Tabletop Teleporter: Evaluating the Immersiveness of Remote Board Gaming

Jasmin Odenwald
Bauhaus-Universität Weimar
Weimar, Germany
jasmin.odenwald@gmail.com

Sven Bertel
Hochschule Flensburg
Flensburg, Germany
sven.bertel@hs-flensburg.de

Florian Echtler
Bauhaus-Universität Weimar
Weimar, Germany
florian.echtler@uni-weimar.de

ABSTRACT
Communication with remote persons over a video link is common today, e.g. to connect with family members abroad, particularly during the COVID-19 pandemic. However, social activities such as board games are rarely shared in this way, as common video chat software does not support this scenario well. However, interactive tabletops provide inherent support for natural tangible interaction with items on the tabletop surface.

We present the Tabletop Teleporter, a setup designed to merge two remote locations into a single shared interaction space. We evaluate the system using a board game, focusing on the perceived immersion and connectedness of participants. Our evaluation shows that most measures for the social quality of a remotely shared game are not significantly different from one played with co-located participants, and that players prefer our setup over a pure videochat scenario.

Author Keywords
interactive surface; tabletop; tangible; gaming; board game; evaluation; social aspects

CCS Concepts
•**Human-centered computing** → *Collaborative and social computing devices; Empirical studies in collaborative and social computing; Human computer interaction (HCI); User studies;*

Figure 1: Two participants (child and adult) remotely play a board game using two linked interactive surfaces.

INTRODUCTION
In an increasingly mobile world where people regularly move house due to personal, financial, or career-related reasons, technology designed to connect with remote friends and family members is also increasingly important, particularly during the global COVID-19 lockdown. A scenario which is now commonplace in the developed world is the usage of videoconferencing software such as Skype or Zoom to stay in touch with remote persons.

However, this class of software is by design limited to face-to-face conversations. Although it usually provides features to share, e.g., the content of one's computer screen, such functionality underlines the primarily office-related focus of these software packages. Other, more leisure-oriented activities, such as playing a board game, are therefore difficult to conduct over such a medium.

In this paper, we present our implementation of Tabletop Teleporter, a system designed to merge two remote interactive tabletops into a single common workspace. In addition to a face-to-face videochat on a vertical screen, the system captures a second video stream from a horizontal table surface in front of the participant which is projected onto the corresponding surface at the remote location (and vice versa). This shared environment can then be used to interact and collaborate with a remote person through a richer interaction vocabulary, e.g. by pointing and using tangible objects, than that offered by a video link alone.

We present results of a qualitative and quantitative evaluation based on a board game played remotely, with a distinct focus on the immersion and connectedness felt by the participants. Our results confirm our hypothesis that the social quality of the remotely-played game is comparable to one played by co-located participants.

PerDis '20 June 4–5, 2020, Manchester, United Kingdom

ISBN 978-1-4503-7986-1/20/06. . . 15.00
DOI: 10.1145/3393712.3395337

RELATED WORK

The topic of remotely-connected interactive surfaces has already been explored by various researchers. Wilson et al. present PlayTogether [18], a system based on the PlayAnywhere device [17] which uses an infrared camera to differentiate between projected content and physically present objects. More recently, Junuzovic et al. presented IllumiShare [12], a shared-surface setup in the form factor of a desk lamp, while Unver et al. present a tabletop-sharing application based on the commercial HP Sprout device [16]. Both these systems have to deal with video feedback loops, in which the projected image is inadvertently recorded by the camera and sent to the remote side, causing unwanted effects. IllumiShare uses a modified projector with extended blanking period and a synchronized camera for this task, while the Sprout-based system attempts to employ digital echo cancellation techniques.

In contrast to these existing systems which focus on one identical hardware setup at all locations, one unique aspect of our Tabletop Teleporter is that it is able to deal with heterogeneous hardware setups, as it is entirely built on open-source network protocols such as TUIO [14] and SurfaceStreams [6]. For example, our evaluation was conducted on a combination of a SUR40 interactive surface and a custom portable "lamp" with integrated projector and camera, both with an additional vertical screen for face-to-face communication. This heterogeneous setup also has the advantage of avoiding the problem of video loops entirely, as the SUR40 uses infrared imaging cells built directly into the surface which do not re-record the displayed remote image.

