Using teamwork to enhance the social presence on a distributed playground

Steven Gerritsen
Human Media Interaction
Master
University of Twente
Enschede, Netherlands
steven.gerritsen@gmail.com

Robby Van Delden
Human Media Interaction
Group
University of Twente
Enschede, Netherlands
robbyvd@gmail.com

Dennis Reidsma
Human Media Interaction
Group
University of Twente
Enschede, Netherlands
d.reidsma@utwente.nl

ABSTRACT

Pervasive play in distributed settings enhance the social bonds between the physically separated players. There have been many attempts to enhance this social bond even further by various means like including embodiedness or social touch. We tried to accomplish this enhancement of the social bond by adding teamwork to our distributed playground. With help of our Interactive Pong Playground, we tried to show that enforcing teamwork between remote players enhances social presence. During the experiment we compared the effects of non-enforced teamwork with enforced teamwork en tested what effects different player distributions had. Results indicate that we don't have a good grip on the hypotheses, yet. Enforcing teamwork didn't seem to work for us and the different distribution types did not give significant results in social presence. However, participants loved to play the game, and their comments indicate that we seem to affect something, if not social presence.

Keywords

Interactive Playground, Distributed Play, Teamwork, Social Bonding, Social Presence, Pervasive Play

1. INTRODUCTION

Pervasive computing is a relatively new and exiting research area. It contains many opportunities for creating innovative games and physical activities. Last decade many different systems have been created to enhance traditional play, stimulate physical activity and encourage social bounding. However, most of them require players to be present in the same physical location or do not support team play.

Nowadays people tend to have little time left for physical activity and social interaction. While time is limited, social interaction and physical activity are important for the human well-being. It is part of human nature to connect socially with one and another. Sports make people come together to enjoy the social contact while simultaneously improves their physical health [17].

While physical activity enhances the social bonding between people, Mueller et all. showed that this not only works with direct contact, but also in a distributed setting [6, 7, 9]. In various experiments they let people bond while performing physical activity together, while at the same time separated by location. Distributed play lets people play together while physically separated, allowing a social connection without having to come together. This social bond enhances engagement in the physical activity while this same activity enhances the social connection. This opportunity to let people play together while physically separated let to many innovative systems.

This study focusses on teamwork in a distributed play environment. In the field of pervasive play there is much research already done. A collection of this research has been captured in a technical report by Gerritsen et al. [3]. Research about distributed play specifically has also a lot of coverage, as can be found below.

1.1 Related Work

Breakout for two [6, 7, 16] is a football game where two players use a football trying to hit different planes on a 'screen'. The planes, that break on the third hit, can be hit by both players. The player who can break most of the planes wins. During this activity players could see and/or speak to each other. The image of the other was also projected on the screen behind the planes.

Air hockey over a distance [11] let people play the well known game airhockey against a remote players. Users where able to communicate by an video conference that was projected on a screen at the middle of the airhockey table.

Remote impact [10] is a system that let users use extreme forceful behaviour like punching and kicking in an fighting game. Players had to fight each other by hitting the representation of the opponent that was projected on a cushioned surface.

Table tennis for three [13, 12, 14] is a game where three remote players play against another. Like with breakout for two, players have break the planes (by hitting them tree times) that are displayed and the player that breaks the most

planes wins. The difference here is that it is an table tennis game and you now have two opponents to take in account.

Jogging over a distance [9, 15] allows people with different jogging skills or who jog on different locations to enjoy the social connection of jogging together. With the help of an headset users are able to communicate. An integrated sound-scape gives the jogger feedback on the physical exertion of his partner; presenting sound from the back with a lower exertion level or from the front with a higher exertion level.

Two Tug of War games [2, 4] promoted a remote touch concept to increase social bonding. These distributed tangible games allowed players to play the traditional Tug of War game against remote players. The rope that acts as the interface also gives haptic feedback about the actions of the other player, enhancing the feelings of social presence.

A distributed kite-flying and jump-rope game [18] allowed users to share a physical and social experience with an geographical separated player. The rope functions as a tangible connection to the virtual space, letting players having fun in an virtual but social environment.

Enhancing social connections is a challenge in distributed play. Due to the physical separation there needs to be some intervention to enhance this social bond. Related work focusses on various ways to do this:

- Video and Sound;
- Embodiedness;
- Social touch.

This study focusses on using teamwork in distributed play to enhance the social bond. Most people agree that in traditional games, team sports have been known for enhancing social bonds between team players. Implementing this in distributed games can give us the opportunity to create team-based games that improve social bonding between its players.

1.2 Game and Goal

In a game you can design the play style for it to *allow* teamwork, but we think that if you design it to *enforce* teamwork, the social bond is vastly enhanced. We expect that by doing this, players are forced to focus more on their teammate and therefore enhance the social bond between them.

In a game that supports teamwork, different distributions of the players are possible:

1. All co-located. All participants are physically on the same location.

2. Co-located teams. Distribute the players so that one team is placed in one location and the opposing team on the other location.

3. Remote teams. Here you place one player of each team in one location, and the other player in the other location. So that team members are physically separated.

The first distribution type does not contain any remote players, but is used as a baseline in this study.
For the second distribution type, we think that the social connection between remote players gets worse. We think this happens because they don't effect each others game-play.
We think that using the third distribution type enhances the social connection between distributed players, because team members have a bigger effect on each others game-play.

To test these ideas of enforced teamwork and distribution types, we hypothesise:

Hypothesis H1 When distributing the game, the average social presence between players will go down.

Hypothesis H2a When distributing the game, the social presence between the distributed players will go down more than the social presence between the co-located players.

Hypothesis H2b In distributed play with enforce teamwork, remote players have a lesser social connection than co-located players.

Hypothesis H3a The average social bond between remote groups is better when using distributed teams.

Hypothesis H3b The average social bond between all players is better when using distributed teams.

Hypothesis H4 Enforcing team play between team members improves their social presence.

Hypothesis H5 The social bond with a remote opponent is better with physically enforced teamwork with a remote team member.

