Remote Wavelength: Design and Evaluation of a System for Social Connectedness Through Distributed Tabletop Gameplay

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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. We are interested in how to better design systems for remote tangible gameplay that support social connection. We investigate this topic through the design and evaluation of a prototype system for playing the board game Wavelength across two locations. First, we describe the design goals that informed our prototype: "Remote Wavelength". Then, we discuss the results of a qualitative user study in which ten friend groups played Remote Wavelength. Our findings indicate that a synchronized, tangible gameboard benefits player engagement, communication, and awareness. Our results also illustrate the value of integration across communication and gameplay systems. We conclude by offering considerations for the design of both digital and remote tangible gameplay systems.

CCS CONCEPTS

• **Collaborative Interaction**; • **Collaborative and Social Computing Devices**; • **User Studies**;

KEYWORDS

Social connection, Friends, Tabletop games, Remote, Distributed, Tangible, Prototype, Design

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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 [21, 39], and for most who enjoy them the social interaction is one of their key motivations for play [74, 92]. 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 [99]. Remote games also helped people forced to isolate due to the Covid-19 pandemic [93] socialize safely with friends and family outside their household [30, 40]. Supporting people to maintain social connections, even over distance, has substantial benefit. People with strong social relationships are generally healthier than those without [28, 34] 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 [31]. Fortunately, enjoying shared experiences (such as tabletop games) while connecting on a video call helps people maintain social bonds with distant loved ones [7].

Given that people often use remote tabletop gameplay to keep in touch with distant friends, our research seeks to provide considerations for designing remote game systems that better support social connection over distance. For our purposes, we understand social connection to consist of feelings of closeness and togetherness, exchanges of meaningful communication, and mutual enjoyment of a shared activity. We 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 we are interested in social connection as experienced between two individuals or a small group, rather than at a macro or community level [3]. Lastly, we intend for this working definition of social connectedness to encompass feelings of social presence [41], as well as the quality of the dialogue and social interaction between individuals [98].

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 [99]. 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 [99], exploration of the design space through ideation [54] and speculation based on material theory [52]. 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, we adopt a Research through Design (RtD) approach [102] and investigate how social connection during remote tangible gameplay can be better supported by creating and studying a prototype system called *Remote Wavelength.* Our system enables users to play the party game *Wavelength* across two locations.
Through our prototype design and evaluation, we seek to answer three main research questions:

- How do players use a remote, tangible gameplay system to socialize and play a tabletop game together?
- How does a remote gameplay system with a tangible gameboard impact players' experiences of social connection during remote play?
- What considerations are important in the design of a system that connects friends through remote tangible gameplay?

Building on prior work (e.g., [54, 74, 94, 99]), we articulate several goals that guided our design-led process, including *head-to-hand player representation for better awareness, tangible gameboard, synchronization across locations, flexible gameplay, and integrated communication and game space.* We describe *Remote Wavelength,* which features a pair of tangible synchronized gameboards and an audio-video link between two locations. We then describe our user study, where we invited groups of friends to play *Remote Wavelength* and share their experiences with the system. We learn that tangible game pieces help players communicate, engage with gameplay, and feel present with remote players, which all contribute to a sense of connection. We suggest that designers leverage these benefits of tangibility by creating components that engage multiple senses and are flexible enough for improvised use. We see that players find the physical gameboard engaging and specifically better than playing on a computer, because it reduces distractions and (for remote workers) enables play in a leisure context. We also discover how other elements of the game system influence connection, including administration of turn-taking, integration of a remote communication channel, and mechanisms used to address limited awareness of remote players. We discuss how designers can improve connection through integrating gameplay, game theme, and communication within one system. We also identify potential strategies to address the disconnect players feel when struggling to 'read' players over distance. Our discussion extends existing design implications for remote gameplay and social connectedness by offering a perspective rooted in both player experience and design practice. We contribute to the HCI community a design case study in the form of *Remote Wavelength,* as well as additional considerations for the design of remote tangible game systems for social connection. Through this we hope to improve the tabletop gaming experiences and connectedness of friends separated by distance.

2 RELATED WORK

In this section, we review existing research on designing for social connectedness during shared leisure activities over distance and draw inspiration from the design of adjacent gameplay applications, such as digitally augmented board games. Lastly, we survey some existing tools for remote gameplay and review the emerging scholarly work in this area.

2.1 Shared Activities to Connect Over Distance

Researchers have found that social interaction is one of the primary reasons people enjoy board games [74, 92], and that stronger feelings of social presence improve the player experience of digital games [17]. The value of social time during gameplay extends beyond the game, helping friends and family maintain social bonds. For example, research has demonstrated that families who play video games together feel closer as a result [87]. People have also reported that remote gameplay helped them connect to friends and family during the Covid-19 pandemic [30, 40, 99]. This suggests that social connection is an important affordance of remote tabletop game systems.

People connecting over distance are eager to go beyond traditional video conferencing and enjoy remote activities together [7]. Researchers have developed and tested numerous systems for enabling shared activities over distance, including TV watching [47], reading [68], yoga [58], jogging [57], dining [1], shopping [96], cycling [60], and geocaching [29], which indicates the HCI community's enduring interest in the topic. Many of these examples (e.g. [47, 58, 66, 68]) highlight how seeing video of remote contacts during an activity supports social presence and emotional connection, which informs the choice to include video in our system. We are particularly inspired by systems for structured play activities over distance, such as puzzles and escape rooms. For example, work on the distributed puzzle application *Puzzle Space* suggests providing audio-visual feedback as puzzle pieces move [66]. Research on *Escaping Together*, a distributed escape room, highlights the importance of system feedback that helps players confirm whether they are interacting with the same situation and objects [77].

