Design and Evaluation of a System for Social Connection through Remote Tabletop Gameplay

by

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Abstract

Playing remote tabletop games is a fun way to connect with distant friends. Yet most systems for remote tabletop gaming lack support for tangible and social interaction, two important aspects of gameplay for most players. I am interested in how to better design systems for remote tangible gameplay that support social connection. I investigate this topic through the design and evaluation of a prototype system for playing the board game Wavelength across two locations. First, I describe my design process and the requirements that informed my prototype: “Remote Wavelength”. Then, I discuss the results of a qualitative user study in which ten friend groups played Remote Wavelength. My findings indicate that a synchronized, tangible gameboard benefits player engagement, communication, and awareness. My results also illustrate the value of integration across communication and gameplay systems. I conclude by offering considerations for the design of both digital and tangible remote gameplay systems.

**Keywords**: Collaborative interaction; Social connection; Tabletop games; Remote; Distributed; Tangible
This thesis is dedicated to everyone who fostered my passion for games.

To my parents, grandparents, and family—from Euchre to Hūsker Dū, you instilled a love of games early. I am deeply grateful for a childhood full of play.

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## List of Acronyms

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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>CMC</td>
<td>Computer Mediated Communication</td>
</tr>
<tr>
<td>HCI</td>
<td>Human Computer Interaction</td>
</tr>
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<td>RTD</td>
<td>Research Through Design</td>
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Chapter 1. Introduction

Tabletop games—including board games, card games, party games and role-playing games—can be a fun way to spend time with friends. These games are becoming increasingly popular (Grand View Research, 2019; Jolin, 2016), and for most who enjoy them the social interaction is one of their key motivations for play (Rogerson et al., 2016; Woods, 2012). Unfortunately, people are not always able to get together to play in-person. They can turn to remote gameplay—where players use technology to mediate their communication and gameplay across households—as a potential substitute. Remote tabletop games help friends connect when someone moves away to seek work, education, or other opportunities (Yuan et al., 2021). Remote games also helped people forced to isolate due to the Covid-19 pandemic (World Health Organization, 2022) socialize safely with friends and family outside their household (Heshmat & Neustaedter, 2021; Kleinman et al., 2021). Supporting people to maintain social connections, even over distance, has substantial benefit. People with strong social relationships are generally healthier than those without (Haslam et al., 2015; House et al., 1988) and the effect of social relationships on mortality is comparable to that of other well-known risk factors such as smoking, obesity and physical inactivity (Holt-Lunstad et al., 2010). Fortunately, enjoying shared experiences (such as tabletop games) while connecting on a video call helps people maintain social bonds with distant loved ones (Brubaker et al., 2012).

Given the value of remote tabletop gameplay for keeping in touch with distant friends, one important design consideration for remote tabletop game systems is fulfilling our need for social connection. I seek to provide guidance on how to design remote gaming and communication systems that enhance players’ feelings of connection over distance. For my purposes, I understand social connection to consist of feelings of closeness and togetherness, exchanges of meaningful communication, and mutual enjoyment of a shared activity. I focus on connection between friends—the people one knows, likes and chooses to spend time with—as one type of connection that can be nurtured through gameplay. This means I am interested in social connection as experienced between two individuals or a small group, rather than at a macro or community level (van Bel et al., 2009). Lastly, I intend for this working definition of social connectedness to encompass feelings of social presence (Kreijns et al., 2022), as well
as the quality of the dialogue and social interaction between individuals (Yarosh et al., 2014).

Social connection is important, but there are several known challenges with connecting using existing remote gameplay systems, such as maintaining player awareness, incorporating physicality, and synchronizing the game state across households (Yuan et al., 2021). To address these challenges, research is beginning to explore the design of remote tabletop games and game systems in relation to social connectedness. This research remains in its early stages and has focused on identifying design implications through the study of current remote gaming practices (Yuan et al., 2021), exploration of the design space through ideation (Mills et al., 2021) and speculation based on Material Theory (Maurer & Fuchsberger, 2019). There is little work that has investigated how these implications might be incorporated into a fully realized game system or how they will be received by players. To address this gap, I designed and evaluated a prototype system for remote tangible gameplay and social connection. I call this system Remote Wavelength, as it enables users to play the party game Wavelength across two locations.

1.1. Research Context

![Figure 1.1. Research context within human-computer interaction](image)
This research is situated within the discipline of Human-Computer Interaction (HCI). HCI is an interdisciplinary endeavor, drawing on approaches from fields such as computer science, social science and design to investigate how people interact with computing systems and build useful, usable technologies (Association for Computing Machinery, 2022). This work explores a practical application of HCI that sits at the intersection of several research themes, including games and play, computer-mediated communication, and tangible interaction (Figure 1.1). My goal was not to contribute new approaches to tactile interaction or Computer-Mediated Communication (CMC), but rather synthesize insights from across these areas to design a prototype game system. I then evaluated the prototype I created to better understand how to address a particular design challenge: supporting social connectedness during gameplay over distance.

In exploring social connection, I focus on connection between adult friend groups. In some cases, these groups contain people with other relationships, such as romantic partner, sibling, classmate or colleague, but in general my work does not speak to the needs of populations such as multi-generational family groups, older adults, teens and children. It is also important to note that I aim to promote the connection of social groups who wish to maintain existing bonds, not those who wish to form new friendships by playing games with strangers.

This work also focuses on tabletop gaming, specifically multi-player games with structured rules and physical materials that sit on a table. This excludes other types of playful experiences such as video games, lawn games or open-ended play. While the distinction between video games and tabletop games is blurring as the latter are digitized for remote play, I see tabletop games as any game initially designed with the intent that it be played at a table, with physical components.

1.2. Research Questions

This thesis explores the design, use and evaluation of systems for remote tabletop gameplay and social connection. It addresses the overall research question of “How might we design systems for remote tabletop gaming play that support social connection between players?” To guide my inquiry into this high-level design question, I have developed three sub-questions. In particular, I focus on tangible interaction—a key
part of in-person gaming yet often absent in remote play—and its potential to support social connection.

**Question 1:** How do groups of players use a remote, tangible gameplay system to socialize and play a tabletop game together? Previous work has investigated the existing remote gaming practices of tabletop game players in the context of the Covid-19 pandemic. Yuan et al. (2022) documented the digital and hybrid (digital-physical) practices that players developed to maintain connection during social isolation. They found there were drawbacks to each approach. Digital applications lacked the sensory appeal of material board games, and while some players implemented a hybrid setup, they had difficulties synchronizing physical game states between households. A handful of prototype systems have been developed for tangible remote gameplay, but these systems have so far only explored only two-player games, such as chess or checkers (Günther et al., 2018; Odenwald et al., 2020; Wilson & Robbins, 2007). It remains to be seen how larger groups of players (who might engage in more complex social interactions) use a system for remote tangible board game play and social connection.

**Question 2:** How does a remote gameplay system with a synchronized, tangible gameboard impact players’ experiences of social connection during remote play? Currently, we know little about how the design features of a system for tangible remote gameplay shape players’ social connection over distance. As mentioned above, research has explored existing methods for remote board game play, but these methods are limited to digital board game play, or, if they incorporate physical play, do not synchronize physical components across households (Yuan et al., 2021). In addition, researchers have explored the role of sociality when playing collocated traditional and hybrid (i.e. both digital and physical) tabletop games (Rogerson et al., 2016; Wallace et al., 2012; Xu et al., 2011). However, we do not yet know how these findings apply to gameplay over distance.
Question 3: What considerations are important in the design of a system that connects friends through remote tangible gameplay? Existing literature provides limited guidance on how to design systems for connecting while playing remote tangible table games. Researchers have created systems for tangible remote play (Günther et al., 2018; Odenwald et al., 2020; Wilson & Robbins, 2007), but their work provides little guidance that might inform the design of future systems, particularly in the area of designing for social connection. Maurer & Fuchsberger (2019) have discussed the design of games themselves for improved remote play. My work is informed by this but is distinct, as I focus primarily on the system for enabling play.

This work investigates the above questions through the design and evaluation of system for remote tangible play, which I call Remote Wavelength (Figure 1.2). Design considerations were generated through the Research through Design process, which explored the design space through a series of design proposals and the process of iteratively prototyping a remote tangible gameplay system. These design considerations were then extended and refined through evaluation. To evaluate the system, I conducted a qualitative user study of the prototype remote gaming system to better understand players’ experiences, behaviours and social interactions during gameplay.
1.3. Methodological Approach

Figure 1.3. Select prototypes from the RtD process. From left to right: a) Integrated player video and game objects in a Fiasco prototype; b) RFID tagged game pieces in a Distributed Letter Jam prototype; c) Early prototype of Remote Wavelength

To investigate my research questions, I design and evaluated a prototype system for remote gameplay. To capture insights from the design process, I used a Research through Design (RtD) methodology. RtD applies the tools and methods of design to the production of knowledge (Zimmerman et al., 2007). The methodology is well-suited to investigating a problem space, generating new possibilities, and contributing to a conceptual or theoretical understanding of the topic through application (Zimmerman & Forlizzi, 2014). Given the preliminary nature of work in the distributed board game space (Maurer & Fuchsberger, 2019), using an RtD approach helped me explore the problems facing players who want to connect through gameplay, as well as generate possibilities to address these issues through system design. In addition, the act of prototyping and evaluating a system (i.e. design practice) is a technique well-suited to the development of design implications or considerations (Sas et al., 2014)—one of the main goals of my work (see RQ3).

To evaluate the system, I conducted a qualitative user study. This approach was well-aligned with my research questions, as qualitative research contributes an understanding of how people attribute meaning to the many factors involved in a complex situation, and produces rich descriptions of participant behaviours (RQ1) and experiences (RQ2) (Creswell, 2013). Under the umbrella of qualitative research, I adopted a user study method because it focuses on understanding user experiences with a system to better inform the design of the system (Rubin et al., 2008), which assists in answering RQ3.
Both qualitative research and RtD can leverage the perspective of the designer-researcher and the first-hand insights that emerge from reflexively engaging in the design process (Devendorf et al., 2020; Neustaedter & Sengers, 2012; Odom et al., 2018). Throughout the research process, I was able to draw upon knowledge of the design space accrued through a lifetime of tabletop gaming. I regularly play distributed tabletop games to connect with friends and family across Canada and have experimented with a variety of commercial and homebrew remote tabletop gaming systems. During the design process, I self-tested several lo-fidelity prototypes, including an early iteration of Remote Wavelength (Figure 1.3a-c), which helped contextualize insights and inform requirements for the system.

Drawing on personal experience with a topic can be a strength of qualitative research, but it also introduces potential for bias (Creswell, 2013). Given this, it should be noted that my experience is largely limited to the modern, Western tabletop games (e.g., Euro games, role playing games, party games) and social groups of adults aged 25-35 with high digital and games literacy. This influences my understanding of the needs of social gaming groups, though I attempted mitigate this bias by reviewing other research on social gameplay (e.g., Xu et al., 2011; Yuan et al., 2021) and incorporating the perspectives of study participants with aried gaming experience and preferences. It's also important to acknowledge that this research is limited in terms of the types of friend groups studied and their level of familiarity with technology for remote connection.

1.4. Organizational Overview

In Chapter 2, I review the literature on topics related to my research. This section covers research across three areas: 1) social connection over distance, 2) hybrid game design and tangible interaction in games, and 3) research on remote tabletop gameplay and game systems.

In Chapter 3, I describe my design process, which included an exploration of the problem space, ideation, and prototyping. I articulate the design requirements that emerged through this iterative design process. I then describe the final design of the Remote Wavelength system, include software and hardware.
In Chapter 4, I detail how I conducted a qualitative user study to evaluate *Remote Wavelength*. This includes an overview of participant recruitment, the activities included in the user study, and specific areas of inquiry that guided the post-study discussion.

In Chapter 5, I report on the results from the user study. This includes how tangibility shaped user experiences and how additional elements of the system design shaped their feelings of social connection.

In Chapter 6, I discuss the implications of my results, identifying several considerations for the design of future systems for remote tangible play.

In Chapter 7, I conclude my thesis by revisiting the research questions and summarizing my findings for each. I state my core research contributions and identify areas for future work.
Chapter 2. Related Work

In this chapter, I review related work. First, I situate my understanding of social connection within the related literature and describe how this informed my research inquiry. Next, I review existing research on designing for social connectedness during shared leisure activities over distance. Narrowing my focus to gameplay, I then examine how my research can draw on lessons from the design of other technology-mediated game systems, such as digitally augmented board games for collocated play. Lastly, I survey existing tools for remote gameplay and review the emerging scholarly work in this area, with the goal of articulating the knowledge gap I address through my research.

2.1. Social Connection

In the context of Computer Mediated Communication (CMC) technologies, connection seems an intuitive concept, yet is also very difficult to define explicitly, and new understandings are continuing to emerge (Stepanova et al., 2022). For my purposes, I developed a working definition of social connection to guide my research. This definition is important to clarify, as it informed my inquiry during discussions with study participants and helped me determine which data was relevant to the research questions during analysis. Here, I describe the sources that contributed to my understanding of social connection and how it informed my work.

Van Bel et al (2009) propose a measurement instrument for assessing social connection in the context of communication media. They define connection as “a short-term experience of belonging and relatedness” (van Bel et al., 2009, p. 1) and distinguish between two types of social connection: specific and overall. Overall connectedness refers to the sense of belonging that emerges from the size and quality of one’s entire social network. Specific connectedness refers to the feeling of being in contact and in relation with another individual, which is the type of connection I am interested in cultivating through gameplay. To better measure connectedness, van Bel et al also articulate specific elements that compose the theoretical concept of specific social connection. This includes relationship salience, how often one thinks of and feels close to another individual when not in contact. It includes feelings of closeness, having a close relationship where one can communicate well and talk about anything together.
A third component of connection identified is *shared understandings*, which is the feeling of having common interests and ideas, and easily expressing these to another. A fourth dimension is *knowing each others’ experiences*—having an awareness of another’s thoughts and feelings, and believing that they are aware of your own feelings. The fifth dimension is *satisfaction with contact quality*, which refers to the depth of positive feeling one has when interacting with another. Applying these dimensions to my understanding of players’ sense of connection during gameplay meant considering players’ awareness of each other’s thoughts, feelings and experiences, their ability to communicate and develop shared understandings, as well as their overall satisfaction with the quality of interaction.

