required prolonged thinking. The application lessened the need to keep the information about the game state stored in short-term memory, as it was easily available through the application.

While the game provided participants with a physical list of the game's structure, the results of the evaluation indicated a preference for the application. Participants had equal access to the phase order list printed on the Invader board in both tasks, and it was highlighted as an alternative way to see the game structure during instructions of using the application. However, participants rarely referred to the phase order list when the application was in use, preferring to see the current phase and actions from the application. The main differences in how the game structure was presented by the application and the phase order list consisted of what information was displayed at any given time, and the presentation of the information. While the phase order list displayed all phases and actions at all times, the application only displayed information about the currently ongoing phase, eliminating the need for participants to read through all phases and actions to find a specific piece of information. In addition to relevant information being easier to find, text within the application was also physically easier to read, as text in the phase order list was in smaller font size and oriented in an angle to participants.

8.2 Effect on learning the game structure

Participants felt that using the KOKOtap application helped to prevent mistakes while learning and gave them more confidence. Since participants during task A would often verify the completed actions before ending a turn, the verification step became a part of the game flow. While during task B, verifying that all actions have been completed required a participant to either look at the phase order list to confirm what actions they needed to check or rely on still-partial memorization of the game structure. Especially for participants hesitant to ask for assistance, the application functioned as a more discrete way to obtain the knowledge about the game state and structure, lowering the barrier to learning.

Some participants felt that the visual presentation of the Action buttons helped them to better visualize the structure, while others felt that the ability to rely on the application meant that they did not need to learn the structure. Both observations have equal validity, as while some amount of memory cues is helpful to memory recall, an abundance of cues can decrease the effort put into memorization, negatively affecting its results [79]. The presence of the application could therefore negatively impact motivation to memorize the game structure, potentially creating a dependence on the tool. The negative impact is still fairly minor and was overshadowed in the evaluation results by the benefit of a lower barrier of entry into the process of learning.

8.3 Flexibility to personal preferences

According to Bakker et al. [51], when designing systems to be used with peripheral attention, interaction with the system should be flexible enough to adjust to different preferences. These differences in personal preferences were also visible during the evaluation, where the usage of Action buttons varied between participants and depending on the situation. Allowing the Action buttons to be used in a variety of ways meant that participants were able to use the application the way that benefited them the most, some structuring their gameplay around following the actions displayed by the application, and others using it only as needed. Participants who wanted to closely follow the structure presented by the application were able to do so, while those who felt confident in relying more on their memory were not forced to interact with the application beyond the minimum amount. A similar observation about the importance of flexibility was made in a 2012 study [70] into the effects of a digital tool providing computational support for board games, which highlighted flexibility in allowing users to choose which parts of the system to utilize and allowing users to ignore game rules at will.

8.4 Effect on game experience

Designing the user interface of the KOKOtap application to resemble the common themes and visual styles found in board games helped the application to blend in with the physical components of Spirit Island, making its presence more appealing to participants. Participants did not feel bothered by having a digital device present at the game table, many expressing that they soon stopped viewing the device as a mobile phone, instead seeing it as just another part of the board game alongside other game components.

There was no perceived negative effect on participants' experience of playing the game, nor on the social interaction between participants. The design of the application attempted to fade into the background of attention, which is what quickly seemed to happen. As participants got absorbed into playing the game, little of their attention was directed on using the application. When looking at previous studies into the usage of digital interfaces in board games, this could be attributed to two factors: interaction with the application not replacing interaction with physical game pieces and allowing interaction to be quick and imprecise. A study in 2012 [71] found the utilization of a digital interface to lessen players' eye contact with each other. In light of the attention theory covered in chapter 3, the effect could be explained by the digital interface requiring vision to operate, which then competes for the same resource as having an eye contact with other players. Additionally, while maneuvering physical components does not require constant central attention and could be performed at least partially in the periphery (such as visually locating a game piece, but then diverting attention elsewhere while grabbing and moving the piece only using peripheral attention), a digital interface lacking tactile feedback does not enjoy the same benefit, requiring conscious control and thus central attention to interact with. Another study in 2011 [69] found maneuvering physical game components to make players' actions more observable to other players. While actions using physical game pieces could be easily observed even with peripheral attention, interactions with a digital interface were harder to see, especially if the interface was not correctly oriented towards all players or was further away [69]. Keeping the physical interaction with game pieces intact therefore avoided the negative effect to the observability of game actions to other participants.

8.5 Limitations and future work

The largest limiting factor of this study was the small scope of the evaluation, enough to cover a single use case of two participants learning and playing a complex strategy board game in a calm environment but leaving many other use cases and user groups for future research. A larger scope of the evaluation could have made it possible to cover more use cases, including playing in a noisy or distracting environment, playing a board game participants knew well or found easy to play, or playing with a larger group of people. The small number of participants also affected what user groups the evaluation could cover, leaving out the opportunity to evaluate the application's ability to assist players with cognitive disabilities. These caveats could have been negated by widening the breadth of the evaluation at the cost of its depth. The evaluation could alternatively have been arranged remotely by giving instructions to participants on how to use the application with any suitable board games they had access to and collecting results via questionnaires. This would have enabled the evaluation to cover a far greater number of participants from different user groups in a variety of different use cases, but at the cost of the more detailed results that were able to be gathered via observation and in-person interviews. This thesis has therefore mainly served as proof-of-concept for a new type of digital tool for assisting board game play by demonstrating its effectiveness in at least one specific use case.