Beyond the domain of leisure, we 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 [24]. 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. This approach tends to result in a "talking head" version of remote player representation, which omits useful details about players' environments and behaviours [51, 99]. Existing research also highlights the value of the shared gameboard for establishing 'common ground', a mutual understanding of the situation that people leverage to communicate more efficiently [24]. This illustrates the importance of synchronizing game elements over distance, which maintains common ground and thus streamlines player communication. Overall, we see significant prior research on enabling shared activities over distance, though research specific to tabletop gameplay is more limited (see Section 2.3).

2.2 Colocated Hybrid Games

Here, we 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" [2:71]. While these projects generally focus on colocated 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 colocated hybrid games has demonstrated potential ways to synchronize gameboards or share game information across households. Molla and Lepetit tracked pawns on a gameboard using a webcam [55], which could be used to track changes in physical game state across households. *ToyVision* featured actuated game pieces which rotate to change direction [50]. *Hybrid Settlers* demonstrated the ability to update the appearance of a game tile with electrochromic inks [38]. Mora et al. made game tokens interactive using LCD screens and cards with scannable barcodes [56]. Other examples include tabletop touch screens enabling player interaction with the game surface [27, 48] and projection-based augmented reality creating digital effects around game pieces [11, 49]. While these examples were designed and tested for colocated gameplay, the diversity of these techniques illustrates the potential of the design space for remote tangible games.

The study of digitization and augmentation of analog gameplay also has implications for players' social connectedness during remote gameplay. Xu et al. highlight how the work of setting up and maintaining the game (which can largely be automated in a digital version) can be tedious but provides time for social interaction [94]. Automation of game tasks can also lead to confusion if players misunderstand automated steps, as well as reduce conversation and collaboration between players by removing the need to update the game state together [86]. Similarly, digital systems should not necessarily enforce all game rules, as Rogerson et al. point out the importance of allowing players to adapt rules for social reasons [73]. 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.

2.3 Remote Tabletop Games

In this section, we identify challenges facing distant friends who want to connect through remote tabletop gameplay. We 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 current methods friend groups use to play distributed tabletop games together, as well as some of the challenges they experience [99]. They found that players typically 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, Yuan et al. 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 or adopt a hybrid physical-digital approach, and that the hybrid approach better supports a social experience. Unfortunately, current hybrid approaches are limited in that 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 the game state and direct their attention.

Similarly, Gomez and Stawarz conducted an online survey of people who played remote games during the pandemic. Their findings further confirm the awareness issues found by Yuan et al. and demonstrate that tabletop players often incorporate physical props in remote play, though uneven access to physical game objects can result in concerns about cheating. They discuss how players using existing remote play methods find it more difficult to communicate, track turns, and understand the game state. The authors also call for further research to explore how new interfaces and augmented physical objects might support social remote play [69]. Overall, these studies of current remote gameplay practices indicate that players want to include physical, tangible elements in their play, yet struggle to maintain awareness of remote players and access the game state in hybrid systems.

There are a few examples of existing prototype systems for remote gameplay that address some of these concerns 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 [91]. 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* uses a head-mounted display to create a similar effect, enabling players to use their own physical pieces to play chess while seeing digital representations of the remote player's pieces [23]. A pre-study of *CheckMate* found that participants enjoyed the tangible interaction and expressed a desire to see video of remote participants. Odenwald et al. designed *Tabletop Teleporter*—an interactive tabletop enabling two people to play a tabletop game over distance with physical pieces—and evaluated players' social experience quantitatively [63]. 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 chat. In all these works, 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 offers few considerations for the design of game systems for groups to connect over distance.

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 applying Material Experience Theory [20] to the physical nature of board games, Maurer and Fuchsberger generated implications for the design of remote tangible board games [52], though these have yet to be tested through application. *Distributed Letter Jam* explored the design space of remote tangible board games for social connection and proposed a system to play the collaborative word game *Letter Jam*, but the system was not evaluated [54].

In sum, prior work has identified opportunities to design for remote tabletop gameplay [52] and social connectedness [99] 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. [23, 91]). We are aware of one system for remote tangible gameplay which has been evaluated with the immersive and social experience of gameplay as the focus [63]. However, our knowledge of design considerations for remote tangible gameplay systems that support social connection remains limited. Research has not yet explored the design or player experience of a tangible remote game system that connects groups of more than two players. We address this gap through the design and evaluation of *Remote Wavelength.*

3 DESIGN OF THE REMOTE WAVELENGTH SYSTEM

We explored the design of a system for social connection through remote gameplay with an RtD methodology. We built a prototype enabling a group to play the party game *Wavelength* across two locations. Our system combines an audio-visual connection with a tangible, synchronized gameboard. In this section, we provide an overview of our design approach. We discuss why we selected *Wavelength* and provide an overview of how it is played. We then describe the design of our completed prototype and our guiding design goals.

3.1 Research through Design Approach

Using an RtD approach, we applied design practice, tools and methods to prototype *Remote Wavelength* and, in the process, develop design considerations for remote tangible gameplay systems. RtD can provide insights on how existing knowledge can be operationalized in a system [101]—in our case, we explore how knowledge derived from the study of colocated hybrid games and existing forms of remote gameplay can be applied to the design of tangible remote game systems. In addition, contributions from an RtD practice can include design artifacts themselves [19] and design implications or considerations [75]. In this section, we describe the *Remote Wavelength* prototype and the goals that informed its design. This description helps situate the design considerations that emerge from our user study and contributes to addressing our third research question.