Another aspect of social connection that featured heavily in my work is social presence. Social presence is “the subjective experience of being present with a ‘real’ person and having access to his or her thoughts and emotions.” (Oh et al., 2018, p. 1). In other words, it’s the sense that you’re together with someone, and have some insight into their emotional state through awareness of their body language, gestures, and other verbal and non-verbal cues (Biocca et al., 2003). Social presence is an important contributor to social connection, particularly for synchronous communication mediums (IJsselsteijn et al., 2003) and as a result, descriptions of feeling close to and together with remote players featured prominently in how I described social connection to study participants. Lastly, Yuan et al (2021) suggest that to understand connection in a shared activity space, researchers should consider three dimensions—unmediated interactions, technology-mediated interactions and awareness of mediated information. In studying social connection during remote gaming, this informed my interest in observing how participants interacted with collocated (i.e. unmediated) players and remote (i.e. mediated) players, and exploring any contrast between the two. It also highlighted the importance of collecting players’ reflections on their awareness of each other’s feelings and game actions and how the system’s mediation might have impacted that awareness.

### 2.2. Shared Activities to Connect Over Distance

Researchers have found that social interaction is one of the primary reasons people enjoy board games (Rogerson et al., 2016; Woods, 2012), and that stronger feelings of social presence improve the player experience of digital games (Gajadhar, 2012). The value of social time during gameplay extends beyond the game, helping
friends and family maintain social bonds. For example, Wang et al (2018) examined the relationship between how often a family played video games together and parental ratings of family closeness (strength of relationship between an individual and another family member), satisfaction (overall feeling of happiness within family) and communication (open exchange of information and feelings between family members). They established a correlation between co-playing video games and family closeness and satisfaction. They also found support for the presence of a causal relationship between co-playing video games and family closeness, particularly in families with poor communication. While the study is limited to the parental perspective, the initial results suggest that playing video games together as a family has a beneficial effect on family relationships.

In addition to supporting social interaction and bonding when played in-person, games are a popular choice of shared activity for groups connecting over distance. Remote gameplay helped people connect to friends and family during the Covid-19 pandemic. For example, in response to a survey about how games helped people cope with the Covid-19 pandemic, Kleinman et al (2021) found that more than half of the 130 participants mentioned using games to connect with friends, classmates, co-workers and acquaintances. Similarly, Heshmat & Neustaedter (2021) conducted interviews to explore of how people communicated with friends and family throughout the pandemic, and found that people used both board games and video games to connect. Interestingly, they observed that while many of their study participants who played video games together formed enduring habits, those who tried to replicate their in-person tabletop gaming experiences remotely often abandoned the practice shortly afterward. Participants reported feeling too focused on the game, and lacking opportunities for conversation and socializing. To mimic the atmosphere of an in-person game, some participants tried to incorporate physicality into video calls, including game cards and pieces. But the difficulty of coordinating physical game elements over distance led to frustration, leading the authors to report that “board games and card games still do not have strong technological support for play over distance” (Heshmat & Neustaedter, 2021, p. 11). This highlights the importance of games as an activity for social connection, and suggests the incorporation physicality in remote tabletop games as a design challenge that warrants further investigation.
Figure 2.1.  *Puzzle Space.* Players collaborate to complete the on-screen digital puzzle by moving tangible pieces. Players communicate via a video link.

Source: Publications (Pan et al., 2017)

People connecting over distance are eager to enjoy shared activities, tabletop games included (Brubaker et al., 2012). This is an enduring area of interest in HCI, as researchers have developed and tested numerous systems designed to enable social connection through shared activities, including watching TV (Macaranas et al., 2013), reading (Raffle et al., 2011), yoga (Muntean et al., 2015), jogging (Mueller et al., 2007), dining (Barden et al., 2012), shopping (Yang et al., 2018), cycling (Neustaedter et al., 2020), and geocaching (Heshmat et al., 2018), indicating the HCI community’s enduring interest in this topic. Many of these examples (e.g. highlight how seeing video of remote contacts during the activity supports social presence and emotional connection, which informs the choice to include video in my system.

I am particularly inspired by systems for structured play activities over distance, such as puzzles and escape rooms. Pan et al (2017) designed a distributed puzzle
application called *Puzzle Space*, which enables two players to collaboratively assemble a jigsaw puzzle (see Figure 2.1). Each player controls half of the physical pieces, and digital versions of local and remote puzzle pieces are integrated in a digital environment on a laptop screen. The puzzle is assembled on a box with a transparent top, and each piece is tracked by a webcam in the box that recognizes fiducial markers on the piece’s underside. The authors suggest a next step for the work might be adding audio-visual feedback to the system to help collaborators track the movement of (remote) digital puzzle pieces. *Puzzle Space* also demonstrates how distributed players might use local, tangible pieces to control a game in a shared digital space.

*Escaping Together* is a distributed escape room, where pairs of friends collaborate to solve puzzles over distance (Shakeri et al., 2017). Researchers observed how participants in the escape room used audio as well as mobile and stationary video feeds to collaborate across two locations. They noted that participants initially expected all puzzles to be highly integrated and the viewpoints, layout, and objects across each room to be parallel. Participants’ struggles to understand the remote perspective demonstrate the value of system feedback that helps players confirm whether they are interacting with the same situation and objects, particularly when this is not the case. Shakeri et al (2017) also flag the need for people to be able to investigate elements of the puzzle or game at the remote location without requiring help from the remote player. In an escape room, this offers a player an option to proceed with puzzle solving even when the remote player is engaged elsewhere. In a game, a player might prefer to investigate the game state without asking specific questions that could “give away” what they are interested in and offer insight into their strategy.

Beyond the domain of leisure and distributed play, I draw inspiration from prior work on distributed tabletop collaboration. This work establishes the importance of conveying gestural information to help users smoothly complete a tabletop task, which in a game can include pointing to reference game objects and demonstrating or actively performing a game action (Gutwin & Greenberg, 2002). This gestural information is currently lacking in most commercial remote board gaming systems, which often do not include any remote player representations and instead require players to use separate video conferencing software. Commercial video conferencing software tends to capture only a tight, rectangular window around the head and shoulders of each participant, and arrange these videos on screen into a grid. Participants’ interactions with the tabletop, its
contents, the surrounding space and any people in that space are not usually shown. This approach tends to result in a “talking head” version of remote player representation, which omits useful details about players’ environments and actions. (Massimi & Neustaedter, 2014). In a remote tabletop game setting with some physicality, the talking head camera view omits interactions with the physical gameboard, causing players to miss cues about what is happening in the game (Yuan et al., 2021).

Existing research also highlights the value of being able to see and refer to the shared gameboard to establish ‘common ground’. Common ground is a mutual understanding of the situation that people leverage to communicate more efficiently (Gutwin & Greenberg, 2002). Leveraging common ground for tabletop collaboration requires awareness of current visual cues as well as past actions in the workspace. In a game context, common ground enables a Monopoly player to silently extend their hand across the Monopoly board and get a hotel in return, because everyone can see the gesture and knows that the player has four houses on Boardwalk and just paid the cost to upgrade those buildings. This illustrates the importance of displaying player interactions with the game board and synchronizing game elements over , which maintains common ground and thus streamlines player communication. Overall, there is significant prior research on enabling shared activities over distance, though research specific to tabletop gameplay is more limited (see Section 2.4).

2.3. Collocated Hybrid Games

Here, I discuss research from the adjacent domain of hybrid board games, meaning “board games in which play is enacted through both physical components and a ‘smart’ digital element” (Rogerson et al., 2021). While these projects generally focus on collocated play, many of the issues and opportunities that arise when digitizing board games also apply to remote games, which necessarily include a digital element.
Work on collocated hybrid games has demonstrated potential ways to synchronize gameboards or share game information across households, as most hybrid games use technology to track and update the game state. One of the earliest works, STARS, combined an interactive surface that could track game pieces with handheld devices that could also read those pieces and relay private communications (Magerkurth et al., 2004). STARS was evaluated with children ages 11-14, and the authors found that while the hybrid game was very well-received, the camera recognition technology needed to be more robust to account for when people bumped the table or reached across the tabletop out-of-turn. Another early exploration of the hybrid space, False Prophets, integrated a tabletop display system to show the game board, with a custom sensor interface to track the location of game pieces on the board (Mandryk & Maranan, 2002). Players can press buttons on the game pieces to complete in-game actions. Similar to STARS, the system also featured handheld devices that enabled players to receive and review private information. False Prophets was never evaluated. Molla and Lepetit (2010) tracked pawns on a gameboard using a webcam. The system was
implemented to track pawns in *Monopoly*, and demonstrated potential of using a simple webcam for monitoring game states. It also likely addressed some issues of robustness identified by *False Prophets*, as it was resilient to occlusion from players’ hands and the presence of excess pawns on the tabletop, but the system was never evaluated. These examples delineate a genre of hybrid games with augmented tabletop displays (either through projection onto the tabletop or a built-in display), Next, I describe and draw lessons from a few more recent examples of augmented tabletop game systems.

One example of an augmented tabletop system is *Tisch*, an application built for the *Microsoft Surface* (the *Surface* is a full-sized interactive tabletop, not to be confused with more recent Microsoft laptops and tablets). *Tisch* was designed to support play of a variety of role playing games, including Dungeons & Dragons. (Hartelius et al., 2012). The creators of the *Tisch* identified design goals to inform their creation, including minimizing *excise* (the work of setting up and maintaining the game state) and reducing *social weight* (the requirement that players to turn their attention toward the technology and away from the game and fellow players). Following playtesting with the application, its designers stressed the importance of allowing players to adapt gameplay by creating “house rules”. They also suggest that the interface’s adaptability was a key trait, and describe how it was used by players for non-game activities (e.g. doodling) to alleviate a common problem with role playing games, when players’ characters are outside the spotlight and players become bored waiting for their turn. This highlights several ways in which building flexibility into a digital tabletop game system might be useful.
Figure 2.3. VirtualTable, an augmented reality game where projected virtual game objects respond to the movement of physical game pieces
Source: Publications (Dal Corso et al., 2015)

Entertaible is another interactive tabletop designed for collocated hybrid gameplay (Loenen et al., 2007). It is notable for its ability to detect multiple touches simultaneously (up to 40). The designers of Entertaible also created the concept of Adaptive Pawns, made of a transparent material so that light from the tabletop could shine through the top of a pawn placed on its surface and change the pawn’s colour. The Entertaible was informally tested by children, who chose to engage with the table over several other entertainment options, and received significant attention from media and conference-goers, but was never formally evaluated. Dal Corso et al (2015) created a projection-based augmented reality (AR) system called VirtualTable capable of creating digital effects around physical game pieces. Using an overhead projector to display virtual objects on a tabletop, and a Kinect to track the movement of physical objects on the same tabletop, the authors created a mixed reality game where players arrange physical obstacles to block incoming virtual opponents (see Error! Reference source not found.). The system demonstrates how evolutions in sensing technology can be applied to tabletop gameplay by using a Kinect rather than a webcam, but it was never evaluated.
Moving beyond augmented tabletops, Mora et al. (2016) created the game *Don’t Panic!*, which focused on augmenting game pieces rather than the board. Their system design featured interactive game tokens with LCD screens and printed cards with scannable barcodes (see Figure 2.4). Players could perform actions by picking up and moving the tokens and tapping their LCD screens. They could also check the screens for information about the game. Instead of drawing a card, players would press a button to print a card with a description of an in-game event and a barcode to activate that scenario. When scanned, the barcode would update game information on the LCD screens. To evaluate the game, participants played with both a physical prototype and the hybrid prototype and compared the two experiences. Players appreciated that the hybrid version removed some of the work of tracking the game state and enabled the card scenarios to be highly responsive to specific conditions in the game. However, players also commented that the automatic updates made it difficult to keep track of the game state. The authors concluded that one design challenge for hybrid games is finding a balance between digital (system) and physical (player) control of the game state. They suggest that when automating tasks, simple and repetitive bookkeeping tasks can be handled by the system, while tasks that have strategic importance should be executed by players. They also suggest further research to explore additional
technologies for building augmented game pieces, including RFID tags, conductive ink and fabric, and Arduino microcontrollers.

As Mora et al (2016) point out, RFID Readers are another technology that has potential for augmenting tabletop gameplay. RapID is a system that demonstrates the potential for low-latency recognition of RFID tag movements, which can be used to track objects in near real-time (Spielberg et al., 2016). This is an alternative sensing technology which might be used to resolve some of the robustness issues (e.g. occlusion and table movement) that occur when using camera vision. Researchers used the system to implement a version of Tic-Tac-Toe where every piece placed was tracked via an RFID tag and replicated digitally, however the gameplay experience created by the system was never evaluated.

Hybrid Settlers demonstrated the ability to update the appearance of a game tile with electrochromic inks (Jensen et al., 2020). To create the hybrid version, researchers integrated four dynamic tiles into a standard Catan game board. The appearance of the hybrid tiles could be switched between two images drawn in electrochromic ink. The tiles could be controlled by the game software or manually. During playtesting, players reported enjoying the new strategies that were enabled by the dynamic tiles, but also feeling a nostalgia for the traditional style of tile and appreciating that the game was balanced between the two. This illustrates a possibility for updating a remote tangible game board in response to changes to a linked remote board, while also highlighting the importance of preserving some look and feel of the original game tiles.
An example of a system which blends augmentation of game pieces as well as the tabletop is ToyVision (Marco et al., 2013). ToyVision is a toolkit developed to provide a platform for game designers to create hybrid board games with tangible interaction (see Figure 2.5). Unlike previous examples which use digital techniques to alter the appearance or display of game pieces, ToyVision uses mechanical actuation to physically move the pieces. Dragon’s Cave, a children’s game used to demo the technology, featured a rotating Dragon token and opening and closing Treasure Chest, both activated by servo motors. This example shows it is possible to design tabletop games with actuated pieces, with movement controlled by the game system. Unfortunately, I was not able to find an evaluation of the system or evidence of its use beyond the initial demo.