To test this game we created our Distributed Pong Playground (as shown in Figure 1). This game is an interactive embodied version of the traditional Pong game. The game consists of an interactive floor where players control the Pong paddles with their bodies. Four Kinect sensors track the movement of the players on the playground, moving the on the floor projected paddles along with the players' movement. Each player was represented as a uniquely coloured circle that was projected around his feet. In the distributed version of the game, the circles were projected on both sides, so you could follow the remote players while not physically seeing them.

The game, normally played by two players each controlling a paddle, was adjusted to include team play. This variation of the game is played by four players; two on each side. In order to test social binding by enforcing team work we created two different game-types each with four players on the field.

In the first game-type, each player controls his own paddle to bounce the ball toward the opponents (see Figure 2(a)).

Figure 1: Collaborative Pong, an interactive embodied Pong game.
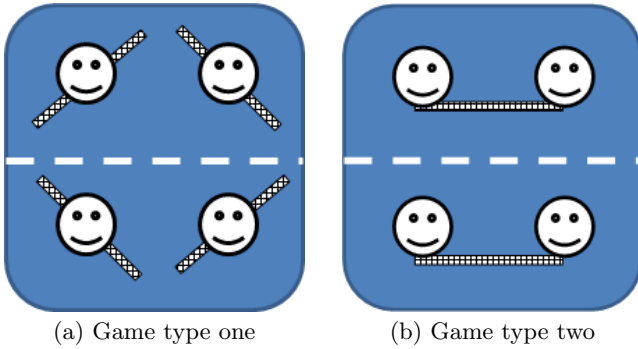

(a) Game type one   (b) Game type two

Figure 2: Two Pong game types.

The paddle rotates around so that it always points towards the ball, what makes it possible to bounce the ball around in an angle. While this game type allows for teamwork to exist, it is possible to play the game without any teamwork occurring. This game-type focusses on parallel [8] play, where each player performs his actions independently from his team member and have no direct influence on another.

The second game-type (see Figure 2(b)) enforces the two team members to play as a team by providing one paddle that is controlled by both players. Each player controls one edge of the paddle, allowing them to move and tilt the paddle to control the ball. The paddle does have an maximal length (twice the size of the personal paddles of game-type one). So if the players move to far apart the paddle 'breaks' and the goal is completely open for the opposite team. This non-parallel game type [8] results in players interacting with another's activity, where bad team play results in preventing both of you from reaching your goal.

Both game-types can be played as a distributed game where the players are distributed between two playgrounds. Audio between the two playgrounds was provided to create an opportunity of communication between the distributed players. Using both the coloured circles and audio, players could anticipate on each other, as needed for teamwork to succeed.

2. EXPERIMENT

The experiment consisted of groups of four players where each group had to play one of the two game types we had created (as described in section 1.2) and one distribution type. This resulted in the six game configurations (see Figure 3, which were randomly assigned to the participant groups.

The first two configurations (Figure 3(a) and 3(d)) consisted of both the non-enforced and enforced teamwork game type and were played with all co-located players. All four players where on the same playground, could directly see and interact with another.

The second configurations group (Figure 3(b) and 3(e)) also consisted of both the non-enforced and enforced teamwork game type, but was played with two players on one location and two players on another location. The teams were created between the co-located players. The team members could see and directly interact with each other, but could not physically see their opponents.

The last two configurations (Figure 3(c) and 3(f)) also containing both game types and again played with two players on one location and two on the other location. Only this time the teams were created between the remote players, resulting in a situation where team members had to work together while not being able to physically see each other.

In figure 3 you can see that in configuration 3(c) and 3(f) the team members are on separate locations, but each player has an opponent on the same location. While the images show that these players are located across from each other, during the experiment they were located diagonal from each other. We did this to prevent players on one location coming to close to each other, because this had as effect that sometimes the tracking system switched the players and therefore switched in witch team the player was. This has no further effect on the study and we will use this method of visualization for all further images.

Because of time constraints we were not able to get enough participants to do each configuration four times, as was our goal. We decided that using less than four groups per configuration gave not enough data to do a solid analysis, so we decided to drop one configuration. In our reasoning configurations 3(c) and 3(f) had the distribution type that resulted in the highest social bound, and configurations 3(d), 3(e) and 3(f) had the best game. Therefore we decided to drop configuration 3(b), which consisted of non-enforced teamwork and with co-located teams.

2.1 Participants

Each experiment session was played by four participants who all knew each other for some time, which was one of the criteria for groups to participate in our experiment. This resulted, with four people per group, four groups per configuration and five configurations, in N=80 for the whole experiment. Per configuration we had N=16. All participants were between 19 and 34 years of age. Of all 80 participants 62 were male and 19 were female and all students at the University of Twente.

(a) All Co-located / Non-Enforced teamwork

(b) Co-located teams / Non-Enforced teamwork

(c) Remote teams / Non-Enforced teamwork

(d) All Co-located / Enforced teamwork

(e) Co-located teams / Enforced teamwork

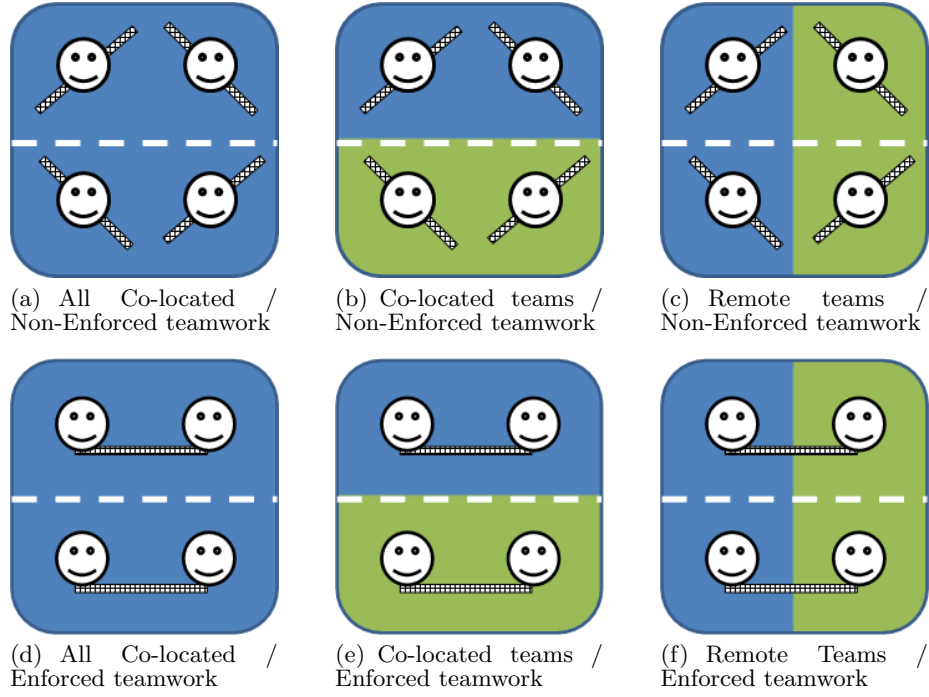(f) Remote Teams / Enforced teamwork

Figure 3: The six different game configurations defined for this experiment. The blue background represent one location, while the green background represents the other location. The dotted line separates the teams.