Regarding the social components of shared surfaces, Hauber et al. [9] investigated how different spatial display arrangements in a mixed tabletop/VR setup can influence collaboration for a photo sorting task. Zillner et al. [21] evaluate collaboration with a life-sized avatar on a shared virtual whiteboard, and find that awareness of the remote particpants' body pose and gestures improves immersion. Similarly, CamRay [1] uses cameras embedded into a large-scale video wall to create a virtual video representation of each user at the remote site.

Remote support for leisure activities has also been a recent focus of research, particularly with an emphasis on spatially distributed families. One example is ShareTable [19, 20] by Yarosh et al., which consists of a projector-camera system built into a cabinet that automatically initiates a connection once the doors are opened. This system was evaluated with remote parent-child pairs and found to be easy to integrate into daily life. Family Portals [11] by Judge et al. presents a tablet-based approach to this topic which offers a small shared workspace for up to three persons, along with video views of the other participants. This system is especially suited to collaborative drawing and does not offer a way to integrate physical objects into the shared space.

Playing board games is a particularly challenging activity to support with such a system. Rogerson et al. [15] have evaluated how players perceive such games, and conclude that materiality in particular is a highly important aspect that should not be overlooked. Consequently, any system designed to support these activities should take care to remove as few physical components of a game as possible, in order to provide a similar experience to playing a board game in the traditional way. For example, Echtler et al. [8] present an interactive dining table which augments board games played on the table surface with projected information. However, one limitation of this setup is that it requires game-specific applications to be written and only focuses on locally played games.

TABLETOP TELEPORTER

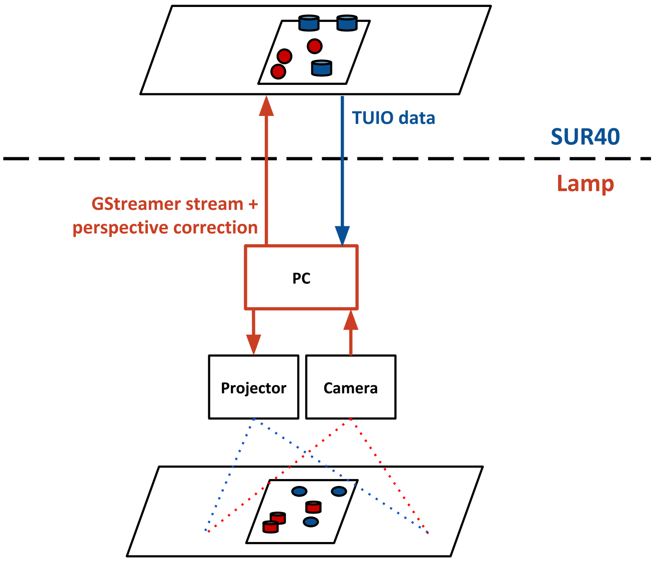

Figure 2: Schematic overview of the system architecture. Blue components are physically present on the SUR40, while red components are physically present beneath the lamp.

Our system consists of two physically separate components: a Samsung SUR40 interactive tabletop running Linux [7] paired with a vertical 40" screen directly behind the horizontal surface (see Figures 1 and 3), and a modified floor lamp containing a downward-facing projector and camera plus an additional 19" vertical screen (see Figure 4). Both systems are equipped with a front-facing webcam which is used together with the vertical screens to run an unmodified video conferencing system (Google Hangouts). We selected an asymmetric setup, as we assume that users in real-world settings will not have access to identical equipment on both sides of the connection. The SUR40 is a high-end dedicated tabletop device with built-in sensors, while the interactive lamp represents a setup that could be reproduced with a laptop, a webcam, and a small projector in everyday environments.