Our design process began in 2020 against the backdrop of the Covid-19 pandemic, which provided many opportunities to try

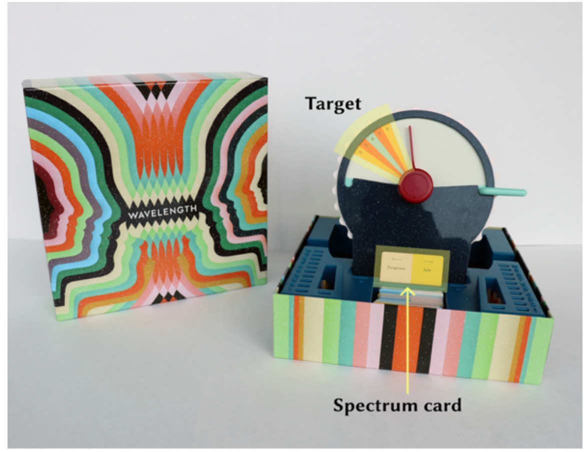

Figure 1: The original *Wavelength* board game, designed by Alex Hague, Justin Vickers and Wolfgang Warsch.

existing remote game systems and learn about the challenges of connecting through remote tabletop gameplay (many of our initial reflections were later confirmed by [99]). With an understanding of current limitations, we began researching emerging technologies that might support remote play and sketching potential solutions. While a complete recounting is beyond the scope of this paper, we created a design workbook [18] to explore a variety of ideas and possibilities for remote game systems. Seeking to combine several of the most promising workbook concepts, we then selected Wavelength as a suitable game and began prototyping *Remote Wavelength.* Throughout the design process, we drew upon our own experiences playing remote tabletop games (the first author is a tabletop gaming enthusiast with many geographically distant friends), and lessons from self-testing of early-stage *Remote Wavelength* prototypes. Leveraging first-person critical-reflexive insights as a key part of the RtD process has a rich history in design research [12, 13, 61]. In Section 3.4, we describe how we combined insights from our design process with findings from relevant literature to produce design goals for our final prototype.

3.2 Choosing a Game to Prototype

We selected the game *Wavelength* [88] because it relies heavily on social interaction between players and the original gameboard is known for providing a deeply satisfying tangible experience [59]. *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, groups were able to learn the game and interface in about five minutes.

3.2.1 How to play Wavelength.

Wavelength is a party game for 2-12 players (Figure 1). Each round one player (the *Psychic)* is given a s*pectrum card,* which establishes a spectrum with two opposing ends, such as "Hot to Cold" or "Sad Song to Happy Song", and a random target location along that spectrum. 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 card* "Hot to Cold," they might say "tea" to get players

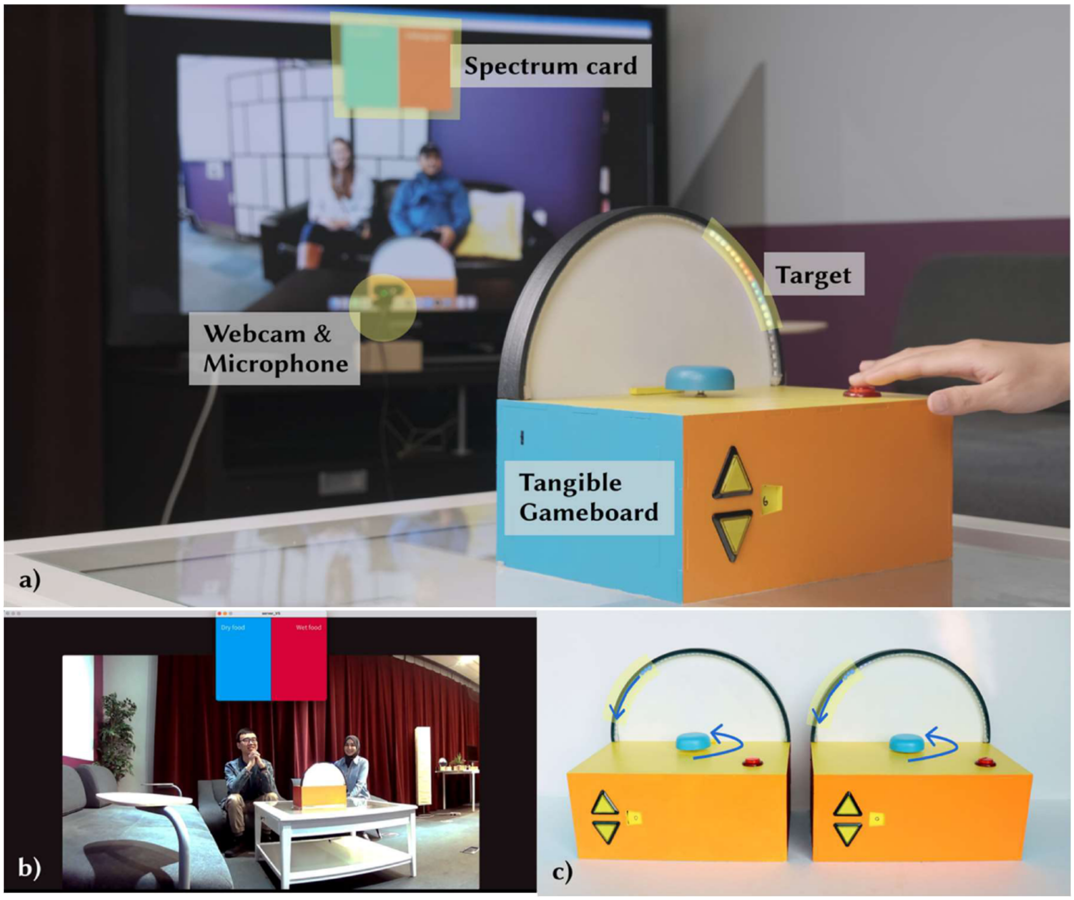

Figure 2: (a) top: a photograph of the *Remote Wavelength* system, including display with video call and *spectrum* card, microphone and webcam, and tangible gameboard. Photograph by Yuncheng Chen; (b) bottom left: the *Remote Wavelength* display showing the spectrum card superimposed on remote player video; (c) bottom right: synchronized tangible gameboards—players enter a guess by spinning the blue dial to move the blue light along the spectrum.

to guess a target that is slightly closer to the "Hot" end of the spectrum. To get players 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.