2.2 Protocol

At the start of each session participants where told that they were going to play a game of Interactive Pong along with all other aspects covered in the consent form. After they signed this form participants were asked to fill in a pre-experiment questionnaire. This was used to verify the familiarity with each other and set a baseline of their social connection. We let the participants choose the teams, so there was no influence from us in this creation. Based on which distribution type the group had to play in (which we randomly assigned before hand), we took the participants the the associated locations. We then explained how the game and teamwork worked in our Interactive Pong game. They did not know of the other game type and distribution types we had.

As soon as all was ready we let them play the game for 1 minute to get used to the game, and to remove any difference in pre-knowledge people may have in playing interactive games and/or pong games. During this minute we could visually show the aspects and rules of the game. With everyone being familiar with the game, we started a 7 minute session where we let them play uninterrupted. After 7 minutes the game 'froze'. This way the game and player end positions were still visible while the players filled in the post-questionnaire. During the questionnaires the participants could therefore look at the game to better remember what it was to play it. At the end of the session we asked the participants in an informal interview what they thought of the game, and after explaining the game- and distribution-types, what they thought of this version of the game that they played. We did this both for information how we could improve our game and to get some qualitative information

for this study.

2.3 Measurements

The pre-questionnaire contained some questions to verify that they all knew each other before the game. This was important for the selection of the participants. The pre-questionnaire also contained the Inclusion of Other in the Self Scale from Aron et all. [1]. This was included to establish a baseline for the Other in the Self Scale.

The post-questionnaire consisted of the Social Presence Questionnaire from Harms and Biocca [5], which tests Social Presence on six different constructs: Co-Presence, Attention Allocation, Perceived Message Understanding, Perceived Affective Understanding, Perceived Emotional Independence and Perceived Behavioural Independence. The post-questionnaire ended with an adjusted version of the Inclusion of Other in the Self Scale from Aron et all. [1]. Instead of asking for the relation with each player, we asked for the relation with each player *during the game*.

2.4 Operationalization of hypotheses

To test the different hypotheses, using the different configurations, we came up with different statistical analyses. For each test we took the data of all participants that participated in one configuration and compared them with the data of another configuration. This means that for each analysis, four groups (of four people) were compared with four other groups (of four people), resulting in 16 data samples being compared with 16 other data samples.

Below we will explain what analyses we did to test each hypothesis, supported by a graphical visualization.
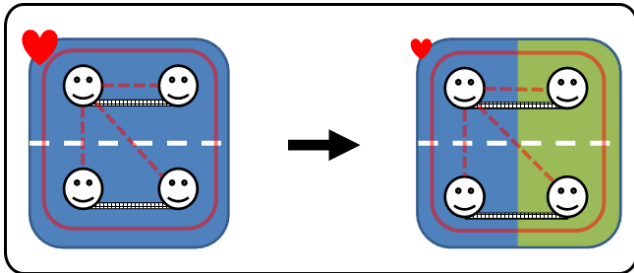
HYPOTHESIS H1 (figure 4)
When distributing the game, the average social presence between players will go down.
We compared the average social bond someone has on a 'all co-located' playground with the average on a distributed playground of the same game-type. We expected this average social bond to be bigger on a 'all co-located' playground than on a distributed playground, no matter the game-type or distribution.

Numbers: The average consisted of the mean of the relation a person has with the other three players on the field. Therefore we compared 16 numbers (4 groups, with 4 players, and each one mean) of one configuration with 16 numbers of another configuration.
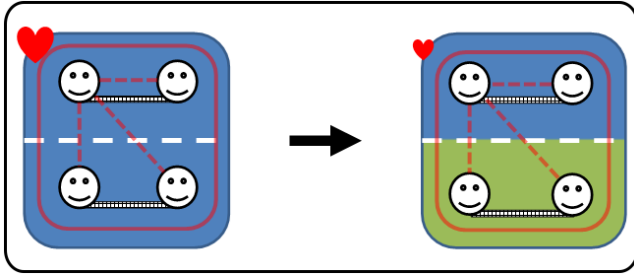
(a) H1.1: Enforced teamwork/All Co-located vs. Enforced teamwork/Co-located teams

(b) H1.2: Enforced teamwork/All Co-located vs. Enforced teamwork/Remote teams
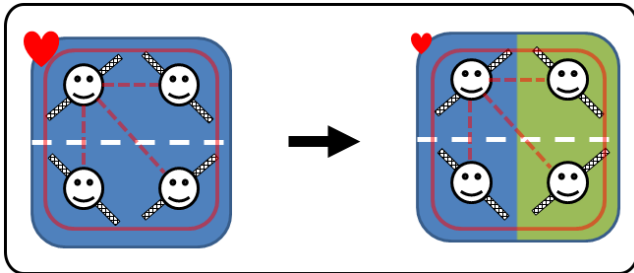
(c) H1.3: Non-enforced teamwork/All Co-located vs. Non-enforced teamwork/Remote teams

Figure 4: Hypothesis H1, the average social presence between players will go down, When distributing the game
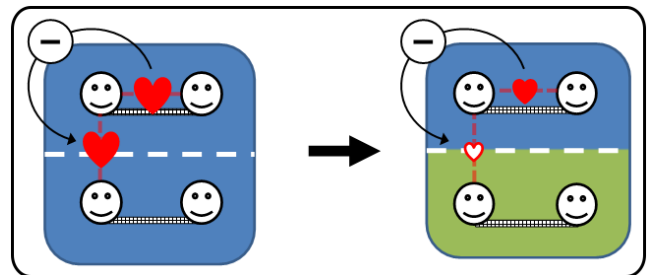
HYPOTHESIS H2a (figure 5)
When distributing the game, the social presence between the distributed players will go down more than the social presence between the co-located players.