Our asymmetric hardware setup poses several design challenges. For example, the SUR40 provides a greyscale video image of objects on or immediately above its surface; as the infrared sensors are directly integrated into the display, this image is taken from *beneath* the objects. On the other hand, the lamp contains a projector-camera combination which records video and projects images from *above* the tabletop surface. Consequently, the physical game board has to be placed at the lamp location, as its image in the rectified video stream can then be transferred to the SUR40 for display using the

SurfaceStreams framework [6]. Any game actions by the player on the lamp side (rolling dice, moving tokens) are consequently also immediately visible on the SUR40. This approach requires that the interactive area on both sides has the same physical dimensions; we adjusted the lamp's projector so that the projected image on the table has the same size as the SUR40 display (89 x 50 cm), and the rectified video stream exactly covers the same area.

Figure 3: SUR40 side, with game board image from remote side.

To also record information about objects (e.g. game tokens) on the SUR40 and deliver them to the lamp, the raw video data from the SUR40 surface is first processed by the reacTIVision [13] software package and converted into a TUIO-based network stream. Game tokens or touch input is sent as pointer objects which are then rendered as bright circles and displayed on the remote device's tabletop through the projector. One of our goals is to keep the system as content-agnostic as possible to avoid implementation of multiple "support apps" for specific games.

However, we need to handle one special case separately, namely dice. The dots on regular dice are very close to the resolution limit of the SUR40 of approx. 0.93 mm (physical display size 890 x 500 mm, sensor resolution 960 x 540 pixels) and would consequently only resolve to a single blob. Larger dice are available, but pose the danger of damaging the SUR40. Therefore, we designed our own dice out of light styrofoam cubes (see Figure 5). These dice are printed with a custom pattern which closely mimics the patterns on regular dice, but at the same time can also be recognized as distinct Amoeba markers by reacTIVision. After image processing, data about the dice are then also sent as TUIO token objects which are again rendered on the remote side, this time as stylized dice images.

EVALUATION

As described earlier, we focused on a scenario based on playing board games as an interaction modality, as this is a popular

Figure 4: Projector/camera lamp (visible at top), with physical game board and projected token/dice markers.

leisure activity as well as a challenge for remote support due to the games' inherent materiality [15]. As a game for the evaluation, we selected Ludo/Parcheesi, as it is very widely known, has simple rules that do not require long explanation, and can be easily modified to adjust for expected game duration. Our variant was designed for two players and an estimated play time of 15 minutes, to avoid exhausting the participants' attention during the user test.

Hypotheses and Experimental Design

Our hypothesis for this setup was that the perceived social quality of interaction by means of a board game is equivalent to the quality of face-to-face interaction. As a control condition, we also designed a third interaction mode, in which the game is played using only the video link, and in which players verbally inform each other about their game actions (similar to "chess by mail"). We hypothesized that the perceived interaction quality of this mode would be lower, as participants would be subjected to a higher cognitive load and have less opportunity for unstructured, informal communication.

Figure 5: Regular dice (front left), overscaled dice (rear left), styrofoam dice with reacTIVision-compatible markings (right).

We recruited 20 participants in pairs of two. All pairs knew each other beforehand, and had already played board games together. Each pair played four conditions against each other: 1) face-to-face game without technological support; 2) game over video link only; 3) game on Tabletop Teleporter (person 1 at SUR40, person 2 at lamp); and 4) same as condition 3, but with swapped roles. The sequence of tests was randomized by means of a balanced latin square design to compensate for possible order effects, although some familiarization with the setup may still occur between conditions 3 and 4 regardless of the order. All games were recorded on video for later analysis. We collected basic demographic data at the beginning of each test. All participants consented to the anonymized use of their data; they did neither receive monetary compensation nor study credits for their participation.[1]

After each game, participants filled in the Game Experience Questionnaire (GEQ, [10]) with the addition of the Social Presence Questionnaire (SPQ, [5]) in order to evaluate the social quality of the interaction. This latter questionnaire is particularly suited for our scenario, as it has not only been tested with digital games, but also with board games [2]. A structured interview concluded each iteration, with questions as listed below.

- Would you consider playing this game variant at home? Why?
- Did you experience any problems during play? If yes, which ones?
- How did you experience capturing the other player's pieces?
- How did you experience the dice?
- Complete this sentence: I found playing this game variant ...
- Did you notice anything else you would like to mention?
- Which variant is your favorite?
- How often would you use this game variant at home, compared with the others?

[1]Free snacks were provided after the study.