3.3 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 2a). Each location is outfitted with a peripheral webcam and microphone. The camera window captures each player from the waist up, including their gestures and gameboard interactions. Player video is transmitted using commercial video conferencing software and shown on a large display, presenting remote players at close to life-size. The use of a large display and microphone also enables colocated 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 2b). Each location has its own an identical, synchronized gameboard. If, for example, a player in one location turns a dial to control lights on the gameboard, that change is reflected in both locations (Figure 2c).

3.3.1 Tangible Gameboard & Hardware. The tangible gameboards consist of two laser-cut and brightly painted wooden boxes. We took care designing the gameboards' look and feel to re-create the sensory and aesthetic appeal of a commercial board game. 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.

Each gameboard contains an Arduino microcontroller which collects data from the board's dial and buttons and controls a servomotor that moves the score counter (Figure 3a). Depending on the stage of the game (which players can advance by pressing a button), lights on an RGB LED strip convey the round's target in red, the

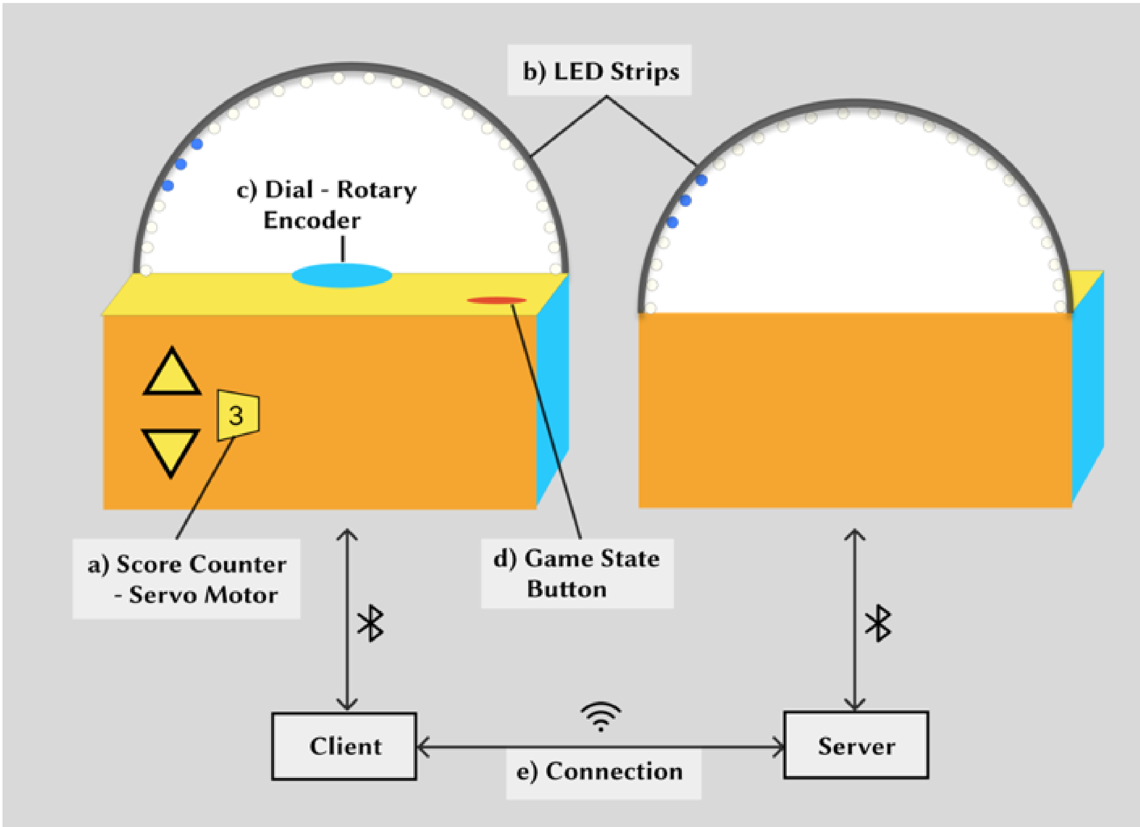

Figure 3: (a) score counter, players use buttons to control a servo motor; (b) LED Strip, used to display target and enter guess; (c) dial to enter guess; (d) button to advance the game state; (e) connection between systems via two laptops on shared wi-fi

players' current guess for the target's location in blue, or an indication of how the two compared and whether points were scored (Figure 3b). When the lights change on the LED strip, a piezoelectric buzzer generates an accompanying sound. As players turn the dial to enter a guess (Figure 3c), the position of the blue light recording their entry moves along the semi-circle of the LED strip in tandem with the dial. Players confirm their guess and progress to the next stage of the game by pressing a button (Figure 3d). The game box is connected via Bluetooth to a computer (also hosting the video call), which is connected in a client-server relationship to the remote location's computer (Figure 3e). The setup is symmetrical across locations.

To enhance the sense that players are interacting with the same object, we 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 also provides visual confirmation that the client-server connection is functioning and the gameboards are synchronized.

3.3.2 Software. Where possible we designed the system's code to enable rules customization [99]. We avoided automating functions such as keeping score and made it simple for players to reset a round if they did not like the *spectrum card* or target assigned. While in our study we encouraged players to work collaboratively, 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.

3.4 Design Goals

We iteratively developed a set of design goals for the prototype by blending insights from our design exploration with lessons from existing literature, including studies of colocated tabletop gaming, current remote gaming practices, and hybrid game design.