While the above examples were designed for collocated gameplay, the diversity of these techniques illustrates the potential of the design space for remote tangible games. These examples provide some considerations for the design of hybrid tabletop games, including preserving rules flexibility in a digital system, respecting player
nostalgia for traditional game pieces, designing for both public and private information, and preparing for unanticipated and disruptive use. I also learned that research has explored technologies such as projection and camera vision (*VirtualTable, False Prophets, AR Monopoly*) and tabletop or embedded displays (*Tisch, Entertaible, Don’t Panic, STARS*) for digital augmentation, but the area of actuated hybrid games (*ToyVision, which was unevaluated*) is relatively less explored (this is also reflected in related work specific to remote games, see Chapter 2.4). This suggests there may be opportunities for further research into hybrid and remote games with actuated components.

The study of digitization and augmentation of analog gameplay also has implications for players’ social connectedness during remote gameplay. Xu et al. (2011) highlight how the work of setting up and maintaining the game (which can largely be automated in a digital version) can be tedious but also provides time for social interaction. Inactive players can converse while one player takes their turn. Or, they might be drawn into the game action, taking part in a shared story as one player dramatizes the physical act of updating a piece (e.g. rolling dice or toppling a competitor’s pawn). As Wasserman puts it, “Players sitting across a table from each other communicate with each other as they manipulate the tangible components of a board game” (2020, p. 83). Some of this communication can be lost if game tasks are digitally automated. Automation can also lead to confusion if players misunderstand what is happening behind the scenes (or screens), as well as reduce conversation and collaboration between players by removing the need to update the game state together (Wallace et al., 2012). Similarly, digital systems should not necessarily enforce all game rules, as it is important to allow players to adapt rules for social reasons (Rogerson et al., 2015). These findings have relevance for designers of remote tabletop games, who will need to balance streamlining gameplay with promoting player autonomy and awareness when digitizing game elements. These insights and guidelines on hybrid game design informed several of the design requirements for my system (see 3.3.2. and 3.3.4).

### 2.4. Remote Tabletop Games

In this section, I identify challenges facing distant friends who want to connect through remote tabletop gameplay and initial design considerations that have been
developed through the study of current remote gaming practices. I discuss examples of remote tangible game systems, illustrating the potential to improve player experience and connectedness and showing where knowledge gaps remain.

Based on their study of remote gameplay during the pandemic, Yuan et al. provide an overview of the current methods friend groups use to play distributed tabletop games together, as well as some of the challenges they experience (Yuan et al., 2021). They found that typically players connect via a general-use video conferencing app, such as Zoom or Discord. Players pair these communication apps with online board game sites like Tabletopia, Board Game Arena and Tabletop Simulator, or game-specific sites like colonist.io or codenames.game to access a digital version of the gameboard. By examining players’ remote gameplay practices with such tools, they uncovered several challenges with the social experience of gameplay, as well as opportunities to improve the design of remote tabletop gaming systems. They found that with existing solutions, players either use an all-digital platform and forgo the satisfaction of interacting with a physical setup, or they adopt a hybrid physical-digital approach. Unfortunately, using a hybrid approach across households means players have uneven access to the physical board, or must maintain their own local copy of the board by moving pieces every time another player does, which is mentally taxing. Players also tend to struggle with the lack of non-verbal cues, as the technologies used for communication either do not include video or have a limited view (e.g., head and shoulders only). These technologies do not convey gestures and body language like leaning in or grabbing game objects—awareness cues that help players understand game state and direct their attention.

From their observations of existing remote play styles, Yuan et al (2021) propose three implications for designing technology to support social connectedness through play. They suggest connecting shared tabletop spaces with augmented game objects, as this has the potential to improve information exchange between players. They recommend systems transmit cues like eye gaze, facial expressions, body language and interactions with the environment to improve player awareness. They also recommend systems include options to customize the game rules, scoring and teams, as players often want to adapt the difficulty level and length of the game in remote play. These implications offer guidance for my work, but what is not yet known is how players will use these features when available and what needs to be considered when incorporating
them into the design of game and system components. Building on the work of Yuan et al (2021), I illustrate through example the impacts these design features can have on player experience and connection.

Ramirez Gomez and Stawarz (2022) also investigated opportunities for remote play in the context of the Covid-19 pandemic. They surveyed 38 people who played remote games during the pandemic to collect information on the player experience of both video games and tabletop games (including board games, card games and role-playing games). Their findings highlight some of the benefits of remote gaming, including the ease of scheduling game sessions and the ability to bring together people from across usually separate friend groups. They also identify additional challenges with remote gameplay, including difficulty tracking whose turn it is (both in game and in conversation), dealing with “Zoom fatigue” when using screens and video calls for remote work as well as play, and for tabletop games, unequal access to the visuals of the game board when one location is hosting the physical game. Similar to Yuan et al (2021) they note the need for greater non-verbal communication between players to minimize conflict and improve social connection. Notably, they identify “opportunities to introduce smart artefacts that afford remote communication during in-game interaction” and call for “further research on their effect on the player experience at a distance” (Ramirez Gomez & Stawarz, 2022, p. 97). Since social interaction is an important part of the player experience, this affirms my goal to understand how a tangible remote game system impacts players’ experiences of social connection.
There are few examples of prototype systems for remote gameplay that address some of these challenges with digital remote play by offering tangible gameplay over distance. *PlayTogether* is a system for distributed tangible gameplay that superimposes a projection of the remote player’s game pieces and forearms onto the local board (Wilson & Robbins, 2007). The work introduces ideas for new gaming experiences (e.g., leveraging the projector to highlight pieces and cue possible next steps), but does not focus on social connection. *CheckMate* (Figure 2.6) uses a mixed reality head-mounted display to position virtual chess pieces upon a physical chess board, enabling players to use their own physical pieces to play chess while seeing digital representations of the remote player’s pieces (Günther et al., 2018). A pre-study of *CheckMate* found that
participants enjoyed the tangible interaction and expressed a desire to see video of remote participants.

Figure 2.7. The two halves of *Tabletop Teleporter*, from left to right:

a) an interactive tabletop displaying a digital gameboard
b) a projector and webcam setup

Players are connected by an on-screen video link

Source: Publications (Odenwald et al., 2020)

Odenwald et al. (2020) designed *Tabletop Teleporter*, an interactive tabletop enabling two people to play a game over distance with physical pieces. Their system featured an interactive tabletop in one location, which could sense the presence of physical tokens as well as display digital game objects (which represented physical objects in the other location). In the second location, a webcam sensed the location of physical game objects, while a projector was used to display digital objects on the tabletop. Players could communicate using a video conferencing link. The researchers evaluated players’ sense of immersion using the system quantitatively. They compared the experiences of ten pairs of friends playing Parcheesi in-person, remotely with the system, and remotely with only a video link. Their experiment demonstrates the promise of tangibles, as it found that players’ levels of immersion and positive emotion playing with the system were similar to playing in-person and greater than playing with only
video. However, a commonality of *Tabletop Teleporter*, *CheckMate* and *PlayTogether*, is that the systems have not been evaluated with more than two players. Overall, the research on existing prototypes highlights the value of tangibility and seeing remote players, but provides limited guidance on how best to design game systems for social connection amongst distributed groups.

We have also seen commercial products like *Tilt Five*, an augmented reality tabletop game system that can be used by distributed groups. *Tilt Five* uses AR glasses to integrate virtual objects with physical game components and board. Another commercial product, *Tabletop Simulator*, is available to play in virtual reality, and while there are no physical pieces, this does allow players to interact with the game through more literal, embodied movements, which perhaps achieves some of the benefits of tangible play. However, the visual representations of remote players provided by these systems are limited to movement of the handheld controllers. The systems do not provide awareness of facial expressions or upper body movements. This may result in reduced awareness of remote players’ thoughts and feelings, an important part of social connection (van Bel et al., 2009), and make it more difficult to collaborate around a shared tabletop (Yamashita et al., 2011). As well, there is no published research evaluating user experiences with these systems.

Lastly, researchers have begun to explore the design of remote tabletop games and systems for social connection, but this work remains in its early stages. Through reflecting on the physical, material nature of traditional board games, Maurer and Fuchsberger generated implications for the design of remote tangible games. They note that one advantage of collocated gameplay that could be explored for remote games is the inherent “fuzziness” of bodily interactions. They argue that digital games often overspecify interaction, and introducing ambiguous non-verbal communication can enrich cooperative experiences in remote games. They also recommend using hybrid game objects to mediate information about the decision-making processes of players (e.g. portraying how players sort cards and resources to plan a turn). In designing for remote gameplay, Maurer and Fuschberger stress the importance of “digitizing the ‘non-functional (from the perspective of the game itself) aspects of co-located gameplay” (2019, p. 2). This includes social interactions between players, which I was eager to explore in my prototype. They conclude by acknowledging that their work explores remote tabletop games from a purely theoretical lens, and they call for future work to
explore the realm of remote tangible play through the design and evaluation of concrete artifacts.

In sum, prior work has identified opportunities to design for remote tabletop gameplay (Maurer & Fuchsberger, 2019) and social connectedness (Yuan et al., 2021) by drawing on theory or examining current gaming practices. There are several examples of technologies developed for remote tangible gameplay without a focus on understanding how the system design contributes to social connection (e.g., Günther et al., 2018; Wilson & Robbins, 2007). I am aware of one system for remote tangible gameplay which has been evaluated with the immersive and social experience of gameplay as the focus (Odenwald et al., 2020). However, there remains a gap in our understanding of how to design a tangible system for groups to connect through gameplay. I address this gap through the design and evaluation of Remote Wavelength.

2.5. Summary

Remote tabletop games are one activity people use to connect with friends over distance. Many people adopted remote tabletop gaming as a social activity during the recent pandemic, which illustrated its potential for connection, but also demonstrated that challenges remain. Incorporating physicality into remote games—a major motivator for tabletop players—is currently finicky or frustrating. Other challenges include uneven access to the game state, lack of awareness of the actions and feelings of other players, and, in some cases, the inability to bend the rules to ease social interactions. Surveys of current remote gameplay practices illuminate these challenges and highlight an opportunity to explore the incorporation of physical, tangible elements into remote play.

Researchers have explored the adjacent design space of hybrid collocated games. Previous work has demonstrated how digital elements can be introduced and superimposed on a physical game with augmented reality, camera vision, interactive surfaces, RFID readers, and more. Previous work has also shown that designers should exercise caution when digitizing tabletop games, as automating game tasks and enforcing rules can remove opportunities for social interaction. Many of these technologies and guidelines have yet to be applied to remote games, but they suggest that blending physical and digital gameplay in a remote context is an area ripe for
exploration. In particular, there has been limited exploration of the potential to use actuated game pieces to synchronize game states.

A few systems have explored enabling tangible remote play by bringing remote game objects onto the local gameboard with projectors and mixed reality headsets. Evaluations of these systems have shown that people value tangible interaction during remote play. Impressively, results suggest that synchronized, tangible remote play with video chat can offer a level of immersion comparable to in-person play. However, this research is so far limited to games for two players, and offers little insight into the design choices that contributed to each system’s development and the impact of those choices on the player experience. I know of no publicly available research exploring social connection in a system that enables tangible tabletop gameplay amongst mixed presence groups of more than two people. I address this gap of through the design and evaluation of *Remote Wavelength*.
Chapter 3. Design Exploration & Prototyping

A significant portion of my research involved designing and prototyping a remote gameplay system. Here, I provide an overview of my design process, including how I explored challenges related to remote gameplay and developed ideas for potential solutions. I then describe the design of my prototype system, *Remote Wavelength*. Lastly, I articulate the design requirements that emerged from design exploration and show how they are instantiated in the design of *Remote Wavelength*.

3.1. Design Exploration

I began the design process by exploring design possibilities. This was a process of experimenting with existing remote game systems to learn more about the design problem, researching emerging technologies, and sketching potential solutions to map the design space and create a set of requirements for the final prototype.

![Design Workbook of Ideas for Social Distributed Board Game Play](image)

Figure 3.1. Design Workbook of Ideas for Social Distributed Board Game Play

3.1.1. Exploring Existing Solutions

As part of my exploration, I played remote board games using a variety of existing systems and reflected on the challenges I experienced as a player. I played games with commercial online board game systems such as *Tabletop Simulator* and *Board Game Arena*, and websites dedicated to specific games, such as *Codenames*,
Werewolf, and Euchre. I tried using existing remote collaboration technologies for gameplay, for example, playing Pictionary using Zoom’s whiteboard feature, or Decrypto in a Google Doc. I attempted tabletop roleplaying with Discord plugins, Roll20, and a hardware setup involving multiple computers. I also experimented with hybrid versions of several games and a boxed Escape Room, which involved holding cards up to the camera and delivering components to a remote location ahead of gameplay. While I was not able to try some more cutting-edge technologies due to hardware availability, I followed developments with systems like Tilt Five and Tabletop Simulator VR. Many of the challenges I identified are encompassed in the work of Yuan et al (2021), who published a study of remote board game play during the later stages of my design process.

3.1.2. Mapping the Design Space with a Design Workbook

Figure 3.2.  **Zoominis**: A design proposal where game pieces are controlled and moved remotely via a swarm interface consisting of tiny wheeled robots.

To structure my ideation and further explore the design space of distributed board game play, I created a Design Workbook (Gaver, 2011). I generated over twenty-five design proposals (Figure 3.1) to document ideas for design features, which “suggest important issues, approaches and options that might be considered in designing for a given situation,” (Gaver, 2011, p. 1). The ideas explore topics like how to represent players, how to track game information, and how to promote socialization. During ideation, I also researched potential technologies for remote tangible gameplay, which helped inspire and ground the design proposals. This included technologies for remotely tracking and representing game pieces, such as interactive tabletops (Loenen et al., 2007), computer vision (Molla & Lepetit, 2010), and projection (Dal Corso et al., 2015) technologies. It also included tangible interfaces with potential for gameplay, such as Sifteo cubes (Pillias et al., 2014), RFID tagged game pieces (Spielberg et al., 2016),
water-based tangible interfaces (Umapathi et al., 2018) and swarm interfaces (Le Goc et al., 2016). See Figure 3.2 for one example of a design proposal that was inspired by a specific technology.