Evaluation Results

Our evaluation focused on three individual groups of results: data from the video recordings, comments from the interviews, and answers to the GEQ/SPQ questionnaires.

Video Recordings

The video data was manually coded by the lead author using Morae[2] with respect to the following events:

- Duration for which a player watched their partner (eye contact),
- Duration for which a player talked to their partner (communication),
- Number of game moves made,
- Number of captured pieces,
- Obvious frustration,
- Obvious excitement,
- Quotations and other noteworthy events.

Of course, frustration and excitement are difficult to measure objectively. However, as all qualitative coding was performed by the same person, we assume the results to be at least consistent across conditions.

Our results show (see Figure 6) that our purely videochat-based control condition led to more communication than all other variants. This is entirely expected, as players had to verbally inform each other about their game actions. The differences were significant for videochat vs. any other condition ($p < 0.001$ in all cases using Wilcoxon signed-rank test). Notably, none of the other three conditions differed significantly ($p = 0.393$, $p = 0.579$ and $p = 0.975$, respectively).

Regarding eye contact, the videochat condition also resulted in the most occurrences, followed by the "lamp" condition. The differences are again significant, both between videochat and lamp vs. each of the two other conditions ($p < 0.05$ for each combination using Wilcoxon signed-rank test). An explanation offered by the video recordings is that players could not directly observe the other player rolling their dice due to the different recording capabilities of the remote side when sitting at the "lamp" and consequently watched the other person directly instead. Interestingly, all other video-derived data (game moves, frustration/excitement etc.) do *not* show significant differences, thereby supporting our hypothesis that the computer-mediated game variants can indeed be an adequate substitute for the regular board game in terms of experience.

[2]https://www.techsmith.de/morae.html

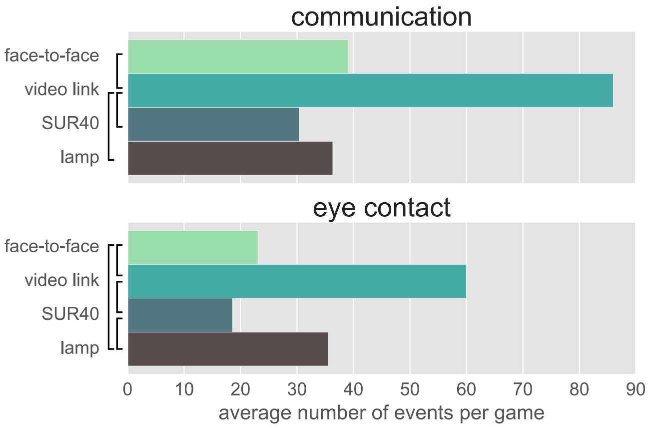

Figure 6: Number of communication and eye contact events. Brackets indicate significant differences.

Interview Comments

With respect to the videochat-based variant, we observed that players exhibit a lower amount of trust towards the other player, particularly regarding the results of their dice rolls. This is evidenced by comments such as "I'll now come over and have a look at it", "I'll get a witness", "If you had rolled 1, I'd have known that you are cheating" (comments translated from German). This behaviour has already been studied by other researchers [3, 4] and is therefore also an expected side effect. In general, the videochat condition was often described as "exhausting", "complicated" or "annoying".

Regarding the lamp and tabletop conditions, players were inclined to experiment with the setup, e.g. by holding their hands under the projected pieces or arranging the pieces into shapes. We noticed slight confusion of some players due to the asymmetric nature of the setup: while the player on the tabletop is able to see the hands of the player on the lamp setup, the opposite is not true. Consequently, some participants sitting at the tabletop pointed at items on the table during discussion and expected the other player to follow, although such action was only visible in the other direction.

Several players on the tabletop side commented on the special dice, e.g. by mentioning "With this kind of die, it would be fairly easy to cheat" or "Why do you have a small die and I have this huge thing that barely moves?". Players again also commented on the asymmetric setup by noticing that pieces of the opposing player on the lamp side can be hidden beneath their own pieces ("I only see my own one, the other one is hidden" and "I don't see yours anymore"). This might pose a problem if the player on the lamp captures a piece of the player on the tabletop: if the second player is inattentive, this action might go unnoticed at first.