In this test we compare the difference of the social bond between a co-located player and a remote player. We do this for every distribution type and compare this with the all co-located version of the same game-type. We suspect that this difference between these social bonds are lower on the all co-located playground is lower than on the distributed playground, because of the lower social bound with the remote player.

Numbers: The used value us the difference between the social bond with the co-located player in the distributed playground (and the player on the same position on the all co-located playground), minus the social bond with the remote player in the distributed playground (and the player on the same position on the all co-located playground). Because we only have one co-located player, we only took in account the adjacent remote player. Therefore we compared 16 numbers (4 groups, with 4 players, and each one difference) of one configuration with 16 numbers of another configuration.

(a) H2a.1: Enforced teamwork/All Co-located vs. Enforced teamwork/Co-located teams
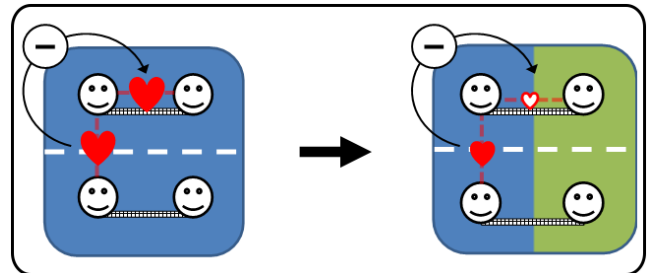
(b) H2a.2: Enforced teamwork/All Co-located vs. Enforced teamwork/Remote teams
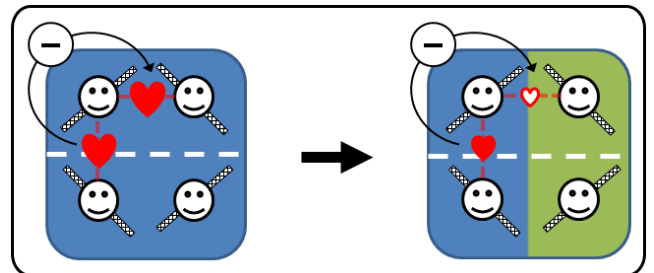
(c) H2a.3: Non-enforced teamwork/All Co-located vs. Non-enforced teamwork/Remote teams
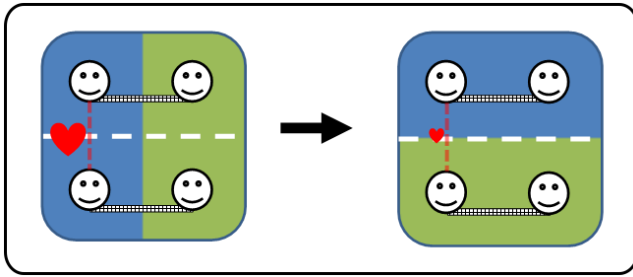
Figure 5: Hypothesis H2a, When distributing the game, the social presence between the distributed players will go down more than the social presence between the co-located players.
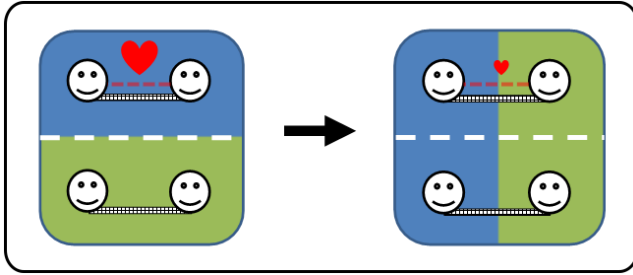
HYPOTHESIS H2b (figure 6)
In distributed play with enforce teamwork, remote players have a lesser social connection than co-located players.
No matter the distribution type, this analysis tests if remote players have a lesser social connection than co-located players. Here we also looked at only one (adjacent) remote player because of the existence of only one co-located player. We did this only for Enforced teamwork, because we missed the distribution type of 'Non-Enforce teamwork/Co-located teams'.
Numbers: We compared 16 numbers (4 groups, with 4 players, for each the *one* indicated social connection) of one configuration with 16 numbers of another configuration.

Figure 7: Hypothesis H3a: The average social bond between remote groups is better when using distributed teams.

(a) H2b.1: Opponents of Enforced teamwork/Remote teams vs. Opponents of Enforced teamwork/Co-located teams

(b) H2b.2: Teammembers of Enforced teamwork/Co-located teams vs. Teammembers of Enforced teamwork/Remote teams

Figure 6: Hypothesis H2b, In distributed play with enforce teamwork, remote players have a lesser social connection than co-located players.

HYPOTHESIS H3b (figure 8)
The average social bond between all players is better when using distributed teams.
This analysis tests if the average social bond between all players is better when using distributed teams, than with co-located teams. Also here we only tested this on the Enforced teamwork configurations, because we missed the 'Non-Enforce teamwork/Co-located teams' version
Numbers: The average consisted of the mean between all three social connections a player has with the three other players. We therefore compared 16 numbers (4 groups, with 4 players, and each one mean) of one configuration with 16 numbers of another configuration.
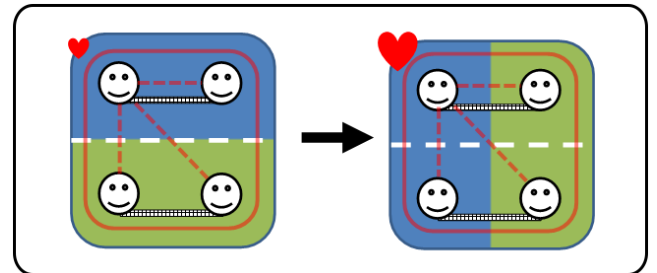
Figure 8: Hypothesis H3b, The average social bond between all players is better when using distributed teams.