### 3.1.3. Learning from an Early Video Prototype: Distributed Letter Jam

**Figure 3.3.** The *Distributed Letter Jam* Prototype, left to right: 
- a) Login screen for household device, such as a computer;  
- b) Login screen for a personal device, such as a smartphone;  
- c) Distributed Letter Jam setup, including RFID readers arranged on the tabletop and remote player video visible on a shared house.

My early design exploration culminated in the creation of a non-functional video prototype of a remote gameplay system for the collaborative board game *Letter Jam* (Figure 3.3). *Letter Jam* is a cooperative word game for 3-6 players that is well-suited to social play amongst friends and family. The game’s mechanics rely on player positions, hidden information, and passing around cards and tokens, which gave me the opportunity to explore these issues in the prototype. I prototyped a remote version of the game which used RFID readers to track tokens, leveraged individual and household displays for public and private information, and displayed remote players in a horizontal row to preserve spatial relationships between players. An overview of the video prototype is available at [https://tinyurl.com/distributed-letter-jam-video](https://tinyurl.com/distributed-letter-jam-video). The work resulted in several preliminary design considerations (Mills et al., 2021), which would go on to inform the development of *Remote Wavelength*. For example, I noted the importance of minimizing keyboard and mouse input during gameplay to preserve table space for the game itself. This informed the development of a self-contained tangible gameboard for *Remote Wavelength*. Considerations identified around handling both public and private game information influenced my choice to select a game with hidden information for my next prototype so I might explore the topic further. Creating the *Distributed Letter Jam*
prototype also highlighted the difficulty of accommodating a variety of household configurations in a system design. Variations between households might include the technology and space available for gameplay, as well as the number of players present at the same location. The latter concern encouraged me to consider the experiences of people alone at their location as well as people collocated with other players when creating and evaluating the *Remote Wavelength* prototype. Most importantly, insights derived from this early prototype cemented my focus on tangibility as a key design challenge for remote boardgame play.

### 3.2. The Remote Wavelength Prototype

Drawing on insights from design exploration, I created a fully functional prototype of a tangible remote gameplay system: *Remote Wavelength*. In this section, I discuss why I selected the game *Wavelength* for my prototype and provide an overview of how it is played. I then describe the design of the completed system, which combines an audio-visual connection with a tangible, synchronized gameboard.
3.2.1. Choosing a Game to Prototype

I selected the game *Wavelength* (Warsh et al., 2020b) because it relies heavily on social interaction between players and the original gameboard is known for providing a deeply satisfying tangible experience (Murray, 2020). *Wavelength* is also a quick-to-learn game with a flexible player count, making it well-suited for groups aiming to connect through remote gaming. During the user study described in Chapter 4, groups were able to learn the game and interface in about five minutes.

3.2.2. How to play Wavelength

*Wavelength* is a party game for 2-12 players (Figure 3.4). Each round one player (the *Psychic*) is given a random target location along a spectrum with two opposing ends, like “Hot to Cold” or “Sad Song to Happy Song.” That player shares a clue with
other players to help them guess the location of the target along the spectrum. For example, if the *Psychic* receives the spectrum “Hot to Cold,” they might say “tea” to get players to guess a target that is slightly closer to Hot. To get them to guess very close to “Hot”, they might say “the sun”. Guessing players debate the clue and position a dial along the spectrum to record their guess. The target is then revealed. Players see how close their guess is, and score points accordingly. This core gameplay can be adapted into versions for competitive and collaborative play.

![Remote Wavelength system](image)

**Figure 3.5.** a) top: a photograph of the *Remote Wavelength* system, including display with video call and spectrum card, microphone and webcam, and tangible gameboard.

b) bottom left: *Remote Wavelength* display showing the spectrum
c) bottom right: synchronized tangible gameboards—players enter a guess by spinning the blue dial to move the blue light along the spectrum.

Photo a): Yuncheng Chen. Reproduced with permission.
3.2.3. Design and Setup of the Prototype

The Remote Wavelength system combines two main components: an audio-video link between locations and a tangible gameboard (Figure 3.5a). A video demonstration of the Remote Wavelength prototype is available at https://tinyurl.com/remote-wavelength-video and included in Appendix D. Each location has a peripheral webcam and microphone. The camera window captures each player from the waist up, including their gestures and gameboard interactions. This is displayed using commercial video conferencing software on a large display, presenting remote players at close to life-size. This provides more context on remote players’ surroundings and actions than the “talking head” video conference style. The use of a large display and microphone also enables collocated players to engage with the game while sitting together on couches around a coffee table. This couch and TV setup mimics a common home environment (e.g., a living room). Cards showing the spectrum endpoints are digital objects, and an image of the active spectrum card is overlaid on player video (Figure 3.5b).

3.2.4. Tangible Gameboard & Hardware

Figure 3.6. Creating the look and feel of Remote Wavelength

The tangible gameboard consists of two laser-cut and brightly painted wooden boxes. I took care designing the gameboard’s look and feel to re-create the sensory and aesthetic appeal of a commercial board game (Figure 3.6). Participants described the
completed prototype as “robust,” “well-made” and “tactile,” indicating some success. The box is completely enclosed and the technology inside is wireless and battery-powered.

Figure 3.7. Prototyping the hardware within *Remote Wavelength*

Each gameboard contains an Arduino microcontroller connected to a power source, sensors and actuators (Figure 3.7). The Arduino collects data from the board’s dial and buttons and controls a servomotor that moves the score counter. Depending on the stage of the game (which players can advance by pressing a button), lights on an RGB LED strip turn on and off to convey the round’s target in red, the players’ current guess for the target’s location in blue, or an indication of how the two compared and whether points were scored. When the lights change on the LED strip, a piezoelectric buzzer generates an accompanying sound. As players turn the dial to enter a guess, the blue light recording their entry travels along the semi-circle of the LED strip in tandem with the dial (Figure 3.5c). The game box is connected via Bluetooth to a computer (which is also hosting the video call), which is connected in a client-server relationship to the remote location’s computer. The setup is symmetrical across locations.

To enhance the sense that players were interacting with the same object, I designed the back of the gameboard to mimic the output of the front. This included a mirrored LED strip, so players’ view of the remote gameboard on-camera matched their view of the local gameboard. This has the added benefit of providing visual confirmation that the client-server connection is functioning and the gameboards are synchronized.
3.2.5. Software

People playing remote games with friends and family often want to improve the social experience of gameplay by modifying the game rules. For example, they might form custom teams, add a scoring handicap or change the difficulty level to account for different player abilities, or offer players the option to take back a turn (Yuan et al., 2021). Given this, I designed the system’s code to enable players to customize the rules of the game (Figure 3.8). I avoided automating functions such as keeping score and made it simple for players to restart a round if they did not like the spectrum card or target assigned. The system did not require players to commit to a specific team or order of gameplay. A player could choose to play the Psychic role twice in a row, share that role with another player, or forego it altogether.

Figure 3.8. Prototyping the user flow for Remote Wavelength

3.3. Design Requirements

I iteratively developed a set of design requirements for the prototype by drawing on existing literature, including studies of collocated tabletop gaming, current remote gaming practices, and hybrid game design. I also leveraged lessons from my design exploration and self-testing of the early-stage prototypes.
3.3.1. Head-to-Hand Player Representation for Better Awareness

Awareness plays an important role in remote collaboration activities and is an important design consideration for remote tabletop games specifically (Yuan et al., 2021). For remote collaborators, improved awareness can streamline communication, facilitate task sharing, and assist with predicting what will happen next (Gutwin & Greenberg, 2002). In a tabletop game, this might mean discussing what is happening in the game, coordinating updatee communal information like round counters, and guessing an opponent’s upcoming move. Awareness also includes insight into other players’ emotional states, which is part of feeling a sense connection (van Bel et al., 2009). My design was guided by the desire to convey the expressions, gestures, and body language of remote players to improve awareness of both player feelings and the game situation. Representing gestures within the context of the workspace (or in this case, gamespace) is another important factor (Tang et al., 2007). In the prototype, I took care to set up a video connection including both facial expressions (head) and interactions with the gameboard (hand).

3.3.2. Tangible Gameboard

Research on traditional tabletop games suggests that physical, tangible game pieces are an important part of the experience for players. Rogerson et al. found that, alongside sociality, materiality (i.e., the physical game components, game box, and play space) is a key factor in players’ enjoyment (Rogerson et al., 2016). Maurer and Fuchsberger later drew on this finding to suggest physicality as a lens for enriching distributed play (Maurer & Fuchsberger, 2019). Physical game objects provide a collective record of events, helping players track the game state (Rogerson et al., 2020). They act as a thinking aid, for example as players move around resources to plan future actions (Shaer & Hornecker, 2010). They support discussion by externalizing players’ thoughts as they manipulate objects, and providing physical records of their interactions (Hornecker & Buur, 2006). Given the rich contributions of tangible objects to player enjoyment and communication, I incorporated tangibility as a core part of the Remote Wavelength design, through the inclusion of a physical gameboard.
3.3.3. Synchronization Across Locations

As a corollary of including a tangible gameboard, tangible elements must be synchronized across locations. Primarily, this reduces players’ mental loads, removing the work of maintaining the physical game state across multiple households (Yuan et al., 2021). To enable this, the Remote Wavelength prototype includes networked gameboards that updated near-simultaneously. Another facet of this requirement that emerged through my design process was the importance of mirroring the appearance of the gameboard across locations, as well as mirroring the information they displayed. While self-testing an initial prototype with others in my research group, we noticed that the remote gameboards looked clearly separate when viewed over video conference. This made it challenging to overcome feelings of remoteness and to believe we were playing the same game. It led me to align the visual design the prototype’s physical components across the local (front) and remote (back) perspectives (Figure 3). I also reproduced the LED strip on the back of each board, so when players turn the dial and enter their guess, they see the lights moving in sync across both locations.

Figure 3.9. View of Remote Wavelength Gameboard, Front and Back.
3.3.4. Flexible Gameplay

Guided by many of the findings from research on game automation, one of my design requirements was to keep gameplay flexible (Rogerson et al., 2015; Wallace et al., 2012; Xu et al., 2011). Customization for a better social experience is recommended for supporting social connection through remote tabletop gameplay (Yuan et al., 2021). This requirement for flexible gameplay informs elements of my gameboard design, such as player-controlled scorekeeping, as well as how I programmed the game. Where possible, I avoided enforcing specific rules. The digitized portion of the game allows players to fulfill the *Psychic* role as an individual or team, take turns in any order, and swap spectrum cards as desired.

3.3.5. Integrated Communication and Game Space

Another of my design requirements was to integrate the players’ communication and game spaces. Having game objects and player video in close proximity on screen may help improve awareness of remote players, which was one of the initial design considerations I surfaced through prototyping *Distributed Letter Jam* (Mills et al., 2021). To achieve this in the *Remote Wavelength* prototype, all digital game elements work intentionally with the remote player video display. Digital game cards are overlaid on the video conferencing window. Designing the back of the gameboard to mimic the front also aligns with this requirement, since players can retrieve useful game information through the same channel they use to communicate with remote players.

3.4. Summary

In this chapter, I discuss how my design process contributed to my research and resulted in a prototype game system. I detail how I explored the design space through the creation of a Design Workbook and an early video prototype. I briefly describe how insights from this design exploration informed the creation of *Remote Wavelength*, a prototype which combines a video link for social connection with two synchronized gameboards for tangible gameplay.

I conclude by articulating the five design requirements that emerged from the design process and are incorporated into the design of *Remote Wavelength*. These
include: *Head-to-Hand Player Awareness*, which was implemented in the form of a room-scale video link; *Tangible Gameboard* and *Synchronization Across Locations*, which led to the development of two identical, remotely connected game boards; *Flexible Gameplay*, which informed the design of the game’s software and scorekeeping function; and *Integrated Communication and Game Space*, which informed the choice to include game objects within the video conferencing window.
Chapter 4. Evaluating Remote Wavelength

In this chapter, I describe the evaluation of Remote Wavelength. This includes the choice of method, the recruitment process and participant sample, the study steps, and data analysis.

4.1. Study Method

I conducted a qualitative in-lab study to explore how participants use and experience Remote Wavelength. I sought to understand what people did and did not like about the system, how they felt it affected their sense of connection, and how it compared to in-person play and other remote play experiences. I chose to conduct the study in-lab because it enabled me to closely observe participants and avoided logistical difficulties of building, shipping, setting up, and maintaining multiple prototypes in remote locations. This study received approval from the Research Ethics Board at Simon Fraser University.

4.2. Participants

I recruited ten groups of 3-5 participants, 37 participants in total. See Table 1 for group size distributions. All participants were adults between the ages of 18-34. Participants were asked to self-identify their gender. Eighteen participants identified as female (17) or she (1); 18 participants identified as male (17) or man (1); and one participant identified as non-binary.

The study took place in-person at the Simon Fraser University Surrey Campus. Students compose a sizable portion of the study sample, including 19 undergraduate students and 11 graduate students. Due to recruitment through Simon Fraser’s Interactive Arts and Technology program, students with a background in HCI, design, or technology make up 64% of the study sample. Other participant fields of study included language studies, environment, computer science, and business. Non-student participants were working or seeking work in the fields of engineering, data analysis, and economics. Given this, it should be noted that all participants had post-secondary education. Reviewing their fields of expertise, it is likely most participants had strong
familiarity with technology for remote connection because of the requirements they faced for work or study during the pandemic.

Participants were recruited in groups where most participants were known to each other. The study was advertised via posters, social media, email, and word of mouth. Participants were offered 20 CAD per hour as compensation. In my recruitment materials, I asked interested participants to “bring a few friends” to play a game together. People who enjoyed tabletop games were encouraged to apply, but prior experience was not a requirement. To get an approximate measure of the social ties between participants, I asked them to estimate how well they knew each person in their group, from 1 (met today) to 5 (know each other very well). A summary of these scores for each group is included in Table 1, Column 5. Types of social ties between participants included friend, spouse or partner, sibling, colleague, and classmate. Some participants shared a mutual friend but did not know each other prior to the study. Overall, I feel the sample achieved a good representation of the types of social ties that might exist between a friendly online games group.