3.4.1 Head-to-Hand Player Representation for Better Awareness. Awareness of remote collaborators plays an important role in distributed tabletop activities [83] and is an important design consideration for remote tabletop games specifically [99]. For remote collaboration, improved awareness can streamline communication, facilitate task sharing, and assist with prediction of what will happen next [24]. In a tabletop game, awareness might support activities like discussing game events, coordinating to update communal game pieces, and predicting an opponent's upcoming move. Awareness also offers insight into other players' emotional states, which is part of feeling a sense connection [3]. Our design was guided by the desire to convey the expressions, gestures, and body language

Figure 4: View of *Remote Wavelength* Gameboard, Front and Back

of remote players to improve awareness of both player feelings and the game situation. Specific to a tabletop setting, greater awareness of remote participant's upper bodies has been shown to support more fluid collaboration [95], which informed our emphasis on showing remote participants from "head-to-hand". In addition, our design exploration involved playing a variety of tabletop games with both fully remote play groups and mixed presence groups, which caused us to consider awareness of colocated players as well. This contributed to our choice to convey awareness cues via video rather than other potential mediums (e.g. head mounted displays or HMDs), as it is challenging to perceive facial expressions through current HMD technology [46]. When incorporating this design goal in our prototype, we took care to set up a video connection conveying both facial expressions (head) and interactions with the gameboard (hand).

3.4.2 Tangible Gameboard. We know from research on traditional tabletop games that physical, tangible game pieces are an important part of the experience for players [10]. Rogerson et al. identify materiality (i.e., the physical game components, game box, and play space) as one of four significant factors in players' enjoyment of tabletop games. They found that players enjoy moving and touching physical components, feeling their texture and weight—and that this is one of the key reasons people play tabletop games [74]. Maurer and Fuchsberger later drew on this finding to suggest physicality as an opportunity for enriching distributed play [52]. Recent work has also shown that players who shifted to digital remote play during the pandemic lamented the loss of tangible interaction [99]. In addition to being satisfying for players, using physical objects for gameplay can leverage some of the benefits of tangible interfaces. This includes acting as a prop that aids player thinking (for example as players move around resources to plan future actions) [76] and supporting collaboration by externalizing players' thoughts as they manipulate objects [33]. Given the rich contributions of tangible objects to player enjoyment and the tabletop gaming experience, we incorporate tangible aspects as a core part of our design, through the inclusion of a physical gameboard.

3.4.3 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 [99]. To enable this, our prototype includes networked gameboards that update near-simultaneously. Another facet of this goal that emerged through our design process is the importance of mirroring the gameboards' appearances across locations, as well as the information they displayed. While self-testing our initial prototypes, we noticed that the remote gameboards looked obviously 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 us to align the visual design our prototype's physical components across the local (front) and remote (back) perspectives (Figure 4). We 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.

3.4.4 Flexible Gameplay. Guided by many of the findings from research on tabletop game automation, one of our design goals is to keep gameplay flexible [27, 73, 86, 94]. Automating gameplay (e.g., score calculations) can speed up play, but performing these tasks manually helps players learn the game and track the game state. Yuan et al. also found that people who play to socialize with friends and family often customize game rules for a better social experience [99]. This included forming teams (even when the game did not call for it), adjusting game difficulty, length or scoring mechanism, and allowing a player to rewind a turn. This goal of offering flexible gameplay informs our gameboard design, which includes player-controlled scorekeeping, as well as the game's programming, where we aimed to avoid enforcing specific rules. Our programming of digital elements allows players to fulfill the *Psychic* role as an individual or team, customize scoring rules, and swap *spectrum cards* as desired. Based on personal experiences with digital systems where turn order is determined by the system and strictly enforced, we also decided to apply flexibility to the game's turn-taking mechanism—rather than assigning and tracking player turns, we left the option for players to perform the role of *Psychic* in any order. In further support of this design choice, we also noted that flexible turn-taking has been beneficial in other contexts, such as in gameplay between a parent and child [97]. Instead of assigning turns, we imagined the video conferencing setup would offer the illusion of sitting around a shared table with consistent left and right neighbours, as for in-person play [54]. We hoped this would provide a default turn order while enabling players to make exceptions if desired.

3.4.5 Integrated Communication and Game Space. Another of our design goals is 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 [54]. This integration of workspace and interpersonal space has been explored in other domains [9, 37], but we have not yet seen many examples where it is used for gameplay. In our design process, we discovered several promising technologies that could be adapted for integrated gameplay. For example, a tool to poll meeting participants by having them physically raise their hand [14] might enhance voting-based games, or a drawing tool which overlays images of people and their sketches [42] might support social connection during drawing games like *Pictionary*. We thought this indicated a rich opportunity space, which we wanted to begin exploring. To achieve integration in our prototype, all digital game elements work intentionally with the remote player video display, and digital game cards are overlaid on the video conferencing window. Designing the back of the gameboard to mimic the front also supports this goal, since players can retrieve useful game information through the same channel they use to communicate with remote players.

4 EVALUATION METHODOLOGY

We conducted a qualitative in-lab study to explore how participants use and experience *Remote Wavelength*. We seek to understand what people do and do not like about the system, how they feel it affects their sense of connection, and how it compares to in-person play and other remote play experiences. We chose to conduct the study in-lab because it enabled us to closely observe participants and avoids logistical difficulties of building, shipping, setting up, and maintaining multiple prototypes in remote locations. Our study received approval from the Research Ethics Board at our home institution.

4.1 Participants

We 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); Eighteen participants identified as male (17) or man (1); and one participant identified as non-binary.