In general, both the tabletop and lamp conditions were described favorably: "I would have imagined it to feel weird. But after a while, I totally forgot that the other person isn't sitting directly opposite me." or "I would have felt the same way if he was sitting in a completely different building/town/continent."

Some players commented that capturing pieces felt different, as it was not possible to physically remove the opponent's pieces, and missed that additional haptic component. The tabletop condition was viewed slightly more positive than the lamp variant, as the player at the SUR40 could also see the opposing player's arms and hands, thereby improving the feeling of presence. On the other hand, players on the lamp could only see the pieces moving, but not the hands of the player performing this action.

Questionnaires

The combined GEQ/SPQ questionnaire provides results in several different categories (GEQ: competence, immersion, flow, tension, challenge, positive/negative affects; SPQ: empathy, negative feelings, involvement). In our data, we found significant differences in the categories immersion, challenge and positive affects. Immersion was significantly higher for tabletop than for video chat (pairwise Mann-Whitney tests after Kruskal-Wallis omnibus tests; $W = 8506.5$, $p = 0.01$, $r = -0.57$) and as well as, surprisingly, for the traditional game ($W = 8506.5$, $p = 0.01$, $r = -0.62$). Immersion was also higher for the lamp than for video chat ($W = 8142$, $p = 0.04$, $r = -0.46$) and for the traditional game ($W = 8248.5$, $p = 0.02$, $r = -0.51$). Challenge was significantly higher for the video chat than for the three other conditions (tabletop: $W = 4041$, $p = 0.02$, $r = -0.53$; lamp: $W = 4003$, $p = 0.01$, $r = -0.57$; traditional game: $W = 6015$, $p = 0.01$, $r = -0.59$). Similarly, positive affects only differed between video chat and the other three conditions (always rated lower for video chat; tabletop: $W = 5916.5$, $p = 0.01$, $r = 0.59$; lamp: $W = 5573$, $p = 0.07$, $r = -0.40$; traditional game: $W = 3744$, $p = 0.001$, $r = -0.73$). No significant differences were found for the categories competence, flow, tension, negative affects, empathy, negative feelings, and involvement.

The question about wanting to play game variants again showed no significant differences among traditional game, lamp and tabletop; only for video chat, this was significantly lower than for all three other conditions (tabletop: $W = 281.5$, $p = 0.02$, $r = -0.50$; lamp: $W = 280.5$, $p = 0.026$, $r = -0.50$; $W = 101.5$, $p < 0.001$, $r = -0.61$).

In all cases, the videochat-based variant showed significantly less favorable results than the others. It was perceived as less immersive, as more challenging, and triggered less positive emotions than the other variants (see Figure 7). These results are likely due to the fact that this variant required constant "bookkeeping" from the players to keep their game boards in sync, and therefore needed additional effort that was not focused on the actual game experience in any way.

In contrast, our evaluation showed nearly no differences between the face-to-face game and the lamp/tabletop-mediated variants, with the exception of the immersion category. Interestingly, the perceived immersion was actually slightly higher for the lamp/tabletop conditions. We assume that this is due to the fact that the large horizontal screens capture the players' attention better than a regular game board. Also, perceived novelty might have played a role here, as participants later described the tabletop/lamp conditions as "futuristic" and "attractive".

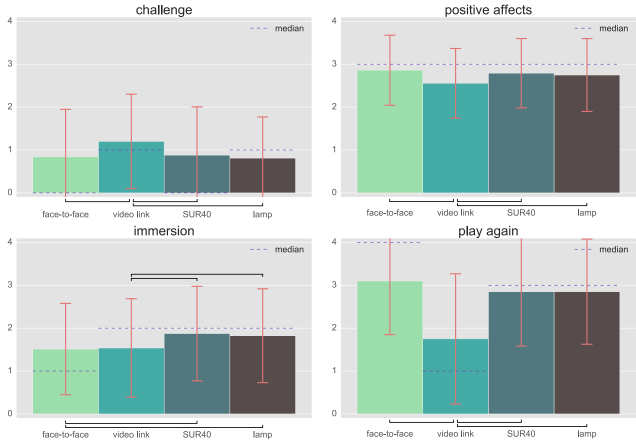

Figure 7: Categories with significant differences among conditions; whiskers show the standard deviation. Brackets indicate significant differences.