In addition to addressing the gaps in evaluation mentioned before, future research could be used to evaluate the application's effectiveness in prolonged use or its effect on awareness. The application was seen as especially helpful while learning a new board game, with some participants speculating that the effect might decrease as they became more familiar with a game, while some participants who played board games less frequently disagreed, indicating a user's overall familiarity with board gaming possibly having an effect on the application's usefulness beyond the use case of learning a new board game. An increased awareness to the other participant's actions was observed by one participant. As the effect to awareness was not noticed initially after the first task, but only when the participant was able to reflect on the whole experience after both tasks, it could indicate that other participants might also have experienced a difference in awareness but were not aware of it. Interviews may have therefore been an insufficient evaluation method in attempting to investigate awareness, as they relied on participants being aware of possibly not having been aware of the other participant’s turn progress at some points during the tasks. Questioning the participants about the other participant’s turn progress during the tasks could have given better insight. As of now, the results only indicate a possibility of increasing awareness, but more research would be needed to gather conclusive results.

9. CONCLUSION

This thesis presented a design and implementation of the KOKOtap application that attempted to assist players in the mental tasks that are part of playing board games by providing players with visual reference of the game's current state and allowing players to track their turns and actions. The effectiveness of the application and its effect on the playing experience were evaluated with a user study, where participants were taught to play a complex strategy board game, asked to play the game both with and without the help of the application, and then to reflect on their experience. The most notable effect of the application was that keeping track of the game state required less mental effort from participants. Using the application did not have a perceivable negative effect on the experience of playing the game.

The first research question, **How does a digital tool keeping track of the game state in a complex board game affect the players' experience?**, aimed to directly examine the effects the KOKOtap application had on the playing experience, before discussing the implications in a more generalized way. To answer the question, participants in the user study were interviewed about their thoughts on the experience when playing both with and without the application. The results showed all participants having expressed needing to exert less mental effort when playing with the application, many additionally expressing that they felt more confident in not having made mistakes or forgotten something they should have done. When participants did not have to keep track of the game state only using their mental resources, but could delegate some of the effort to the digital tool that kept track of the game state for them, they found the activity of playing a complex board game easier, and were able to be more confident in their ability to play.

The second question examines the broader implications of the research by asking: **Can a digital tool help players with mental tasks in board games?** By showing that the KOKOtap application had a positive effect on the mental task of keeping track of the game state, this thesis therefore demonstrates a successful example of a digital tool helping players with mental tasks in board games, showing that the potential of digital tools in board games is clearly not limited to just the automation of manual tasks, but can also be used to great effect in supporting other aspects of board game play.

The final research question, **What design considerations are impactful for a digital tool helping players with mental tasks in board games?**, was answered through first analyzing the context of playing a complex board game through the theoretical perspective of calm design and peripheral interaction and then evaluating the effects of the chosen design considerations. Flexibility of how the application could and should be utilized was the design consideration with the clearest effect, allowing its usage to be easily integrated into different playing styles, from being closely followed by players who relied on it to guide them through the game, to only serving as a back-up to players more confident in relying on their memory. An appealing and calm visual design was another consideration that helped the application to blend in with the board game and fade into the background of attention, where it allowed players to focus on the experience of playing.

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APPENDIX A: CONSENT FORM

This user experience test is a part of a master's thesis work at Tampere University. By participating in the testing, you will help to evaluate the usefulness and design of digital tools used as support in playing board games.

In this user experience test you will be asked to play two games of the board game Spirit Island, and afterwards answer a few questions about your playing experience. By participating in this test, you agree to the following terms:

- Recording: The test session will be recorded for analysis purposes. The recording will capture your interactions with the board game, application, and the other participant.
- Confidentiality: Any information collected during the test will be confidential. Your identity will not be disclosed, and your data will be anonymized in any reports.
- Voluntary Participation: Participation in this test is entirely voluntary. You may withdraw your consent and stop participation at any time and for any reason.
- Data Usage: The data collected will be used solely for research and development purposes related to the board game helper application. Any data will not be shared with third parties.

Feel free to ask any questions you may have about participation.

By signing below, I confirm that I have read and understood the information provided above.

Signature: ____

Name clarification: __________________________________

In Tampere, _____ . _____ . 2024

APPENDIX B: BACKGROUND QUESTIONNAIRE

Please take a moment to fill out the following background information.

Demographic information

Name	___________________________
Age	_________
Gender	[ ] Male [ ] Female [ ] Other / Prefer not to disclose

Board game experience

How often do you play board games or card games?	[ ] Daily [ ] Weekly [ ] Monthly [ ] Rarely [ ] Never
If yes, what board- or card games do you play most often?	____ ____ ____
Have you played the board game Spirit Island?	[ ] Many times [ ] A few times [ ] Once or twice [ ] Never
Have you used any board game support applications before?	[ ] Yes [ ] No
If yes, what support applications have you used?	____ ____ ____

APPENDIX C: INTERVIEW QUESTIONS

Interviews were conducted in Finnish.

Part 1: Experience of playing the game

1. Did you feel like you could partake in planning the game turns?
    a. What things made it easier / more difficult?
2. Did you feel like you were in control of the game situation?
3. How did you feel about the amount of information the game expected you to remember and keep track of?
4. How did you know the current state of the game?
   (e.g. what is the current game phase, or what actions you have completed)
    a. If you ever lost track of the game state, how did you solve the situation?

Part 2: About using the application

- How did using the application affect:
    a. your playing experience?
    b. the flow of the game?
- Did you ever forget to advance the application forward?
  (e.g. forgetting to mark a turn as complete and advancing to the next phase)
- How and when did you notice the situation?
    a. How did it affect the game?
    b. How did you feel about the presence of a mobile phone on the table?
- Would you have interest in using the application in the future?
    a. In what kind of situations would you see yourself using the application?
    b. When would you see yourself not using the application?