Our study took place in-person at our home institution. Students compose a sizable portion of the study sample, including 19 undergraduate students and 11 graduate students. Due to recruitment through a design and technology-focused program, students with a background in HCI, design, or technology make up 64% of the study sample. Other participant fields of study include 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 our recruitment materials, we 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, we asked participants 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, we feel our sample achieved a good representation of the types of social ties that might exist between a group of friends coming together to play remote games.

We asked participants 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. Overall, our sample included participants of varying familiarity with tabletop games and remote gaming.

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*. We feel our sample encompasses both casual and hobbyist game players, with diverse gaming preferences.

4.2 User Study Method

Our study consists of four main phases: learning the game in-person, playing the game remotely, reflecting on the experience, and completing a demographic survey. First, each group 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. We 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 (Figure 5). After giving brief instructions on how to use the functionality specific to the remote system, we observed participants playing the game together remotely. The researcher conducting observations switched study rooms halfway through the 30-40 minutes allocated for remote gameplay. In recording our observations, we focused on how participants interacted with the gameboard, how they communicated with remote and local participants (including non-verbal communication), and the content of participant conversations. Video recordings were taken in both locations.

Third, we led participants through a reflection and discussion of the gameplay experience. They were given worksheets with question prompts, which probed what players liked and disliked about their gameplay experience, what ideas they had for improving it, what helped and hindered their sense of connection, and how their sense of connection during remote gameplay compared with their connection in-person. Questions used to initiate group discussion are listed in Table 2 according to the worksheet section

Table 1: Study Participants

Session #	Size of Group	Participants in Room A	Participants in Room B	Strength of Relationship (from *1 – Met today* to *5 – Know each other very well*)	
				Mean	Standard Deviation
1	4	2	2	2.83	1.34
2	3	1	2	3.17	0.41
3	5	2	3	1.95	1.15
4	3	1	2	3.17	1.47
5	3	2	1	4.17	0.98
6	4	2	2	2.33	1.61
7	4	2	2	3.17	1.85
8	3	2	1	2.00	1.55
9	3	2	1	2.00	0.89
10	5	2	3	3.20	1.20
Total	37	18	19	3.17	1.42

Table 2: Group Discussion Question Prompts

Worksheet Section Header	Question Prompt
Tell us about the Remote Wavelength Experience...	What did you like about playing Remote Wavelength?
	What did you dislike about playing Remote Wavelength?
	What ideas do you have for improving the experience of playing Remote Wavelength?
Help us understand your Sense of Connection during Remote Wavelength. . .	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)?
General discussion (no worksheet)	*(Optional, if participants had remote gaming experience)* Compare Remote Wavelength with other remote tabletop game systems you have used. How was your experience different between the two (if at all)?
	Any other questions or comments about the experience?

they appeared in. To record their individual thoughts and reflections, participants spent 5-10 minutes writing responses to each worksheet 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. As discussion progressed, the study facilitator also asked follow-up questions to help participants elaborate on their responses, (e.g. *"Tell me more about ___."; "What do you think contributed to your feeling of ____?"*). After discussing their worksheet responses, the facilitator asked participants to compare *Remote Wavelength* with their other remote gameplay experiences (if applicable) and opened discussion to anything else participants wished to add. 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.

4.3 Data Collection and Analysis

We collected data including video recordings of gameplay, notes on study observations, participant worksheets, and audio recordings of the group discussion. The first author 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). Notes taken during gameplay observation were digitized, and during this process we 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). The first author 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. The first author then analyzed the notes using an affinity diagramming process [32] (Figure 6a). While affinity diagramming is often described as a group activity, in practice diagrams are sometimes completed by an individual researcher