Evaluation with 5-year-old child

As our primary application scenario includes connecting spatially distributed families (similar to [20]), we performed an additional informal evaluation with a 5-year-old girl, the daughter of one of the authors. The girl played the same game as the other participants with a familiar person, but was provided with a shortened, informal interview afterwards instead of the full questionnaire. Results from the interviews anecdotally show that, after a brief familiarization phase, the girl accepted the mediated remote game as an equivalent alternative to the regular board game.

CONCLUSION & FUTURE WORK

In this paper, we have presented the Tabletop Teleporter, a system to merge two heterogeneous interactive tabletops into a single workspace. Our setup is designed to facilitate remote interaction between two participants, with a particular focus on leisure activities such as board games. We evaluated our system with 20 participants in pairs of two who played a simple board game and answered questions about the social components of the experience afterwards. Our findings confirm our hypothesis that with respect to social experience, this setup can serve as an equivalent substitute for face-to-face board gaming.

One limitation of our work currently is that the content-agnostic approach only works for games in which no exchange of physical components is required. For some games, e.g. where cards are drawn from a common pile, a possible workaround would be to provide two separate piles at each location, although this might subtly alter the balance of the game. However, once a direct exchange of cards or tokens is required by the rules, only a digital representation of the items would of course be possible to exchange, which in turn would require an implementation that is aware of at least some of the game rules. For games which only require more than one class of token to be available, an extended version of the Amoeba-based dice with different markers below each class of token would be feasible (but also require at least a rudimentary game-specific implementation component).

In the future, we plan to extend our setup to support more than two locations, and to perform longer-term evaluations "in the wild" by installing permanent devices in semi-public locations.

ACKNOWLEDGMENTS

We thank all the volunteers who participated in our study, and all colleagues who provided helpful comments on previous versions of this document.

REFERENCES

[1] Ignacio Avellino, Cédric Fleury, Wendy E. Mackay, and Michel Beaudouin-Lafon. 2017. CamRay: Camera Arrays Support Remote Collaboration on Wall-Sized Displays. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. Association for Computing Machinery, New York, NY, USA, 6718–6729. DOI: http://dx.doi.org/10.1145/3025453.3025604

[2] Jonathan Barbara. 2014. Measuring User Experience in Board Games. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS)* 6, 1 (2014), 64–79.

[3] Ernst Bekkering and JP Shim. 2006. Trust in videoconferencing. *Commun. ACM* 49, 7 (2006), 103–107.

[4] Nathan Bos, Judy Olson, Darren Gergle, Gary Olson, and Zach Wright. 2002. Effects of Four Computer-mediated Communications Channels on Trust Development. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '02)*. ACM, New York, NY, USA, 135–140. DOI: http://dx.doi.org/10.1145/503376.503401

[5] Y.A.W. de Kort, W.A. IJsselsteijn, and K. Poels. 2007. Digital games as social presence technology: development of the social presence in gaming questionnaire (SPGQ). In *Proceedings of the 10th Annual International Workshop on Presence*. Starlab, Barcelona, 195 – 203. http://repository.tue.nl/663080

[6] Florian Echtler. 2018. SurfaceStreams: A Content-Agnostic Streaming Toolkit for Interactive Surfaces. In *The 31st Annual ACM Symposium on User Interface Software and Technology Adjunct Proceedings (UIST '18 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 10–12. DOI: http://dx.doi.org/10.1145/3266037.3266085

[7] Florian Echtler and Martin Kaltenbrunner. 2016. SUR40 Linux: Reanimating an Obsolete Tangible Interaction Platform. In *Proceedings of the 2016 ACM International Conference on Interactive Surfaces and Spaces (ISS '16)*. Association for Computing Machinery, New York, NY, USA, 343–348. DOI: http://dx.doi.org/10.1145/2992154.2996778