Table 4.1. Study Participant Groups

<table>
<thead>
<tr>
<th>Session #</th>
<th>Size of Group</th>
<th>Participants in Room A</th>
<th>Participants in Room B</th>
<th>Strength of Relationship (from 1 – Met today to 5 – Know each other very well)</th>
</tr>
</thead>
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<tr>
<td></td>
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<td></td>
<td>Mean</td>
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<td>2</td>
<td>1</td>
<td>2.00</td>
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<tr>
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</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>18</td>
<td>19</td>
<td>3.17</td>
</tr>
</tbody>
</table>

To understand participants’ range of gameplay experiences, I asked about their frequency of remote gameplay, their experience with tabletop games, and their preferred tabletop games. All participants had played tabletop games, but reported varying levels of experience. 17 participants identified as experienced or very experienced with tabletop games, while 20 identified as slightly or somewhat experienced. Ten reported
playing remote games (of any kind) at least once a week. Eleven reported playing remote games at least once a month, twelve reported playing less than once a month, and four participants played no remote games at all. Everyone who played remote games did so with friends, and most also played with some combination of family, colleagues, “online friends” (i.e., friends they had never met in-person), and strangers. My sample included participants with multiple perspectives on remote gaming experiences.

Participants’ gaming interests spanned a range of genres, from party games like *Codenames*, *Jenga* and *Werewolf*, to word games like *Boggle* and *Bananagrams*, to role playing games like *Burning Wheel* and *Dungeons & Dragons*. Some enjoyed classic board or card games like *Chess* and *Poker*. Some participants favoured casual games, like *Uno*, *Monopoly* and *Catan*, and others opted for more complexity, with games such as *Blood Rage*, *Terraforming Mars*, and *Magic the Gathering*. I feel this sample encompasses both casual and hobbyist game players, with diverse gaming preferences.

### 4.3. Conducting the Study

The study of *Remote Wavelength* consisted of four main phases: learning the game in-person, playing the game remotely, reflecting on the experience of gameplay, and completing a demographic survey. First, each group of participants gathered in one location for an overview of the study, how to play the game, and how to use the gameboard. While in-person, participants practiced playing the game with one of the prototype gameboards and physical spectrum cards. This enabled participants to later contrast their remote gameplay with an in-person experience, as well as quickly learn the game in the limited study time. I observed and recorded participants playing in-person for 15-20 minutes.

Second, half of the group was moved to a neighbouring room, where the remote system was already set up. After giving brief instructions on how to use the functionality specific to the remote system, I observed participants playing the game together remotely, switching which room I observed halfway through the 30-40 minutes allocated for remote gameplay. Recordings were taken in both locations.
Third, I led participants through a reflection and discussion on the gameplay experience. I gave them worksheets with question prompts, such as “What did you like/dislike about the Remove Wavelength experience? What aspects of the system helped/hindered your connection to remote players?” To record their individual thoughts and reflections, they spent five minutes writing responses to each question silently, before discussing their answers as a group. This approach preserved some diversity of thought while also benefiting from the elaboration and deeper reflection that occurred when players compared their experiences. Of the two-hour workshop, 45-55 minutes were allocated to this reflection and discussion.

Lastly, participants completed a worksheet of demographic questions and questions about their experiences with tabletop and remote gaming.

4.4. Data Collection and Analysis

Figure 4.1. The Affinity Diagram, after initial clustering but before discussion to refine and merge themes
I collected data including video recordings of gameplay, notes on study observations, participant worksheets, and audio recordings of the group discussion. I transcribed the group discussion from each session and reviewed worksheets for any comments that were not brought up during group discussion (the worksheets were not fully transcribed). I digitized the notes I took during gameplay observation, and during this process I reviewed the gameplay recordings to look at key points in time more closely (for example, when an observation note referred to a participant comment during gameplay, but the full comment was not captured). I transferred the transcripts and observation notes onto digital sticky notes using the whiteboarding software Miro, segmenting the data so that each sticky note covered one topic or idea. Notes were colour-coded based on which part of the reflective discussion they emerged from, including reflecting on the play experience (pink), social connection (blue), general discussion (green), observation notes (light yellow) and researcher memos (orange). Notes were also tagged by group number (enabling each note to be traced back to a specific participant via the transcript) and if relevant, with a location code. I then analyzed the notes using an affinity diagramming process (Holtzblatt & Beyer, 2017). While affinity diagramming is often described as a group activity, in practice diagrams are sometimes completed by an individual researcher (Harboe & Huang, 2015). Coding by an individual researcher is appropriate when it is part of an analysis process that creates emergent themes, which are then reviewed by multiple researchers to produce a final product (McDonald et al., 2019). I generated themes inductively by clustering related notes, and worked with my supervisor (Carman Neustaedter) and a second member of our research lab (Benett Axtell) to discuss and refine the themes (Figure 5.1). Discussion reduced the number of themes from eighteen to seven, through merging some themes and discarding others. Throughout this discussion, the novelty of each finding and its relevance to gaming, technology design and the research questions were used as a clarifying lens. For example, themes about physical/digital integration and integrating remoteness and game story/theme were combined, while a theme about the difficulty of having side conversations on a video call was discarded as not novel or specific to gaming (Hu et al., 2022). As my aim was discovering new design considerations, I looked for themes that were related to the initial design requirements, yet extended my current understanding of how to implement the requirements. This mixed inductive and deductive approach of forming inductive themes from primary data
and then connecting themes to existing research is common in HCI (McDonald et al., 2019).

4.5. Summary

In summary, I evaluated the Remote Wavelength prototype with a qualitative in-lab study. I recruited groups of friends with a variety of relationships and gameplay experiences. I observed participants’ playing the game, and then inquired about their experiences with the system, including their likes, dislikes, and reflections on features of the system that supported social connected. Lastly, I analysed the resulting data to create a set of several themes relevant to social connection through remote tangible gameplay.
Chapter 5. Evaluation Results

In the first section of my results, I describe what we learned about players’ interactions and experiences using a tangible device for gameplay, focusing on how tangibility affected their social experiences. This includes how it affected players’ sense of presence, helped them communicate, and supported their engagement with the game, as well as some drawbacks of using a physical device. In the second section, I share additional observations on how technology design shaped participants’ sense of connection. This includes observations about players’ reactions to the system’s support for communication across households, flexible turn-taking, and awareness of other players. Across both sections, I support each theme with participant comments and researcher observations. Quotations are tagged with group number and a participant-specific identifier (e.g., G10-P1 and G10-P2 refer to two distinct participants in Group 10).

5.1. Impacts of Using a Tangible Gameboard on Social Connection

Here, I discuss participants’ reactions to the Remote Wavelength gameboard and how playing with tangible components affected their sense of social connection.

5.1.1. Tangible Components Support Player Presence

The data from my study illustrate that the synchronized, tangible elements of Remote Wavelength supported players’ sense of remote presence. Specifically, players appreciated seeing remote players affect objects locally and being able to manipulate the gameboard in the remote location. While watching a remote player change the gameboard, one group remarked “It almost feels like you’re here, like a Ouija board…now I really feel your presence with me” (G9-P2). During the post-gameplay discussion, they elaborated further: “The machine really supported the connection. It made [remote participant] feel more present when I could see what she was doing to it” (G9-P1). This participant described having a heightened sense of the remote player being there with them. The sense of presence occurred in both directions, as other players described feeling present in the remote space:
G10-P5: "I feel like when I was tweaking the button, and I know that on the other side the number is changing as well, to some degree I feel like I become the machine... I am present on the other side through the machine."

Players could see and sometimes hear themselves affecting remote objects through the video conferencing link. The visual feedback was made possible by the design requirements, including head-to-hand representation of players (seeing the remote gameboard) and synchronization across locations (mirroring the gameboard changes across locations), and player comments highlighted this as a key feature of the design. Players said that they like receiving audio or visual feedback on their actions from the remote location:

G4-P2: "When I was spamming it [the score] like 'quoosh, quoosh, quoosh' I heard it on your end too and like, so cool."

G6-P1: "I don’t know why, but seeing that physical box in front of me and seeing them in sync...and I know that it will affect something on their side physically, it feels much more connected."

Figure 5.1. A group of study participants celebrate a win with high-fives while playing in-person. The ability to connect via touch was missing in Remote Wavelength.
The sense of presence created by the components of *Remote Wavelength* had limits. Several players expressed a desire to interact with remote space via touch. They commented, “I wish there was a way to poke the other side” (G5-P1) and “Even if others make some [bad] choices, I cannot punch them. I feel less connected, I cannot do anything [to them]” (G7-P4). I saw collocated players use touch to celebrate victories or mourn losses—high-fiving, hugging, or pushing away their fellow players (Figure 5.1). If alone in their location, players would sometimes raise their hands to celebrate or hang their heads in defeat, but their ability to mark emotional moments by exchanging touches with other players was absent.

### 5.1.2. Tangible Gameboard Makes Gameplay More Engaging

Participants had many positive reactions to using a physical, networked gameboard, dedicated to playing the game together. The physical device increased engagement with the game by making it more fun and reducing distractions, and greater engagement may lead to more opportunities to connect with fellow players as well.

Players often referenced the physical gameboard as something they enjoyed about the gameplay experience. Some linked this enjoyment to their sense of connection—as players in Group 6 pointed out, when having fun they “get more engaged” and “talk more, communicate more.” Reflecting on whether the physical gameboard was associated with their sense of connection, G1-P4 said “I think [the gameboard]’s what made us want to continue playing and made it less boring, I don’t think it’s not important [to connection].”

![Figure 5.2. A study participant takes advantage of “being different” (G4-P2) from a remote work setting and gets comfy on the couch](image)
Using the tangible gameboard also provided a dedicated device for gameplay, which removed participants from the desk/computer where they usually work (Figure 5.2). This helped participants switch contexts and immerse in the social experience. It also helped them focus on the game and be more enthusiastic about game time.

G4-P2: “Because it’s a TV and not a computer for me…much better than if I’m at a table and desk…remote work definitely gets me turned off when I have to do stuff at my desk again. Having the opportunity to go on a couch and be far away…being different I think helps.”

The dedicated device removed distractions that might intrude if players were using a multi-purpose device like a phone.

G1-P2: “it’s not all digital, it has a physical thing… That’s pretty cool, you know? When we play Jackbox [a collection of digital party games], you use the phone as the game interface, but you can receive notifications, and someone can call you…in this game I just put my phone away and that’s it.”

Participants also noted that the act of procuring a physical thing, in contrast to logging on to a digital interface, fostered more anticipation and excitement for the game.

5.1.3. Flexible Tangible Components Augment Player Communication

My observations of gameplay showed that the tangible components in Remote Wavelength were used by players as rich communication channels, both to share their in-game strategies and to communicate beyond the requirements of the game. The flexibility of the tangible components also enabled improvised use for communication purposes.

Players frequently used the dial for submitting a guess as a reference to discuss what their guess should be. I observed players collaborate across locations to arrive at a guess. For example, G1-P1 said, “if milk is smelly, it’s in a bad way, like around here” while turning the dial to indicate where they would place ‘milk’ on a spectrum from smelly in a good way to smelly in a bad way. Another participant used the gameboard to show the range of responses they considered plausible, moving the dial while saying “No, no, Maybe, Maybe, Maybe, No” (G8-P2). Using the gameboard simplified communication and cut down on misunderstandings, which helped when audio was not clear. One participant noted how the physical device improved discussion during gameplay:
G10-P1: “Anything that does [have a social aspect], it’s usually constrained by a lot of the similarities here, which is audio...the fact that there’s a physical device does help with it, it’s comparatively better than just an app.”

I often saw players manipulate tangible components of the gameboard in unexpected ways, including when the outcome was not relevant to the game. One player (G4-P2) repeatedly pressed buttons to move the scoreboard up and down (Figure 5.3), creating a loud mechanical noise and physical motion in the remote space (no points had been scored). They later said they had used this to signal their desire for attention. As another participant stated, this ability to “mess around” was an important function of the gameboard:

G10-P2: “[I like] the synchronized UI, especially the scoreboard. Just being able to mess around with each other, I felt like we were more connected that way.”

Figure 5.3. A reenactment of a player clicking the score cup and down, which some players did even when no points were scored.
Photo: Yuncheng Chen. Reproduced with permission.

I also observed players using the gameboard to make jokes. For example, one player (G3-P2) used the game dial to make the equivalent of a sarcastic comment—after getting the clue *Bee Movie* for the spectrum card *bad movie / good movie*, they sarcastically cranked the dial all the way toward ‘good movie’ with an exaggerated motion. Another player (G10-P2) changed the scoreboard to give the group negative
points after a bad guess—everyone laughed. As one participant who was alone at their location shared, these small moments of humour are valuable for connection “Joking around and stuff definitely helps a lot, when we’re laughing and I know we’re laughing about the same thing, that helps me feel part of the group” (G2-P2). The flexible tangible components of Remote Wavelength helped players communicate in a variety of ways, including some not foreseen during the design process.

5.1.4. Drawbacks of a Physical Device

Participants also expressed concerns about the limitations of remote tabletop games that require a physical device. Players’ primary concerns were technological issues, cost, and ease of use. Even if these could be minimized, there are still several hurdles.

Players still wanted to be able to connect with friends who had not invested in specialized equipment. They worried about leaving out people who could only connect digitally.

G2-P2: “One thing was, a combination of digital and physical... then someplace might have only the digital version, and then still be able to play the game.”

In addition, they were concerned that playing remotely would detract from the enjoyment of setting up the physical game together. In a remote context, the setup time becomes more noticeable and perhaps burdensome, since players are unable to share the labour and socialize during game preparation.

G5-P2: “When you’re doing the setup [in-person], you’re talking about the game, or you’re just chatting. If you’re trying to set up a video link with someone, or in the midst of it, you are physically unable to chat.”

G5-P1: “There was still effort to set up...I do feel that that detracts from it. It’s different than just going downstairs, sitting on a couch, and having [a friend] come into the room with the box of Wavelength.”