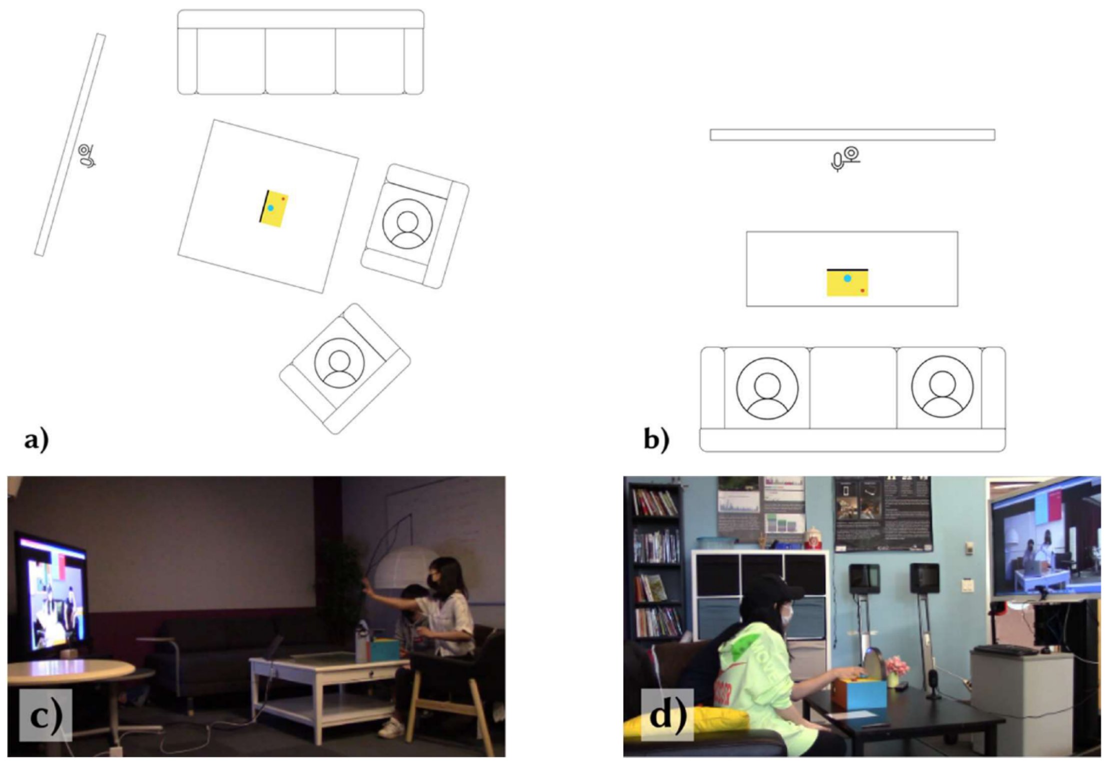

Figure 5: (a) & (b) An approximation of the setup of *Remote Wavelength* across two locations, for a study with four participants. Each room contained a large display with mic and webcam, couches, coffee table, and gameboard, although the setup was not identical across locations. (c) & (d) Actual study footage from each room. Used with Permission.

[26]. 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 [53]. The first author generated themes inductively by clustering related notes (see Figure 6b for a screen shot from early in the affinity diagramming process), and three of the authors worked together to discuss and refine the themes. 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 [35]. As our aim was discovering new design considerations, we looked for themes that were related to the initial design goals, yet extended our current understanding of how to implement the goals. This mixed inductive and deductive approach of forming inductive themes from primary data and then connecting themes to existing research is common in HCI [53].

5 RESULTS

In the first section of our results, we describe what we learned about players' interactions and experiences using a tangible device for gameplay (RQ1), focusing on how tangibility affected their social experiences. This includes how it influenced players' sense of presence, helped them communicate, and supported their engagement with the game, as well as some drawbacks of requiring a physical gameboard. In the second section, we share additional observations on how technology design shaped participants' sense of connection (RQ2). 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, we 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

We 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 our 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,

Figure 6: (a) top: the completed Affinity Diagram, multiple themes were merged to become sections in the results; (b) bottom left: an interim Affinity Diagram, grouping data from the first three study sessions; (c) one of the seventeen initial themes with a few sample notes, including participant comments on pink and blue notes, an observation note in light yellow, and a researcher memo in orange.

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: *“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”* (G10-P5).

Players could see and sometimes hear themselves affecting remote objects through the video conferencing link. The visual feedback was made possible by our design goals, *head-to-hand representation of players* (seeing the remote gameboard) and *synchronization across locations* (mirroring the gameboard changes across locations), and we heard that this was a key feature of the design. Players commented 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."*

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). We saw colocated players use touch to celebrate victories or mourn losses—high-fiving, hugging, or pushing away their fellow players. 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 the task of playing the game together. The physical device increased engagement with the game by making it more fun and reducing distractions, and this greater engagement may have increased opportunities for connection as well.

Players often referenced the physical gameboard as something they enjoyed about the gameplay experience. Some players 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."* When explaining to other participants why they thought 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]."*

Using the tangible gameboard also provided a dedicated device for gameplay, which removed participants from the desk/computer where they work. 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—*"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."* (G1-P2). 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. Overall, there were several ways a physical device made gameplay more engaging, including building excitement, reducing distractions, and separating the experience from remote work.

5.1.3 Flexible Tangible Components Augment Player Communication. Our 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. We 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 guesses they considered plausible, moving the dial while briefly indicating how they felt about each guess (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 *"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"* (G10-P1).

We 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, 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."*

We 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 to Good Movie" they 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 Physical Gameboard include Solo Setup and Potential for Exclusion. 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 wanted to be able to connect with friends who had not invested in specialized equipment. They worried about excluding 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 must setup alone and are unable to 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 exclusivity and inability to connect with others during setup.

5.2 Impact of System Features on Player Experience & Social Connection

Here, we 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 Digital-Physical Integration Improves Player Awareness and Communication. Overall, participants appreciated the *integration of communication and game spaces* (one of our design goals). We found that having game objects in proximity to remote player video supported awareness of remote players. In addition, this integration improved player confidence in the system. Participants also 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 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 Flexible Turn-Taking Complicates Social Interaction. 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 our design goal of *flexibility.* To understand the impact of this choice, we observed how groups playing *Remote Wavelength* took turns as *Psychic* and collaborated on their guesses (and sometimes teamed up to be *Psychic*). We found that groups appreciated flexibility around game roles but disliked the ambiguity of turn order.

When creating the *Remote Wavelength* experience, we 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, G5-P1 had this reflection on turn-taking: *"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 was, 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.

Representing players from head-to-hand was one of our design goals, meant to improve awareness of remote players. The ability to gauge each other's 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. 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 [89]). 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. We 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.

6 DISCUSSION

Our research aims to better understand factors that shape the social experience of friends playing remote tabletop games together. We find 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.

6.1 Design Considerations

Here, we review our findings to refine our initial design goals and generate additional considerations for the design of remote tabletop game systems that support social connectedness among players (RQ3).

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 [99]. We build on and extend this with suggestions on how to design tangible game components and which game elements to prioritize for tangibility. Our study illustrates 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 we interpret into several design opportunities.

First, we 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. [43]) 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 personalize these meeples could leverage an aspect of materiality that tabletop players enjoy (customizing a collection) [74] and perhaps help players identify more strongly with their proxy in the remote space, as has been observed with personalized video game avatars [85]. Building on an idea proposed for colocated gameplay, players could even have the option to view the remote space from their meeple's perspective [80].

Second, participants shared that their sense of presence was augmented by sensing (seeing and hearing) how they affected the remote gameboard and how remote players affected local space. This suggests that visibility to remote players should be a consideration when deciding on the scale and placement of tangible elements. Similarly, it is helpful if the movement of tangible elements produces audio feedback which is loud enough to be heard remotely. We 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.