HYPOTHESIS H3a (figure 7)
The average social bond between remote groups is better when using distributed teams.
This analysis tests if the average social bond between remote players is better when using distributed teams, than with co-located teams. Also here we only tested this on the Enforced teamwork configurations, because we missed the 'Non-Enforce teamwork/Co-located teams' version
Numbers: The average consisted of the mean between the two social connections a player has with his two opponents. We therefore compared 16 numbers (4 groups, with 4 players, and each one mean) of one configuration with 16 numbers of another configuration.
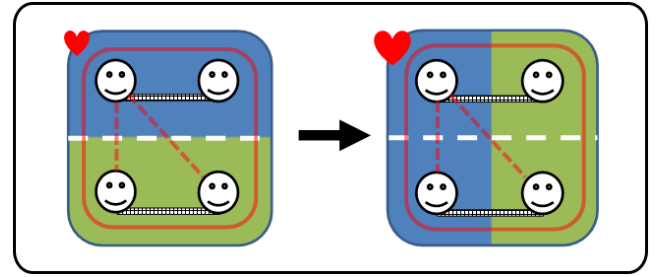
HYPOTHESIS H4 (figure 9)
Enforcing team play between team members improves their social presence.
This analysis tests if the social bond between team members is better when using enforced teamwork, than with non-enforce teamwork. Here we did not test this on the co-located teams configurations, because we missed the 'Non-Enforce teamwork/Co-located teams' version
Numbers: We compared 16 numbers (4 groups, with 4 players, and for each the social connection with the team member) of one configuration with 16 numbers of another configuration.
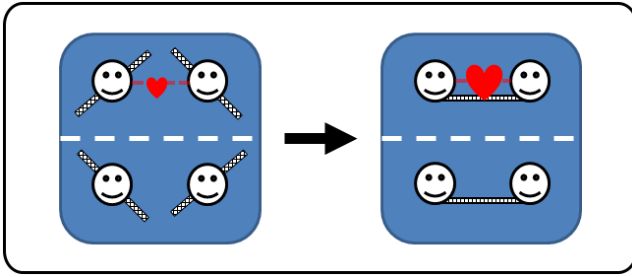
(a) H4.1: Teammembers of Non-Enforced teamwork/All Co-located vs. Teammembers of Enforced teamwork/All Co-located
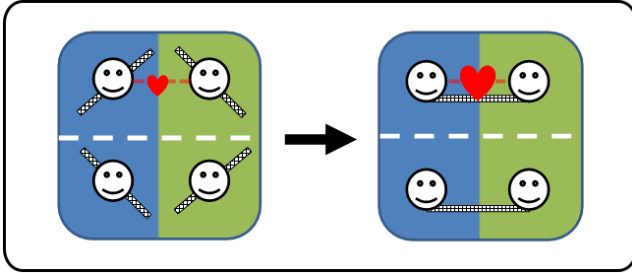
(b) H4.2: Teammembers of Non-Enforced teamwork/Distributed teams vs. Teammembers of Enforced teamwork/Distributed teams

Figure 9: Hypothesis H4, Enforcing team play between team members improves their social presence.

HYPOTHESIS H5 (figure 10)
The social bond with a remote opponent is better with physically enforced teamwork with a remote team member.
This analysis tests if the social bond with a remote opponent is better when using enforced teamwork with a remote team member, than with non-enforce teamwork with a remote team member.
Numbers: We compared 16 numbers (4 groups, with 4 players, and for each the social connection with the remote opponent) of one configuration with 16 numbers of another configuration.
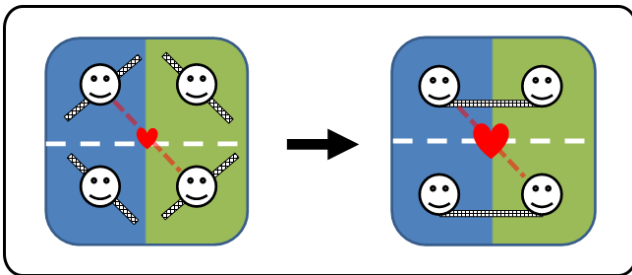

Figure 10: Hypothesis H5, The social bond with a remote opponent is better with physically enforced teamwork with a remote team member.

3. RESULTS

The data collected contained various non-normal distributions. We therefore evaluated the hypotheses using the Mann-Whitney U Test. In table 3 you can see the results for the Social presence questionnaire and for the Other in Self Scale. The social presence questionnaire consists of the constructs: Co-Presence (CP), Attention Allocation (AA), Perceived Behavioural Independence (PBI), Perceived Message Understanding (PMU), Perceived Affective Understanding (PAU) and Perceived Emotional Independence (PEI). The value in the Social Presence column is the average of these constructs. In this table you can see the results mapped to the different hypothesis tests as explained in section 2.4. The Direction (Dir) shows the direction in which we expected (according to the hypothesis) the change to occur. Because this research had an exploratory approach we performed a two-tailed tests, showing both the p-value in the direction we expected (white background in the table) as in the opposite direction (black background in the table).

While the results do not show a overall significant shift, the constructs PMU and PAU show some positive results in Hypotheses H1 and H2. Five of the 13 tests show a significance in Perceived Affective Understanding and four of the 13 show a significance in the Perceived Message Understanding category. Attention Allocation shows significance in 3 of 13; Co-Presence shows significance in 2 of 13; Other in Self shows significance in 2 of 13; Perceived Emotional Independence shows significance in 1 of 13 and Perceived Behavioural Independence shows no significance.

When looking at the questionnaire results of the first hypothesis (H1) we can see that the Perceived Message Understanding and Perceived Affective Understanding are affected, but the Co-Presence and Attention Allocation not at all or even positively while we expected negatively.

The second and third hypotheses (H2a+b) shows consistent affected results. Many of the tested constructs show significant changes in multiple tests. Also in these tests the constructs Perceived Message Understanding and Perceived Affective Understanding are the most affected.

Given these results it seems like we were able to strongly manipulate the Perceived Message Understanding and Perceived Affective Understanding, but not so much the Co-presence and Perceived behavioural independence for both hypotheses H1 and H2(a+b).

The tests done for hypotheses H3 and H4, which analyses our solutions to strengthen the social presence, show that for most constructs the difference between groups have some improvement, but show no significance in the results.

Hypothesis H5, "the social bond with a remote opponent is better with, physically enforced teamwork with a remote team member", shows results in the complete opposite direction. The results show a better social connection with a remote opponent where the gameplay consists of everyone having their own paddle.