In sum, introducing tangibility to remote games offers benefits for player presence, engagement and communication. Potential drawbacks of requiring a physical device include concerns about inclusivity and inability to connect during setup, which makes the work of setup more onerous.
5.2. Impact of System Features on Player Experience & Social Connection

Here, I describe additional features that impacted players’ sense of connection, including the integration of different system elements, support for turn-taking, and representations of remote players.

5.2.1. Integration of System Elements Improves Player Awareness and Confidence in Communication

Overall, participants appreciated the integration of communication and game spaces (one of the design requirements). Participants felt that having game objects in proximity to remote player video supported their awareness of remote players. In addition, this integration improved player confidence in the system. Participants experienced some limitations of the prototype’s digital-physical integration and identified opportunities to further improve the system by integrating elements such as the game’s theme.

Participants commented that displaying spectrum cards as digital objects next to the remote player video drew their attention to remote participants. Checking game information improved their awareness of remote participants, enhancing their sense of connection.

G9-P2: “Because the [spectrum] card was on the screen, I had to look up, and I always remember you were there and I was always looking up there to read the card but also see that you’re playing with us.”

G5-P2: “Visual cues help you communicate on video calls a lot, so being able to play the game where the information was close to the people you’re looking at, helps maintain that visual connection with them.”

Having the gameboard visible on screen contributed to this visual connection as well. A few participants reflected that they found themselves looking more toward the remote gameboard to track game information than to their own local gameboard.

Players also imagined how this integration between game objects and remote player video could be applied in other remote games, helping them feel closer to remote friends. One player imagined a live video or picture of themselves superimposed on their avatar in-game.
G5-P3: “Can you imagine if you were playing Among Us, and each of the characters looked like the player?...it would screen capture your face...and then you would see their reactions as you come up to them...I feel like that would be a much better interaction as a game, because you feel like you’re playing with your friends, not just like, a green space man.”

For some participants, having game objects displayed digitally rather than on the local gameboard gave them more confidence that the remote players were seeing the same thing, “I liked the [spectrum cards] on the screen better than on the device...It was very clear for all participants what side was what” (G4-P1). It also increased participants’ perception that the gameplay was designed for remote connection, “If it has the thing [card] showing up on the screen, I feel like it’s built for this remote setting” (G6-P1). This participant continued that because the system seemed purposefully designed for a remote setting, it gave them confidence that all players’ views were the same. This confidence impacts player experience and communication. As one participant pointed out, worrying about whether things are the same on both sides and constantly adapting one’s communication to include remote players is exhausting, so streamlining the trust-building process eases the burden on players.

In addition to these benefits, there were some limitations. As one player pointed out, when remote players stood up, game elements could occlude the remote players, highlighting the challenge of integrating these information streams without interference.

Our findings also emphasize that a strong visual connection is needed between physical and digital game objects. Over half of the ten groups commented that the visual alignment between the physical device and the digital game items was insufficient, saying things like “One thing I don’t like about the remote version is the virtual card on the TV—there’s no obvious link between the physical machine with the virtual card on the screen” (G10-P5). Participants did occasionally confuse which side of the gameboard corresponded to which side of the spectrum card. Several participants recommended solutions, like making the spectrum cards half-circle-shaped and reproducing the spectrum card colours on the gameboard.

One group also discussed how to better align physical and digital game objects with the game theme. Since the player giving clues was called the Psychic, one player (G9-P1) thought the physical gameboard should imitate a crystal ball. Another group member agreed that tying the game theme into the remote setting might diminish the
awkwardness of remote interaction, saying, “you could work with the disconnect and tie that in, so it feels like you’re less apart. Even though you are, there would be a reason for it” (G9-P3). As an example, they suggested incorporating the feeling of distance between players into the game by encouraging them to roleplay as a medium contacting ghosts. Clearly, integration—between the gameplay, theme, and the social, physical, and digital elements of the system—is important for a seamless and connected player experience.

5.2.2. The Social Impact of the System’s Approach to Turn-Taking

Turn-taking plays a significant part in many tabletop games. Although possible with a digital system, our prototype did not automate turn order. This aligned with the design requirement of flexibility. To understand the impact of this choice, I observed how groups playing Remote Wavelength took turns as Psychic and collaborated on their guesses (and sometimes teamed up to be Psychic). I found that groups appreciated flexibility around game roles but disliked the ambiguity of turn order.

When creating the Remote Wavelength experience, I hoped that the arrangement of the remote player video stream (which offered each player consistent left and right neighbours, including on-screen neighbours) would suggest a turn order to follow. However, this was clearly not the case. Of ten groups, none of them followed a consistent turn order while playing remotely, yet the majority successfully followed a turn order while playing in person. For example, Group 8’s turn sequence was 1, 1, 2, 3, 1, 1, 3, 2, where Player 1 was in one room and Players 2 & 3 another. Players noticed and disliked this confusion.

G1-P2: “To track who is going to play next was a bit challenging.”

G3-P5: “I think number one [of my dislikes] was there’s a lot of confusion as to whose turn it was.”

Lack of clarity around turns was detrimental to connection. Players pointed out that uncertainty around the active player hindered their ability to socialize. It took more energy and effort to organize the group and made it difficult to tell who should speak, draining their desire to engage socially. For example, one player had this reflection on turn-taking:
G5-P1: “I feel like when you’re communicating remotely, you want to eliminate as many sources of questions as possible, because it’s hard to ask questions and get answers. It’s just like, uncertainty should be removed so there’s no hesitation, it’s easier to hesitate when you’re talking remotely.”

This suggests that in a remote context, it is easier to communicate if turn order is specified by the system. At the same time, players took advantage of the flexibility inherent in our design. We observed players team up to take on the Psychic role together, choose to act as Psychic twice in a row if they failed on the first try, and restart a turn rather than forfeit if the Psychic accidentally gave the target away. Players sought clarity around whose turn it is, but appreciated the option to customize turn-taking.

5.2.3. Players Link Game Performance and Sense of Connection

Wavelength is a highly social game, and participants mentioned the interplay between their success in-game and their feelings of connection. Most obviously, through participating in a shared activity and being encouraged to discuss their opinions to win, players felt more connected. How well players performed in the game and whether they were able to notice non-verbal hints from the Psychic also played a role in their connectedness.
Figure 5.4. A screenshot of the display showing remote players. In this reenactment of gameplay, the player on the left looks contemplative with their hand to their chin, while the player on the right can be seen pointing to the gameboard, but the details of their facial expressions and emotions are not visible.

One of the design requirements was improving awareness by providing head-to-hand representations of remote players. This meant the system needed to capture both facial expressions (head) and their interactions with the gameboard (hands) and portraying this to remote players. The ability to gauge each other’s facial expressions was not entirely absent in Remote Wavelength (we observed a participant laugh at the Psychic’s reaction after a very off-target guess, saying, “Look at [remote Psychic]’s face, hahaha” (G2-P3)), but in most cases only large gestures and exaggerated emotional reactions were perceptible (Figure 5.4). This reduced the degree to which players were able to “read” the Psychic while making their guesses.
Picking up non-verbal hints from the Psychic is considered cheating (for Wavelength, it is explicitly against the rules (Warsh et al., 2020a)). Thus, some participants felt removing the ability to read other players was an improvement. One player cited the game Werewolf (which relies on social deception) as a game that is improved by online play. They felt that “for certain games where you’re hiding stuff from other people, remote seems to be the better option” (G7-P1). Others felt strongly that their attempt to read the Psychic, and the Psychic’s struggle to keep a “poker face”, were important parts of gameplay.

G10-P1: “The psychic was getting sidelined more in the remote game. After the remote version started, everyone’s discussing, but in-person reading their poker face was a huge part of the whole thing, and that whole aspect just went off because we were busy discussing. And people on the other end won’t really be able to really pick up on those minor facial cues...”

G10-P5: “[trying to read the Psychic] is definitely a very important part of the game. It’s a fun part, and if you took that away, it’s less fun. It’s that simple.”

This is an example of when strict interpretation of the game rules may not align with what enhances player enjoyment and social experience. I found further evidence of this in groups where, perhaps because they were unable to “cheat” by reading fellow players, they found themselves amidst a string of poor guesses. Players often perceived their failures as spotlighting their disconnection and attributed poor performance to their remoteness. During remote play, Group 10 experienced a string of successive failures, and commented on their performance: “We’ve lost our Wavelength” (P4) “The connection was severed” (P3), and “That hurt, that really hurt” (P1). A player in another group remarked that “Misunderstandings hit harder if you were apart” (G4-P2). Players’ assessment of their performance appears intertwined with their feelings of connection.

5.3. Summary

In this chapter, I presented the results of the user study I conducted to evaluate Remote Wavelength. This included observations about how people used a system for remote tangible gameplay (RQ1) and how it impacted their sense of connection (RQ2). I described the impacts of using a tangible gameboard, including potential improvements for player presence, engagement, and communication. I also described the drawbacks of using a physical device for remote gameplay, including how it might exclude some
players who do not have the device and require additional setup. In addition, I discussed how integrating technology for gameplay and communication helps players feel more confident in the system, how poor performance in a game that relies on social mechanics can cause players to feel disconnected, and how ambiguity around turn order makes it more difficult to socialize with other players.
Chapter 6. Discussion

My research aims to better understand factors that shape the social experience of friends playing remote tabletop games together. I found a tangible gameboard has several benefits (as well as drawbacks) for social connection and that some areas where issues of gameplay and connectedness intersect include communicating with remote players, managing turns, and reading remote players’ emotions for greater fun and success in the game. Here, I review findings from the study in Chapter 5 to refine my initial design requirements and generate additional considerations for the design of remote tabletop game systems that support social connectedness among players.

6.1. Design Considerations

6.1.1. Choosing Tangible Components for Presence, Remote Touch, and Multi-Sensory Feedback

Prior HCI research indicated that tangible, synchronized components are important to player experience and social connection (Yuan et al., 2021). I build on and extend this with guidance on how to design tangible game components and which game elements to prioritize for tangibility. My study results illustrate that tangible components can improve a player’s sense of presence, helping the player extend themselves into the remote space by acting upon it over distance, which I interpret into several design opportunities.

First, I see an opportunity for remote game system designers to encourage presence by including tangible components representing the player, giving them a remote proxy (e.g. (Kuzuoka & Greenberg, 1999)) that they can easily identify with and communicate through. For example, players could control a miniature or meeple (a person-like pawn) to represent their game character and act as their avatar in the remote space. Enabling players to customize these meeples could leverage an aspect of materiality that tabletop players enjoy (Rogerson et al., 2016). Building on an idea proposed for collocated gameplay (Smit et al., 2019), they might even view the remote space from their meeple’s perspective. This aligns with Maurer and Fuchsberger’s observation that ‘physical components represent a player personally, to some extent could even be considered a ‘physical avatar’” (2019, p. 13).
Second, participants shared that their sense of presence was augmented by sensing (seeing and hearing) how they affected the remote gameboard. Their awareness of remote players was also improved by seeing other players interact with the tangible gameboard, a known benefit of tangible interaction (Hornecker & Buur, 2006). This suggests that tangible game elements should be visible for all players. This has implications for the scale and placement of tangible elements relative to the system’s video link (or other solution for representing remote players). For example, with a front-facing (vs top-down) video link like ours, these elements should be large and replicated on both front and back of the gameboard so players can see their manipulations. Similarly, if the movement of tangible elements produces audio, this feedback should be loud enough to be heard remotely. I suggest selecting components that make remotely audible sounds or purposefully adding audio into game systems to emphasize the movement of components in the remote location. Intentional design of the system’s audio qualities has the potential to enhance player presence and engagement with the game.

Third, I learned that some players desire to interact via touch with those joining remotely. This suggests that there is room for designers to explore how tangible game pieces might send a physical sensation to remote players. I observed in-person players use touch to connect during emotional moments, celebrate a win with remote players or seek attention (as G4-P2 did). I see an opportunity for designers to increase remote presence and emotion sharing over distance by exploring actuated game artifacts, like wearables that transmit touch (Singhal et al., 2017), or game pieces that can move around the table and bump into remote players (Le Goc et al., 2016). Extrapolating beyond touch, it may also be worthwhile for designers to explore creating shared gaming experiences across households through activating other senses, such as smell (Oddfish Games, n.d.; Strong & Gaver, 1996).

### 6.1.2. Applying Flexibility to Tangible Components and Turn-Taking

Prior work has shown that flexible game rules, scoring, and team formation can benefit players’ social experience (Bergstrom & Bjork, 2020; Yuan et al., 2021). My work builds on this by demonstrating how to apply flexibility to the design of synchronized tangible game objects. I also reflect on the limits of flexibility when applied to turn-taking.
I found that the tangible components of remote tabletop games can be a rich communication channel and were used by players to convey game information, humour, and a desire for attention. Previous work has illustrated that interaction with game objects can operate as a form of communication, providing information about players’ in-game actions and strategies (Wasserman, 2020). I extend this to include how people playing remotely use tangible game objects for purely social purposes, sharing information not necessary to the game. When designing remote games, this understanding of game components as a communication channel suggests designers should strive to make these components dynamic tools that can express a variety of information. For example, a sliding scale could register how much is exchanged in a trade, or risked in a wager, or to keep score. That same scale might also be coopted to communicate a player’s enthusiasm or disappointment. My observation that players used tangible components to make jokes and seek attention highlights the value of enabling players to manipulate tangible components without permanently impacting game state (e.g., if a player changes the slider, the system should allow changing it back). This suggests an opportunity for remote gameplay system designers to explore flexible interfaces that better enable players to develop improvised uses for social purposes.