Third, we 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. We observed players use touch to connect during emotional moments, celebrate a win with remote players or seek attention (as G4-P2 did). We see an opportunity for designers to increase remote presence and emotion-sharing over distance by further exploring actuated game artifacts. For example, designers might adapt remote tangible interfaces [6] to create gameboard features that players can manipulate simultaneously, or apply swarm user interfaces [45] to create game pieces that can move around the table and bump into remote players. Similarly, we can imagine designers integrating game systems with tools that help people celebrate, for example by squeezing hands [79] or patting each other on the shoulder [14] over distance. 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 [62, 81].

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 [4, 99]. Our work builds on this by demonstrating how to apply flexibility to the design of synchronized tangible game objects. We also reflect on the limits of flexibility when applied to turn-taking.

We 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 [90]. We 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. Our 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. We suggest designers might apply principles for appropriation [15] to the design of the system's tangible components and better support players to improvise social uses.

In our current iteration of *Remote Wavelength*, we found that, while players sometimes took advantage of self-determined turn-taking, it also introduced ambiguity. Our approach of seating players around a table on a video conference provided insufficient structure. To balance clarity and flexibility, designers of remote game systems must carefully consider how they implement turn-taking. Given the parallels between managing turn-taking in-game and in conversation [84], we speculate that solutions could be inspired by remote meeting and facilitation tools. Examples include a speaker's queue [36], 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) [14]. We also suggest a digitally tracked yet flexible turn order could be provided by leveraging the benefits of flexible tangible game 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 our study we learned how a physical gameboard could increase engagement with the game. Using a dedicated physical device rather than a computer created excitement, removed distractions, and provided a break from a computer-work context. Future implementations of remote tangible games can continue to leverage these benefits by enabling players to disengage from their typical computer-use setting once the system is setup, as using different devices can help people maintain a boundary between work and leisure [16]. We 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. We see significant design work ahead to create tangible game systems with the portability and adaptability to work across such settings.

We 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 [64], remote tangible game systems may be more readily adopted if they are able to interface with digital-only players. Designers might also consider whether some of the engaging 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 mixed presence groups who want to connect both locally and remotely by enabling play with a smartphone and shared TV [8, 84], rather than at a personal computer. Similarly, apps might nudge players to silence notifications or take screen breaks while playing a game on their phone or computer, proactively reminding players of tactics that might improve their engagement in a remote gaming session [100].

6.1.4 An Integrated Remote Experience to Increase Player Connection and Confidence in the System. We explored integrating communication and game space within a remote gaming system, and found that it has potential to support player connection. In addition, our results highlight further opportunities for integrating game theme within a remote gameplay system, such as 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 [70, 103], we imagine systems augmenting player video with crowns, space helmets, or other props that could support gameplay and tie into the game story. We 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 [22] or for improv actors to configure an immersive video scene [5]. 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 [44]. We suggest that to inspire confidence and streamline player interaction, the system needs to not only work well but also *appear* to work well for remote interaction, and integrating communication, gameplay and game theme can help with this.

6.1.5 The Case for Helping Players Cheat. We 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* [78], *Hanabi* [2]*)* or compete to figure each other out with help from social cues *(e.g., Werewolf* [65], *Coup* [82]*).* Our 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. We suggest designers might adapt existing systems for awareness over distance to a game context, perhaps borrowing from a posture-sensing chair concept [67] to display when players are fidgeting or tense, or adding musical cues to the game that reinforce the emotional tone of player conversations [25]. We also argue for making allowances to present this information to remote players, even when it is officially considered cheating. This builds on existing findings that game customization supports social connection [99] by identifying a new type of rule-breaking functionality that may be needed.

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

6.2 Limitations and Future Work

Our research included a single game, and while many of the insights we describe here are applicable beyond *Wavelength,* the nature of the game we chose to study does shape our results. Our findings on tangibility, integrated communication and gameplay, and flexible system design address widely applicable topics such as the design of game objects, player interaction and the digitization of gameplay—these are issues for the design remote tabletop game systems more generally. However, some of our findings may apply only to a subset of games which share mechanics with *Remote Wavelength*, such as bluffing and deception games where player awareness has a heightened role. Similarly, there are likely additional considerations that are 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 our work goes beyond existing research on distributed gameplay by exploring mixed presence groups of varying sizes, it remains limited to two locations. We see opportunities for future work to investigate systems that accommodate even more varied player distributions.

In addition, our study focused on friends within the 18-35 age group. We feel that this demographic was suitable for our study because they have been identified as having a lot of spare time for gaming [72]. We 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 we chose to test our prototype in a lab, participants played the remote game for 30-45 minutes. Our 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.

7 CONCLUSION

Our work contributes the design and evaluation of a system for social connectedness through distributed tabletop gameplay. Through a process of design exploration, we developed a set of design goals for promoting social connection during remote gameplay, including *head-to-hand player representation for better awareness, tangible gameboard, synchronization across locations, flexible gameplay, and integrated communication and game space.* We built a prototype based on these goals and conducted a user study to understand players' experiences with the prototype. The results offer insight into how players might use such a system and how it shapes their experience of social connection. Reflecting on these results, we offer considerations for designers of remote tangible gameplay systems for social connection. We discuss the design of synchronized tangible game components and how the system design might incorporate flexibility that supports social experiences. We suggest that some of the benefits to player engagement we observed in our system are not exclusive to tangibility and may be applied in digital systems. We highlight the benefits of integration for player connection and confidence in the system. Lastly, we extol the virtues of helping players cheat. We look forward to future work that extends these findings through the study of additional games, player populations, household configurations, and extended use. Ultimately, our research contributes to better, more social gameplay experiences for friends separated by distance.

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