[8] Florian Echtler and Raphael Wimmer. 2014. The Interactive Dining Table, or Pass the Weather Widget, Please. In *Proceedings of the Ninth ACM International Conference on Interactive Tabletops and Surfaces (ITS '14)*. ACM, 419–422. DOI: http://dx.doi.org/10.1145/2669485.2669525

[9] Jörg Hauber, Holger Regenbrecht, Mark Billinghurst, and Andy Cockburn. 2006. Spatiality in Videoconferencing: Trade-Offs between Efficiency and Social Presence. In *Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work (CSCW '06)*. Association for Computing Machinery, New York, NY, USA, 413–422. DOI: http://dx.doi.org/10.1145/1180875.1180937

[10] W.A. IJsselsteijn, Y.A.W. de Kort, K. Poels, A. Jurgelionis, and F. Bellotti. 2007. Characterising and measuring user experiences in digital games. In *Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE 2007)*. Salzburg. http://repository.tue.nl/661449

[11] Tejinder K. Judge, Carman Neustaedter, Steve Harrison, and Andrew Blose. 2011. Family Portals: Connecting Families Through a Multifamily Media Space. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 1205–1214. DOI: http://dx.doi.org/10.1145/1978942.1979122

[12] Sasa Junuzovic, Kori Inkpen, Tom Blank, and Anoop Gupta. 2012. IllumiShare: Sharing Any Surface. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*. ACM, New York, NY, USA, 1919–1928. DOI: http://dx.doi.org/10.1145/2207676.2208333

[13] Martin Kaltenbrunner and Ross Bencina. 2007. reacTIVision: A Computer-vision Framework for Table-based Tangible Interaction. In *Proceedings of the 1st International Conference on Tangible and Embedded Interaction (TEI '07)*. ACM, 69–74. DOI: http://dx.doi.org/10.1145/1226969.1226983

[14] M. Kaltenbrunner, T. Bovermann, R. Bencina, and E. Costanza. 2005. TUIO: A Protocol for Table-Top Tangible User Interfaces. In *Proceedings of Gesture Workshop 2005 (GW '05)*.

[15] Melissa J. Rogerson, Martin Gibbs, and Wally Smith. 2016. "I Love All the Bits": The Materiality of Boardgames. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 3956–3969. DOI: http://dx.doi.org/10.1145/2858036.2858433

[16] Baris Unver, Sarah A. McRoberts, Sabirat Rubya, Haiwei Ma, Zuoyi Zhang, and Svetlana Yarosh. 2016. ShareTable Application for HP Sprout. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. ACM, 3784–3787. DOI: http://dx.doi.org/10.1145/2851581.2890252

[17] Andrew D. Wilson. 2005. PlayAnywhere: a compact interactive tabletop projection-vision system. In *Proceedings of the 18th annual ACM symposium on User interface software and technology (UIST '05)*. ACM, 83–92. DOI: http://dx.doi.org/10.1145/1095034.1095047

[18] Andrew D. Wilson and Daniel C. Robbins. 2007. PlayTogether: Playing Games across Multiple Interactive Tabletops. In *Proceedings of the IUI Workshop on Tangible Play: Research and Design for Tangible and Tabletop Games (IUI '07)*.

[19] Svetlana Yarosh, Stephen Cuzzort, Hendrik Müller, and Gregory D. Abowd. 2009. Developing a Media Space for Remote Synchronous Parent-child Interaction. In *Proceedings of the 8th International Conference on Interaction Design and Children (IDC '09)*. ACM, New York, NY, USA, 97–105. DOI: http://dx.doi.org/10.1145/1551788.1551806

[20] Svetlana Yarosh, Anthony Tang, Sanika Mokashi, and Gregory D. Abowd. 2013. "Almost Touching": Parent-child Remote Communication Using the Sharetable System. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work (CSCW '13)*. ACM, New York, NY, USA, 181–192. DOI:http://dx.doi.org/10.1145/2441776.2441798

[21] Jakob Zillner, Christoph Rhemann, Shahram Izadi, and Michael Haller. 2014. 3D-board: A Whole-body Remote Collaborative Whiteboard. In *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology (UIST '14)*. ACM, New York, NY, USA, 471–479. DOI: http://dx.doi.org/10.1145/2642918.2647393