In my current iteration of *Remote Wavelength*, I found that, while players sometimes enjoyed self-determined turn-taking, it also introduced ambiguity. Although players had consistent left and right neighbours and the remote setting mimicked the in-person arrangement of sitting around a table, this was not sufficient for groups to follow a specific turn order. To achieve a balance of clarity and flexibility, designers of remote game systems must carefully consider how they implement turn-tracking. Rather than having players determine turns, perhaps flexibility can be introduced through an override option or specific function to pass the turn back and forth. I suggest the need for digitally tracked yet flexible turn order could be addressed by leveraging the benefits of flexible tangible play pieces. For example, a pawn that tracks the changing turns, but that can also be activated by players to replay a turn or nudge the active player to hurry up. Given the parallels between managing turn-taking in-game and in conversation (Triay & Wood, 2022), I also speculate that solutions could be inspired by remote meeting and facilitation tools. Examples include a speaker’s queue (Hughes & Roy, 2021), where turn order could be automatically assigned but customized if desired, or tangible video
avatars, which can be used to sort people into breakout groups (teams) and single out an active speaker (player) (van Dijk, 2022). I also suggest a digitally tracked yet flexible turn order could be provided by leveraging the benefits of flexible tangible play pieces. Imagine, for example, a pawn whose movements track the passing of turns, but that can also be activated by players to replay a turn or nudge the active player to hurry up.

6.1.3. Including Digital Players and Bringing Positive Aspects of Physical Gameplay to the Digital Realm

During my study I learned how a physical remote gameboard could increase engagement with the game. Using a dedicated physical device, rather than a computer, generated excitement, removed distractions, and provided a break from a computer-work context. Future implementations of remote tangible games should continue to leverage these benefits by offering players a chance to disengage from their typical computer-use setting once the system is setup. I envision a remote gameplay experience that takes place in the living room, at the kitchen table, or even on the patio as people get comfortable in household contexts more associated with leisure than work. I see significant design work ahead to create systems with the portability and adaptability to work across such settings. I also see research opportunities to explore how the context of play affects adoption and how players’ perceptions of a dedicated, tangible game evolve over long term usage.

I saw that requiring a dedicated, physical board for gameplay has drawbacks, the most significant being that players did not want to leave out friends who may not have the hardware but still want to play. This suggests that, similar to mixed-reality remote collaboration systems (Oyekoya et al., 2013), remote tangible game systems may be more readily adopted if they are able to interface with digital-only players. Given this, designers might also consider whether some of the qualities players appreciate in a physical gameboard might be adapted for digital apps. For example, digital tabletop gaming applications could better meet the needs of remote workers by enabling them to play with a smartphone or TV in their living room, rather than at their computer or desk. Similarly, apps might nudge players to silence notifications while playing a game on their phone or computer.
6.1.4. An Integrated Remote Experience to Increase Player Connection and Confidence in the System

I explored integrating communication and gameplay spaces within a remote gaming system, and found that it has potential to support player connection. Through my design work, I discovered two possible approaches to this integration: 1) overlaying digital game objects on the communication platform, which I implemented in the form of a spectrum card on top of player video; 2) designing the remote gameboard so that meaningful game information is captured and transmitted through video conference, which I implemented by reproducing the front of the gameboard on the back. Based on participant responses, both techniques can support integration of communication and gameplay. When integration involves game objects in digital and physical realms, the visual aspects of these objects must be tightly coupled as well. Designers might draw on lessons for connecting the digital and physical elements of tangible user interfaces to inform this aspect of the design (Ishii, 2008).

In addition, my results highlight further opportunities for integration within a remote gameplay system, like linking player avatars with player video or bringing the game theme into the communication platform connecting players. As video conferencing systems continue to refine filters, backgrounds and viewing modes (Ray, 2020; Zoom Video Communications, Inc., 2020), I imagine systems augmenting player video with crowns, space helmets, or other props and backdrops that tie into the game story. I suggest designers of game systems might draw inspiration from other tools that immerse players in a shared task space, such as systems for collaborative work while video conferencing (Grønbæk et al., 2021) or for improv actors to configure an immersive video scene (Branch et al., 2021). Giving games and game systems this built-for-remote feel not only has the potential to make remote gaming more immersive and fun, but also to increase player confidence in the system. This is important for social connection because low confidence in a system can cause players to spend time confirming what others can do and see, a distraction from socializing together (Kuzuoka et al., 1994). I suggest that to inspire confidence in the system and streamline player interaction, the system needs to not only work well but also appear to work well for remote interaction. Integrating communication and game spaces can help with this.
6.1.5. The Case for Helping Players Cheat

I saw that players were concerned about their ability to ‘read’ each other remotely and often attributed their losses to their remoteness. This conflation of one’s gaming success with successful social connection might be particularly noticeable in *Wavelength*, which asks players to guess what others are thinking. But there are many other games where players must collaborate with limited verbal communication (e.g., *The Crew* (Sing, 2019), *Hanabi* (Bauza, 2010)) or compete to figure each other out with help from social cues (e.g., *Werewolf* (des Pallières & Marly, 2001), *Coup* (Tahta, 2012)). My results suggest that for hidden information games, players feel their distance more acutely when a failure in-game spotlights their inability to read remote players. In other words, negative game outcomes draw attention to the difficulty of telling how a remote player is feeling, which then makes players feel less connected.

System designers might counteract this in part by emphasizing players’ wins more than losses, focusing on moments when they successfully empathize with remote players. To address the root cause of this issue, designers will need to develop ways of representing players’ emotions and body language at a sufficient fidelity for players to feel they can read each other over distance. I suggest designers might adapt existing systems for awareness over distance to a game context, perhaps borrowing from a posture-sensing chair concept (Papanikolaou et al., 2015) to display when players are fidgeting or tense, or adding musical cues to the game that reinforce the emotional tone of player conversations (Hagerer et al., 2015). I also argue for making allowances to present this information to remote players, even when it is officially considered cheating. During gameplay for social connection, the focus should be on capturing social cues that make the game fun, rather than what is allowed by the game rules.

Through this discussion I have evolved my initial design requirements and, based on my study findings, introduced new opportunities for improving connectedness during remote tabletop gameplay. I offer considerations for incorporating tangibility, flexibility, game-communication integration, and (possibly illicit) awareness of remote players into remote gameplay systems. My goal is for these considerations to offer generative resources that can guide future practice within this emerging design space.
6.2. Summary

In this chapter, I drew on the study results reported in Chapter 5 to identify considerations for the design of remote tangible tabletop game systems that support social connection between groups of friends. I listed five design considerations and for each one discussed opportunities to implement the consideration in future systems.

Firstly, I recommended that designers of remote tabletop game systems choose tangible components that enhance player presence. I articulated several ways this might be accomplished, such as by choosing components players can easily identify with, transmitting touch over distance, and offering multiple forms of sensory feedback on how one’s tangible manipulations are affecting the remote location. Second, I suggested that flexible system design be applied to the system’s tangible components and turn order. For turn-order, I recommend that this be specified by the system but that players be able to override it. Thirdly, I suggest that future systems should accommodate digital-only players and that certain advantages of tangible systems, such as the ability to play in a leisure context rather than at a computer and desk, might be leveraged in digital-only systems. Fourthly, I imagine possibilities for helping players feel a system is built-for-remote, which might make gaming more immersive and increase player confidence in the system. Lastly, I highlight how helping players read each other remotely, even if against the rules, can sometimes benefit their social experience overall.
Chapter 7. Conclusion

In this concluding chapter, I summarize the research contributions made in this thesis. I present the findings relevant to each of the research questions articulated in Chapter 1. Next, I acknowledge the limitations of my research and suggest opportunities for future work on social connectedness through tangible remote games. Lastly, I situate this contribution within the broader realm social gameplay and express my hopes for the future of remote tabletop gaming experiences.

7.1. Contributions

The core contribution of my research is the design and evaluation of a system for social connectedness through distributed tabletop gameplay. In chapter 1, I outlined three research questions that motivated my design inquiry and user study. Here, I review each question and how it was answered through my research, to summarize the contribution of my work.

Question 1: How do groups of players use a remote, tangible gameplay system to socialize and play a tabletop game together? In exploring how people play remote games together, previous work has focus on existing solutions which lack synchronized tangible components (Yuan et al., 2021), or in cases where tangible systems have been evaluated, they have not been examined with more than two players (Günther et al., 2018; Odenwald et al., 2020; Wilson & Robbins, 2007). Based on this, I identified a research gap around understanding the social and gameplay interactions of larger groups (e.g. 3-5 players) playing a remote tangible game, which informed my first research question.

To answer this question, I conducted a user study to learn how players used a remote tangible gameplay system, in this case the Remote Wavelength prototype. I observed groups of playing with the Remote Wavelength system for 30-45 minutes. Across ten studies with 38 players, I heard them exclaim when they saw the remote player affect the state of the local gameboard, describing how it felt like the remote player was more present with them (see 5.1.1). I saw how people used the tangible components to communicate about the game, make jokes and seek attention from other players (see 5.1.3). I watched them struggle to consistently follow a turn order in the
game and later heard how this made informal turn-taking in conversation harder as well (see 5.2.2). I watched players engage in the game, watching the gameboard and each other or, sometimes, disengage by looking around the room or checking their phones (see 5.1.2). I observed as they questioned each other about what they each could see and do, to build confidence in how the system worked (see 5.2.1). I heard them lament when they lost, and speculate about the source of their disconnect (see 5.2.3). Overall, I was able to observe a variety of player behaviours and, by piecing together these behaviours with players’ own reflections on their experiences, identify common themes that might inform the design of future remote tangible tabletop game systems.

**Question 2: How does a remote gameplay system with a synchronized, tangible gameboard impact players’ experiences of social connection during remote play?**

To design better remote tangible gaming systems, we need to understand how such systems impact players’ experiences of social connection. Research on the digitization of tabletop games and its impact on the social experience offers some insight, but there are likely other considerations specific to remote play (Rogerson et al., 2015; Wallace et al., 2012; Xu et al., 2011). Yuan et al (2021) explored players’ social experiences with current remote gaming practices, but these practices did not include systems with synchronized, tangible game elements. Odenwald et al (2020) evaluated the effect of a synchronized, tangible remote game system on overall immersion and social interaction, but their discussion of how specific system design features impact social connection is limited. Thus, I aimed to contribute a better understanding of how a remote gameplay system with a tangible gameboard impacted players’ experiences of social connection.

To address this research question, I conducted a qualitative user study to gather reflections from players on how the features of a remote tangible gameplay system, in this case *Remote Wavelength*, impacted their sense of connection. Through individual comments and group discussions, I collected descriptions from 38 people about their experiences playing with the *Remote Wavelength* system for 30-45 minutes.

I learned that players appreciated seeing and hearing themselves interacting with the remote space, and that the ability to do so supported their sense of presence. I also learned that one thing they missed during remote play was the ability to reach out and ‘touch’ remote players (see 5.1.1). I heard that the tangible gameboard—in part because it was cool, fun, different from computer work and less distracting than other
technologies—helped players engage with the game (5.1.2). I learned that the tangible gameboard offered players more ways to communicate, which was important because they could not always rely on the audio link (see 5.1.3), but also that there are drawbacks to using a physical device and players worried about excluding friends who didn’t have one (see 5.1.4). Players told me that integrating game objects with the video link helped them attend to remote players and gave them confidence in the system, as it was clearly built for remote play (5.2.1). Players shared their confusion around how to take turns, and described how this impacted their social experience by making it less clear when it was their turn to talk (see 5.2.2). Lastly, players described how when playing remotely they were less able to read other players. They suggested that even if this was considered cheating, it was an important part of their gameplay experience and helped them connect with other players (see 5.2.3). Together, these learnings gave me an understanding of how players experience remote tangible gameplay and how the system impacted their sense of connection. This understanding then guided my development of considerations for the design of future remote tangible tabletop game systems.

Question 3: What considerations are important in the design of a system that connects friends through remote tangible gameplay? In chapter 3, I described my design exploration, including how I experimented with existing solutions, generated ideas to map the design space, and crafted early prototypes to identify preliminary considerations for the design of a remote gameplay system. Applying a Research through Design process, I learned about some of the challenges for improving remote tabletop games and developed a set of design requirements for promoting social connection in a remote gameplay system. These requirements included head-to-hand player representation, tangibility, synchronization, flexibility, and integrated communication and game space. I then built the Remote Wavelength prototype to incorporate these requirements and evaluated it with users to better understand their experience of gameplay and social connection.

As a result, I offer several considerations for designers of remote tangible gameplay systems for social connection. My initial design requirement suggested that a remote tabletop game system include tangible and synchronized game elements (see 3.3.2 and 3.3.3). These requirements drew on prior work, which found that physicality is an important element of the gameplay experience (Rogerson et al., 2016), and lack of
synchronization across households is a significant challenge for players who want to incorporate physicality into their remote gameplay (Yuan et al., 2021). Building on this, results from my user study suggest considerations for the design of tangible elements specific to remote play, including how those elements might better support player presence through remote touch and multi-sensory feedback (see 6.1.1). I expand the design requirement around flexibility via rules customization (3.3.4), which was based on lessons for digitizing tabletop games (Rogerson et al., 2015; Wallace et al., 2012; Xu et al., 2011). In addition to allowing for flexible implementation of rules, I suggest flexible use of tangible components and structured yet flexible turn-taking (see 6.1.2). Similarly, I extend the initial design requirement around integrating game and communications spaces (see 3.3.5) to include game theme, and highlight how integration benefits not only awareness of remote players (Mills et al., 2021), but also player experience and confidence in the system (see 6.1.4). I also discuss how tangibility benefits player engagement and offer design considerations for digital systems around reducing distractions and enabling people to play remote games in a leisure environment (see 6.1.3). Lastly, I extol the virtues of helping players cheat, and suggest that where social connection is the goal, awareness of remote players might be beneficial even if discouraged by the game rules (see 6.1.5). This adds nuance to the requirement for greater awareness of remote players (see 3.3.1), which was derived from Yuan et al’s (2021) study of current remote tabletop gameplay practices.

7.2. Limitations and Future Work

My research included a single game, and while many of the insights I describe here are applicable beyond Wavelength, the nature of the game I chose to study does shape my results. My findings on tangibility, integrated communication and gameplay, and flexible system design, all of which are relevant to the design of game objects, player interaction and the digitization of gameplay, are issues for remote tabletop game systems more generally. However, some of my findings may apply only to a subset of games, such as bluffing and deception games where player awareness has a heightened role. Similarly, there are likely additional considerations specific to other game genres, such as complex games with many components, roleplaying games, and dexterity games. Future work might explore remote gameplay with other types of tabletop games, or how to make a tangible gameplay system adaptable to multiple
games. Similarly, while my work goes beyond existing research on distributed gameplay by exploring mixed presence groups of varying sizes, it remains limited to two locations. I see opportunities for future work to investigate systems that accommodate even more varied player distributions.