From the qualitative interviews, that we took after the experiment, we got a lot of positive feedback on the game it-

Table 1: This table shows the results of the statistical analysis of the different hypothesis. It shows the direction in which we expected to growth to occur for each of the constructs Co-Presence, Attention Allocation, Perceived Behavioural Independence, Perceived Message Understanding, Perceived Affective Understanding, Perceived Emotional Independence and Other In Self. The black coloured cells show the values where the shift occurred in the 'wrong' direction. Values with a significance are marked with: * <0.05; ** <0.01; and *** <0.001.

	Dir.	CP			AA			PBI		
		Median 1	Median 2	p	Median 1	Median 2	p	Median 1	Median 2	p
H1.1	>	3,7222	3,7778	0,564	3,2500	3,7778	**0,008	3,5000	3,6944	0,897
H1.2	>	3,7222	3,9167	0,724	3,2500	3,2778	0,491	3,5000	3,4722	0,590
H1.3	>	3,9722	3,8056	0,669	3,0833	3,2222	0,696	3,4167	3,5833	0,423
H2a.1	<	1,0000	0,8333	0,445	0,5833	0,3333	0,323	0,5833	1,0000	0,086
H2a.2	<	-1,0000	-0,0833	**0,004	-0,5833	-0,2500	0,171	-0,5833	0,0000	0,305
H2a.3	<	-0,7500	0,0833	*0,015	-0,5833	0,0833	*0,039	-0,4167	0,4167	0,056
H2b.1	>	4,5000	4,1667	0,094	3,4167	3,7500	0,564	3,5000	3,3333	0,210
H2b.2	>	4,5833	4,4167	0,468	4,0000	3,7500	0,210	4,3333	4,0000	0,149
H3a	<	3,3750	3,6250	0,985	3,6667	3,0833	*0,017	3,3333	3,1667	0,780
H3b	<	3,7778	3,9167	0,752	3,7778	3,2778	0,290	3,6944	3,4722	0,361
H4.1	<	4,2500	4,4167	0,361	3,5810	3,6667	0,564	3,6667	4,0000	0,287
H4.2	<	3,9167	4,4167	0,094	3,3333	3,7500	0,094	3,5833	4,0000	0,402
H5	<	3,5833	2,7500	0,287	3,0833	2,9167	0,160	3,3333	2,6667	0,110

	Dir.	PMU			PAU			PEI		
		Median 1	Median 2	p	Median 1	Median 2	p	Median 1	Median 2	p
H1.1	>	3,6944	3,4444	0,254	3,5556	2,8889	**0,002	2,7222	2,2778	0,305
H1.2	>	3,6944	3,0278	*0,011	3,5556	3,6389	***0,001	2,7222	2,1111	0,119
H1.3	>	3,2222	3,3889	0,752	3,1111	3,4167	0,838	2,7778	2,6944	0,539
H2a.1	<	0,5833	1,1667	*0,039	0,1667	0,6667	***0,001	0,0000	0,1667	0,642
H2a.2	<	-0,5833	0,0000	*0,019	-0,1667	0,2500	*0,015	0,0000	0,0833	*0,047
H2a.3	<	-0,1667	0,0000	0,160	0,0000	0,7500	0,056	0,0000	0,3333	0,080
H2b.1	>	3,3333	3,0000	0,119	3,0833	2,5833	0,051	2,3333	2,1667	0,445
H2b.2	>	4,1667	3,2500	***0,001	3,4167	2,3333	*0,021	2,9167	2,0000	0,254
H3a	<	3,0000	3,0000	0,897	2,5833	2,7500	0,323	1,9583	2,1667	0,780
H3b	<	3,4444	3,0278	0,080	2,8889	2,6389	0,590	2,2778	2,1111	0,809
H4.1	<	3,8333	4,0833	0,196	3,3333	3,6667	0,110	2,9167	3,0833	1,000
H4.2	<	3,3333	3,2500	0,752	3,1667	2,3333	0,160	2,5833	2,0000	0,423
H5	<	3,3333	2,6667	*0,011	2,9167	2,0000	**0,004	2,1667	2,0000	0,171

	Dir.	Social Presence p	OIS		
			Median 1	Median 2	p
H1.1	>	0,849	1,2510	0,5000	1,000
H1.2	>	0,584	1,2510	0,0000	0,094
H1.3	>	0,917	0,3333	-0,1667	0,196
H2a.1	<	0,667	2,0000	2,0000	0,669
H2a.2	<	0,094	-2,0000	0,0000	*0,001
H2a.3	<	0,068	-1,5000	-1,0000	0,491
H2b.1	>	0,393	0,5000	0,0000	0,224
H2b.2	>	0,184	2,0000	0,0000	*0,001
H3a	<	0,929	-1,0000	0,0000	0,724
H3b	<	0,617	0,5000	0,0000	0,138
H4.1	<	0,420	2,0000	1,0000	0,564
H4.2	<	0,876	0,0000	0,0000	0,341
H5	<	0,124	-0,5000	-1,0000	0,102

self. The participants liked to play the game and were quite enthusiastic about the game and the possibilities. They immediately had several ideas how to optimize the game and would like to play it again in the future.

4. DISCUSSION

When you look at the results of the two, you can see a consistent effect in H2 but in H1 not so much. Because both hypotheses look at the effects of distribution on the social presence, we were surprised that these results were not unanimous. Thus we performed some additional tests. The test we performed for this is described below (Hypothesis H2E) and the results shown in table 4. Against our expectations the social presence, between co-located players on a distributed playground, was risen. The answer to this could lay in how we performed the analyses. In H1 we compared the averages of all connections a person has, while in H2 we took the difference between the value of the co-located player and a distributed player. By checking the difference between two social bonds within 1 player, we lessen the effect of personal tendencies. This might explain the low results for hypothesis H1. It is a good idea to do more tests like the ones in hypothesis H2a in the future, as it gives more reliable results.
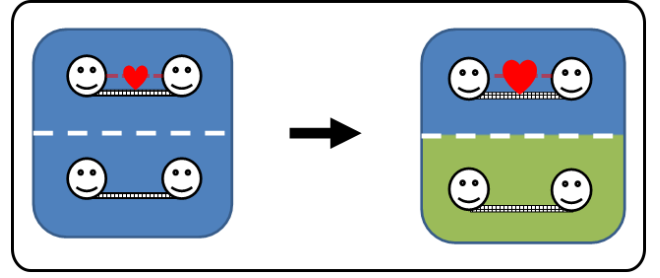
HYPOTHESIS H2Extended (figure 11)
When distributing the game, the social presence between the co-located players will go up.
Here we compared the social bond between co-located players in a distributed playground and the respective players on the 'all co-located' playground.
**Numbers:** We compared 16 numbers (4 groups, with 4 players, for each the bond with the co-located player) of one configuration with 16 numbers of another configuration.