In addition, my study focused on friends within the 18-35 age group. I feel that this demographic was suitable for our study because they have been identified as having a lot of spare time for gaming (Rogerson & Gibbs, 2018). I recommend that future work investigate remote gameplay for people with other relationships (e.g., grandparent-grandchild) and at different life stages (e.g., parents) as they may have unique behaviours and needs.

Lastly, because I chose to test my prototype in a lab, participants played the remote game for 30-45 minutes. My results cannot speak to how the player experience might evolve with longer-term use of the game. Participants’ enjoyment of the system may have been influenced by novelty, as they had typically only played digital remote board games prior to the study. Future work might explore the extended use of remote tangible games with a more robust prototype that can function in the field for prolonged periods. Such work could uncover additional social, domestic, temporal, and ecological factors that might affect long-term adoption of remote game systems.

I look forward to future work that extends my findings through the study of additional games, player populations, household configurations, and extended use.

7.3. Final Words

The potential of technology for keeping in touch over distance is growing, and many friends rely on technology-mediated communication to maintain their relationships. In particular, enjoying shared activities together is a meaningful way for friends to socialize over distance. Yet so far, these experiences pale in comparison to their in-person counterparts. This is true for tabletop games, a leisure activity which helps many friend groups connect and spent time together. Unfortunately, current solutions for playing tabletop games remotely lack many of the social, material factors that contribute significantly to player enjoyment.
In this thesis, I contribute the design and evaluation of a system for remote tangible gameplay that supports social connection between players. I aim to narrow the gap between experiences of in-person tabletop play, which offer rich interactions with physical game components and other players, and experiences of remote tabletop play. To this end, I introduce considerations for the design of remote tabletop game systems that support social connection between players and offer guidance for incorporating tangible elements in a remote game system. I believe that as technologies continue to develop, there will be opportunities to incorporate tangible, social design features into a range of tabletop gaming applications.

To this end, I strive to provide an example that inspires future designers of tangible remote game systems. I aim to provide guidance in the form of design considerations, but beyond that I want to illustrate the potential for innovation in this area, as I believe current remote tabletop gaming experiences might be improved through greater focus on the social elements of gaming. I imagine a world where players can come together around a tabletop to socialize, engage in gameplay, share a sense of presence, and have fun, whatever their location. Ultimately, I hope my research contributes to better, more connected gameplay experiences for friends separated by distance.
References


Study participants wanted!

Do you enjoy playing games to connect with friends?

We’re designing technology to help people connect by playing remote tabletop games, and we need help testing it. Bring a few friends, play a game across two separate rooms using our system, and tell us about the experience. You must be over 18 and fully vaccinated to participate in this user study.

Join this 2 hour in-person user study on SFU Surrey Campus, Room 3950. Receive $40 for participating or, if you are a student, this study may count toward course credit.

Contact [Insert Contact Information] to learn more and schedule a user study session for you and your friends!

Note: You should feel free to decline or withdraw from the study at any time. We will not pressure you to participate due to an existing or prior relationship with me or the University. If you do feel a sense of obligation or pressure, you should decline to participate.
Appendix B. Consent Form

User Research Study, Group Session & Interview - Informed Consent Form

Research Project Title: Evaluation of a System to Play Tabletop Games Over Distance

Ethics Application Number: #30000587

Document Version: V2; October 29, 2021

Principal Investigator: [Redacted]

Collaborators: [Redacted]

This consent form, a copy of which is made available to you, is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask the investigator(s). Please take the time to read this carefully and to understand the information.

This work is funded by an NSERC Discovery Grant.

Purpose
The goal of our research is to better understand how to design technology systems that connect friends playing tabletop games over distance. We aim to use this knowledge to create new communication technologies that meet the needs of friends who are geographically separated. For this study, we are interested in groups where some people are in-person together and some are in another remote location.

Participant Recruitment and Selection
To be recruited for this study, you must be over 18 years of age. Because this study is in-person, you must also be fully vaccinated. Proof-of-vaccination (a vaccine card and photo ID) will be required from all participants at the start of the research study.

Study Method
Part 1) In-Person Group User Research Session
You are invited to participate in an in-person, group user research session which will take 2 hours. Participating in the research will involve spending time in a room with up to 10 people, some of whom may be strangers (8 participants, 2 researchers). Participants will play a game together, first in-person and then remotely across two separate rooms. Then, participants
complete a paper follow-up survey and have a group discussion. To play the game remotely, you will be connected to participants in another room via a video conference link, and you will use a shared physical game board with added technology like sensors and lights. In the survey and discussion, we will ask questions about your past experiences using technology to connect with remote friends, and your experience playing with a remote group in another room during the session. The group session will be video recorded and photographed.

**Part 2: Individual Interview**
Some participants may also complete a 30-60 minute individual interview over Zoom (an online video chat platform). In interviews, we will ask about your previous experience playing a remote game or using technology to connect with friends, as well as your experience in the group research session. Interviews will also explore the same topics as the group session, but in more detail. Not every participant will be asked to do an interview.

**Benefits and Risks**
The risks of the study are expected to be minimal.

Participants who complete the 2-hour user research session will receive $40. For partial completion, the amount received will be prorated (e.g., $10 for 30min of participation, $20 for 1hr of participation). Participants who complete the 30-60 min individual interview will receive $20. The receipt you sign to receive compensation will be stored on SFU Vault separately from other data collected in the study until 2024. If you are a student, you may have the option to receive course credit instead of monetary compensation. To receive course credit, you must confirm it with your instructor ahead of participating in the study.

During both the group session and interviews, we will use Zoom video conferencing to connect over distance. Zoom is a US company, so any data you provide may be transmitted and stored in countries outside of Canada, as well as in Canada. It is important to remember that privacy laws vary in different countries and may not be the same as in Canada.

**Covid-19 Safety Precautions**
The research team will abide by the latest provincial health guidelines in relation to the COVID-19 pandemic. All researchers are fully vaccinated, and all participants are required to show ID and proof of vaccination at the start of the study. All researchers and participants are required to wear masks in the study space. We will make hand sanitizer available to participants and researchers during the group session, and clean the tabletop surface, game system, and pens with anti-bacterial wipes between sessions. Researchers will sanitize their hands prior to distributing study materials, such as paper surveys.

**Research Results**
Research results, such as published papers, can be obtained by contacting the principal investigator:

- [Redacted]

Any published research results will also be made publicly available on the research lab’s website: [http://clab.iat.sfu.ca/publications/](http://clab.iat.sfu.ca/publications/)
What Happens to the Information I Provide?

No one except the researchers identified at the start of this Consent Form will be allowed to see or access any of your written data or individual interview data. However, for your actions and comments in the group session, full confidentiality cannot be guaranteed. While we encourage participants not to discuss the content of the group session to people outside the group, we can’t control what participants do with the information discussed. As well, video chat systems such as Zoom are not considered to be confidential mediums. Thus, you can choose to participate over such a medium, or choose to not participate in the study.

We are collecting four types of data/information. Here we state how each will be handled and stored.

Video Recordings and Images of the Group User Research Session
Video recordings and images will be modified according to your responses below, and will be used to analyze data or, with your explicit permission, be used to disseminate research results. They will be stored on an online storage system (SFU Vault) until 2024 or until the study analysis is completed.

Anonymous Written Data from Paper Surveys
All written information collected will be digitized and labeled with an anonymous participant ID. Paper copies will be destroyed. Digitized versions will be stored on SFU Vault until 2024 or until the study analysis is completed.

Audio Recordings (collected if you participate an individual interview)
Audio-only recordings will be transcribed and then destroyed after transcription. Transcripts will be kept on SFU Vault until 2024 or until the study analysis is completed.

Identifying Information on Study Receipts and Consent Forms
Receipts and consent forms will be digitized and stored on SFU Vault until 2024. Paper copies will be destroyed. The information you provide on these forms (e.g. your name) will not be associated with your study data.

None of the study data will not be uploaded to any online repositories for use in future research. Public presentations of the results will primarily present the results in an anonymized form. Where individual participant data is disclosed, such as exemplar comments via quotes, we will ensure that the selected data does not suggest participant identities.

You Can Refuse to Participate or Withdraw at Any Time

You should feel in no way obligated or pressured to participate due to an existing or prior relationship with me or the University. If you do feel a sense of obligation or pressure, you should decline to participate.

If you agree to participate, you will be free to withdraw at any time for any reason by emailing the Student Study Lead, [redacted], or the Principle Investigator, [redacted]. However, data collected in the group session up to the withdrawal point will still be retained and used by the researchers. Data collected in the individual interview will be destroyed.

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Acceptance of this Form
Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate yourself, as a research participant.

You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

To accept this form, please check the applicable boxes below, and type your first and last names and today’s date in the following boxes as a form of a digital signature.

Options for Use of Video Recordings & Images of Your Participation
You have the option of whether any video or images recorded of you during the user research session may also be used for dissemination of research results. Including videos and images in research presentations can sometimes help in the illustration of research findings, and is common in the Human Computer Interaction research discipline. In order to design technology, it is useful to show how people interact with it. If you do not consent, the video will only be used for internal data analysis purposes. For the group session we will check the consent forms prior to dissemination of any videos/images and ensure that non-consenting participants will be cropped out. Please check your response below:

I DO NOT consent to the public presentation of my participation video or images

I DO consent to the public presentation of my participation video and images:
- without any modification of my face or voice
- only if my face is blurred
- only if my voice is altered

Options for Study Participation
You may consent to participate in the group session, or both the group session and individual interview, or neither. Check all that apply.

☐ By checking this box, I am consenting to participate in Part 1) Group User Research Session.
☐ By checking this box, I am consenting to participate in Part 2) Individual Interview.

First Name: ___________________ Last Name: ___________________
Date: ________________________
Questions/Concerns:

If you have any questions about the study, please contact [redacted]

If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, you may contact the SFU Office of Research Ethics at dore@sfu.ca or 778-782-6618
Appendix C. Study Worksheets

Reflections on the Remote Wavelength Experience
Help us understand your Sense of Connection during Remote Wavelength

For each statement, think about your experience playing the game remotely. Then, share how much you agree or disagree:

I felt like I was **present together** with remote players.

- [ ] Strongly Disagree
- [ ] Disagree
- [ ] Neither agree nor disagree
- [ ] Agree
- [ ] Strongly Agree

I felt like I had opportunities to **socialize** with remote players.

- [ ] Strongly Disagree
- [ ] Disagree
- [ ] Neither agree nor disagree
- [ ] Agree
- [ ] Strongly Agree

What were some **aspects or qualities** of the situation that helped you **connect to remote players** (if any)?

When did you feel like it was **difficult to connect with remote players** (if at all)?

Compare when you played Wavelength with everyone in the same room, and then playing remotely. How was your sense of connection **different** remotely vs in person (if at all)?
Demographic Survey

Tell us a bit about yourself.
This will help us contextualize the data we’ve collected.

What is your age in years? Check one:
[ ] 18-24
[ ] 25-34
[ ] 35-44
[ ] 45-54
[ ] 55-64
[ ] 65+

What gender do you identify as? ______________________________

What is your occupation? ______________________________________

If you are a student, what is your field of study? __________________

For each person in the session, please:
• describe your relationship (e.g. friend, family, classmate, met today), and
• provide a number from 1-5 for how well you know them (5 being very well).

a) __________________________, __________________________
b) __________________________, __________________________
c) __________________________, __________________________
d) __________________________, __________________________
e) __________________________, __________________________
f) __________________________, __________________________

How well do you know this person?
1 - Do not know them
2 - Know them a little
3 - Know them somewhat
4 - Know them well
5 - Know them very well
E.g. __________ Classmate ________, __2

In the past year, about how often did you play games of any kind with people who were remote?
[ ] Never
[ ] Less than once a month
[ ] once a month
[ ] a few times a month
[ ] once a week
[ ] more than once a week

If you play games remotely, who do you usually play with?
(E.g. friend, family, strangers)
How would you rate your experience with tabletop games, such as board games, card games or role playing games?
[ ] No experience
[ ] Slightly experienced
[ ] Somewhat experienced
[ ] Experienced
[ ] Very experienced

If you play tabletop games:
What are some of your favourite tabletop games? (list up to 3)
1) ____________________________
2) ____________________________
3) ____________________________

What are some tabletop games you play most often? (list up to 3, or check “same as my favourite games”)
1) ____________________________
2) ____________________________
3) ____________________________

OR
[ ] They're the same as my favourite games
Feature Sort Activity Cards & Instructions

Feature Sort Activity

Work in groups of 2-4. Go through the deck of cards one at a time. Each card describes an element of the experience that may have affected your sense of connection to remote players during Remote Wavelength. There are also blank cards where you can add your own features.

Sort the items in a line based on:

1) Whether they were **important or not important** to your **sense of connection** (i.e. did they matter a lot to whether you felt connected to remote players, or very little). Arrange items in order from most to least (top to bottom). Discuss why you place each item where you do.

When done, let the facilitator know and they will take a photo of the scale.

```
Very Important to Connection

Not at all Important to Connection
```
<table>
<thead>
<tr>
<th>Arrangement of the play space (tables, chairs, screen, etc.)</th>
<th>Size of the remote player video display</th>
<th>Quality of video stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum Card placed on top of remote player video</td>
<td>Quality of audio stream</td>
<td>Volume of audio stream</td>
</tr>
<tr>
<td>Seeing the lights and score on your game board changed by remote players</td>
<td>Seeing a similar gameboard in the remote players’ space</td>
<td>Level of fun of the game</td>
</tr>
<tr>
<td>Using a physical game board to play</td>
<td>Add your own item. What contributed to your sense of connection?</td>
<td>Add your own item. What contributed to your sense of connection?</td>
</tr>
</tbody>
</table>
Appendix D. Supplemental Video Files

Creator/Director:
Yuncheng Chen

Description:
The film is complementary to this paper. It summarizes the research presented and demonstrates the functionality and features of the prototype: Remote Wavelength.

Filename:
remote wavelength video.mp4