Hypothesis H3a+b proposed that the social presence is better when using distributed teams instead of co-located teams. While the results show no significance, the participants did comment on our manipulations. When playing against two distributed opponents while having a co-located team member, people commented that it was like they were playing against a computer. We were asked this explicit question a couple of times after the experiment and some participants thought that this was where the experiment was about. They knew we analysed social presence but thought we compared 'playing against a real team' vs. 'playing against a computer'. In other distribution types no comments like this were made. These comments, about playing against a computer, make us believe that we did in fact affect something, although we don't know why this doesn't show in the results.
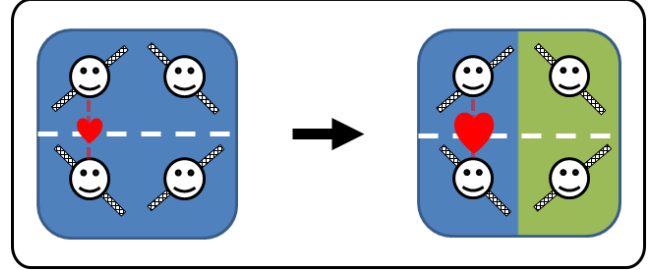
Hypothesis H4 proposed that the social presence improves when enforcing teamwork. Given the results from the questionnaires no significance that we changed the social presence. Reactions from participants on the other hand, tend to indicate that we did affect something. We think the difference between the questionnaire results and these comments could be in the experience and successfulness of the teamwork. With enforced teamwork people have to adjust their behaviour to their team member. When this happens successful they might experience a satisfying game. But when the teamwork doesn't work like it should, this can lead to

(a) H2a.1: Enforced teamwork/All Co-located vs. Enforced teamwork/Co-located teams
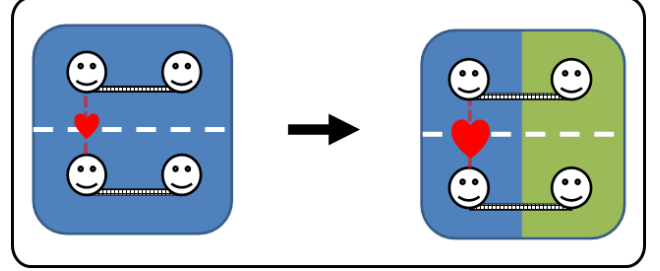
(b) H2a.2: Enforced teamwork/All Co-located vs. Enforced teamwork/Remote teams

(c) H2a.3: Non-enforced teamwork/All Co-located vs. Non-enforced teamwork/Remote teams

Figure 11: Hypothesis H2Extended, When distributing the game, the social presence between the co-located players will go up.

frustration. We think that this is what happened during the experiments. The chance that this frustration occurs is also bigger in a game with distributed teams than with co-located teams.
So while we got some positive reactions, it appears not to be successful for everyone and thus we think that this is not the solution to improve social presence in distributed play.

The last hypothesis (H5) shows a tendency towards the complete opposite of what we thought would happen. It might be that in a non-enforced teamwork game the distributed opponent has more effect on the game by himself, while in enforced teamwork game his effects are linked the the behaviour of the co-located player who is easier to keep an eye on. This could be the reason that the social presence with the remote opponent appeared stronger in a game without enforce teamwork.

Table 2: This table shows the results of the extended analysis of hypothesis H2. It compares the social bond between co-located members. The direction suggests that we expected the social bond between co-located players on a distributed playground to be higher than the bond similar players on a co-located playground. It shows the results for the constructs Co-Presence, Attention Allocation, Perceived Behavioural Independence, Perceived Message Understanding, Perceived Affective Understanding, Perceived Emotional Independence and Other In Self. The black coloured cells show the values where the shift occurred in the 'wrong' direction. Values with a significance are marked with: * <0.05; ** <0.01; and * <0.001.**

	Dir.	CP		
		Median 1	Median 2	p
H2E.1	<	4.4167	4.5833	0.780
H2E.2	<	3,4259	4,5000	**0,003
H2E.3	<	3,7500	4,0833	0,056
	Dir.	AA		
		Median 1	Median 2	p
H2E.1	<	3.6667	4.0000	0,160
H2E.2	<	3,0000	3,4167	*0,047
H2E.3	<	3,0833	3,4167	0,149
	Dir.	PBI		
		Median 1	Median 2	p
H2E.1	<	4,0000	4,3333	0,080
H2E.2	<	3,3333	3,5000	0,254
H2E.3	<	3,4167	4,0000	*0,023
	Dir.	PMU		
		Median 1	Median 2	p
H2E.1	<	4,0830	4,1667	0,696
H2E.2	<	3,5000	3,3333	**0,867**
H2E.3	<	3,3333	3,5000	0,515
	Dir.	PAU		
		Median 1	Median 2	p
H2E.1	<	3,6670	3,4167	**0,445**
H2E.2	<	3,5000	3,0833	**0,323**
H2E.3	<	3,1667	4,0000	0,086
	Dir.	PEI		
		Median 1	Median 2	p
H2E.1	<	3,0833	2,9167	**0,696**
H2E.2	<	2,6667	2,3333	**0,669**
H2E.3	<	2,6667	3,2500	0,867
	Dir.	Social Presence p		
H2E.1	<			0,763
H2E.2	<			0,741
H2E.3	<			0,283
	Dir.	OIS		
		Median 1	Median 2	p
H2E.1	<	1,0000	2,0000	0,445
H2E.2	<	0,0000	0,5000	0,073
H2E.3	<	0,0000	-0,5000	**0,724**

5. CONCLUSION

Social connections are a challenge in distributed play. Previous studies have looked into Video and Sound; Embodiedness; and Social touch to enhance this. We looked for the first time what effects teamwork has on the social bond in distributed play. We hypothesized that enforcing teamwork between remote players would enhance the social presence between players. We analysed the difference in social presence between enforced teamwork and non-enforced teamwork and also checked the difference in different player-distribution variations. These tests we performed on our Interactive Pong Playground. Participants really liked the game and liked to play it again sometime.

From this study it is clear that the decline of social presence when distributing a game is a relevant problem. So while distributed play enhance social bonds on a distributed playground [6, 7, 9], social connections are a lot stronger between co-located players.

However enforcing teamwork didn't work for us. The results we got form the questionnaires sometimes seemed to support our ideas, but often also countered them. However, comments form participants indicate that we did affect something. This suggests that we don't have a good grip on the hypotheses, yet.

Our two solutions to re-enhance the diminished social aspects (Enforce teamwork and distribute players so that they have distributed team members), don't seem to enhance the social presence between distributed players significantly. Given the remark of players who thought that they were playing against a computer, in a playground with distributed opponents, it might be intriguing to find out what we did affect if not the social presence (eg. engagement).

Finally, because enforced teamwork did not enhance social presence in distributed play, it might be interesting to see what other ways there are to enhance social presence between distributed players.

6. ACKNOWLEDGEMENTS

7. REFERENCES

[1] A. Aron, E. N. Aron, and D. Smollan. Inclusion of Other in the Self Scale and the structure of interpersonal closeness., 1992.

[2] T. Beelen, R. Blaauboer, N. Bovenmars, B. Loos, L. Zielonka, R. van Delden, G. Huisman, and D. Reidsma. The Art of Tug of War: Investigating the Influence of Remote Touch on Social Presence in a Distributed Rope Pulling Game. In D. Reidsma, H. Katayose, and A. Nijholt, editors, *Proceedings of the 10th International Conference on Advances in Computer Entertainment - ACE '13*, pages 246–257, Boekelo, The Netherlands, 2013. Springer International Publishing.

[3] S. Gerritsen, R. van Delden, and D. Reidsma. Pervasive Play: Past, Present and Future. Technical report, University of Twente, Enschede, Netherlands, 2015.

[4] A. Harfield, I. Jormanainen, and H. Shujau. First steps in distributed tangible technologies: a virtual tug of war. In *Proceedings of the 8th International*

Conference on Interaction Design and Children - IDC '09, page 178, New York, New York, USA, 2009. ACM Press.

[5] C. Harms and F. Biocca. Internal Consistency and Reliability of the Networked Minds Measure of Social Presence. In *Seventh Annual International Workshop: Presence 2004*, pages 246–251, Valencia, 2004. Universidad Politecnica de Valencia.

[6] F. Mueller. Exertion Interfaces for Sports Over a Distance. In *Proceedings of User Interface Software and Technology - UIST '02*, pages 4–5, New York, New York, USA, 2002. ACM Press.

[7] F. Mueller, S. Agamanolis, and R. Picard. Exertion interfaces: sports over a distance for social bonding and fun. In *Proceedings of the conference on Human factors in computing systems - CHI '03*, number 5, page 561, New York, New York, USA, 2003. ACM Press.

[8] F. Mueller, M. R. Gibbs, and F. Vetere. Towards understanding how to design for social play in exertion games. *Personal and Ubiquitous Computing*, 14(5):417–424, July 2010.

[9] F. Mueller, F. Vetere, M. R. Gibbs, D. Edge, S. Agamanolis, and J. G. Sheridan. Jogging over a distance between Europe and Australia. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology - UIST '10*, page 189, New York, New York, USA, 2010. ACM Press.

[10] F. F. Mueller, S. Agamanolis, M. R. Gibbs, and F. Vetere. Remote impact: shadowboxing over a distance. In *Proceedings of the 27th international conference extended abstracts on Human factors in computing systems - CHI EA '09*, page 3531, New York, New York, USA, 2009. ACM Press.

[11] F. F. Mueller, L. Cole, S. O'Brien, and W. Walmink. Airhockey over a distance: a networked physical game to support social interactions. In *Proceedings of the 2006 ACM SIGCHI international conference on Advances in computer entertainment technology - ACE '06*, page 70, New York, New York, USA, 2006. ACM Press.

[12] F. F. Mueller and M. R. Gibbs. A physical three-way interactive game based on table tennis. In *Proceedings of the 4th Australasian conference on Interactive entertainment - IE '07*, pages 1–7, Melbourne, Australia, 2007. RMIT University.

[13] F. F. Mueller and M. R. Gibbs. Evaluating a distributed physical leisure game for three players. In *Proceedings of the 2007 conference of the computer-human interaction special interest group (CHISIG) of Australia on Computer-human interaction: design: activities, artifacts and environments - OZCHI '07*, number November, page 143, New York, New York, USA, 2007. ACM Press.

[14] F. F. Mueller, M. R. Gibbs, and F. Vetere. An Exploration of Exertion in Mixed Reality Systems via the "Table Tennis for Three" Game. In E. Dubois, P. Gray, and L. Nigay, editors, *The Engineering of Mixed Reality Systems*, Human-Computer Interaction Series, chapter 9, pages 165–182. Springer London, London, 2010.

[15] F. F. Mueller, S. O'Brien, and A. Thorogood. Jogging over a distance: supporting a jogging together experience although being apart. In *CHI '07 extended abstracts on Human factors in computing systems - CHI '07*, page 2579, New York, New York, USA, 2007. ACM Press.

[16] F. F. Mueller, G. Stevens, A. Thorogood, S. O'Brien, and V. Wulf. Sports over a Distance. *Personal and Ubiquitous Computing*, 11(8):633–645, Oct. 2007.

[17] D. Putnam, Robert. *Bowling Alone*. Simon & Schuster, 2000.

[18] L. Yao, S. Dasgupta, N. Cheng, J. Spingarn-Koff, O. Rudakevych, and H. Ishii. RopePlus: bridging distances with social and kinesthetic rope games. In *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11*, page 223, New York, New York, USA, 2011. ACM Press.