Exertion Interfaces: Sports over a Distance for Social Bonding and Fun

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ABSTRACT
An Exertion Interface is an interface that deliberately requires intense physical effort. Exertion Interfaces have applications in "Sports over a Distance", potentially capitalizing on the power of traditional physical sports in supporting social bonding. We designed, developed, and evaluated an Exertion Interface that allows people who are miles apart to play a physically exhausting ball game together. Players interact through a life-size video-conference screen using a regular soccer ball as an input device. The Exertion Interface users said that they got to know the other player better, had more fun, became better friends, and were happier with the transmitted audio and video quality, in comparison to those who played the same game using a non-exertion keyboard interface. These results suggest that an Exertion Interface, as compared to a traditional interface, offers increased opportunities for connecting people socially, especially when they have never met before.

Keywords
Exertion interface, physical interface, sports interface, social bonding, computer mediated communication, interpersonal trust, funology, sport, video-conferencing

INTRODUCTION

"You can discover more about a person in an hour of play than in a year of conversation" (Plato, 427-347 BC). This quotation conveys the motivation for our work perfectly.

Importance of Social Interaction

Social interaction is of the utmost importance for the well-being of individuals as well as society as a whole. However, as Putnam describes in his book "Bowling Alone", people (in American society in this case) increasingly lack social interactions [1]. The desire for social contact with one another is part of human nature, and telecommunication technologies help us bridge distances, connecting us to family members, work colleagues and friends. Although these technologies have improved tremendously over the last few years, they still fall short in important ways.

Many tools from the domain of computer-supported cooperative work are related to the execution of a specific task and fall short of encouraging the participants to interact socially with one another outside of the context of the work assignment. Video-conferencing, for example, connects people who have a reason to meet, but is not very good at encouraging casual social interaction between the participants, especially if they have not met before.

Physical Activity

In contrast, games and sports have been helpful in facilitating social introductions for thousands of years. Sports are fun, played by millions of people everywhere in the world, regardless of age, race or social status. Players come together not only for the physical exercise, but also to enjoy the social contact [2]. This contact is valuable for maintaining bonds between friends, family members and new acquaintances, and improves one's overall well-being and quality of life. Golf weekends, tennis tournaments, kayaking and other sport-related team-building exercises are widely used to foster bonding between co-workers and to support the creation of new teams, especially if they consist of people who have not met before.

Sports over a Distance

Why not combine the advantages of telecommunication technology in bridging distance, and those of sports in facilitating social introductions and fun?

Asserting that sports and games have these socializing effects, a game environment can be a valuable augmentation of what current telecollaboration tools and media spaces [3] try to accomplish in terms of social interaction. If physical exertion can put the user in a heightened state of arousal that supports bonding, it makes sense to leverage the same kind of arousal in a distributed setting. For example, if strangers meet over a networked environment for the first time, a game can break the ice, as it provides rules to follow, an activity or experience to share, and something to talk about.

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EXERTION INTERFACE

To make sports over a distance a reality, a new approach to interface design is needed. An obvious approach for a vast majority of applications is to design interfaces that require the least amount of physical workload to use. We would like to introduce the opposite: Exertion Interfaces.

An Exertion Interface is an interface that deliberately requires intense physical effort.

Exertion Interfaces can be expected to be physically exhausting when used for an extended period of time. They require effort and demand mental workload, and, just like sports, might take a short time to pick up, but a long time to master.

An interface that fosters bonding and team spirit in a social setting has to be fun to use and also encourage interaction with another person, or with a whole team. Many such interfaces have existed in the physical world for a long time, such as the use of balls in sports. We envision Exertion Interfaces being used in the same way traditional sports games function in social relationships. For example, when new members arrive in an organization or business, team-building activities are important in forming new relationships and getting a feel for how one's colleagues think and work. These activities might be formally arranged, but more often they take the form of one person asking another out for a friendly game of tennis, table tennis, golf, etc. Such a first-time encounter might spark a regular sports relationship with the other person, and with time, a new friendship.

The aim is to enable this kind of social relationship to develop when the participants are physically distant, perhaps even on opposite sides of the world. Instead of a traditional gym or sports club, players might go to a "virtual sports club" in their geographic area and engage in new kinds of "sports over a distance" that incorporate Exertion Interfaces.

RESEARCH AIMS

The aim of the research described in this paper has been to develop a prototype "sports over a distance" application that incorporates an Exertion Interface, and to study the effects of this system as compared to traditional kinds of interfaces and game scenarios. We hypothesise that an interaction with a distributed Exertion Interface would function better at introducing people to each other and creating social bonding than a traditional keyboard interface.

RELATED WORK

The concept of fun as a motivational factor has gained increased attention lately, and has emerged into the domain of human-computer interface design, where it is a growing area of inquiry [4]. Leisure activities, based around the concept of social engagement, could potentially be suitable environments to create bonds between people that have to work in a team. Such "entertaining" interfaces could serve as an initial starting point for building strong collaborations, before more traditional Computer Supported Cooperative Work (CSCW) interfaces are utilized to perform a specific task.

Most of these entertaining interfaces, however, are only to be found in game arcades. They all try to combine a known fun, physical experience with a computer game, but fall short in terms of social interaction, because most of them can only be played alone against a virtual computer opponent and do not support the creation of teams.

The 2002 FIFA World Cup Football Stadium [5] mat is a commercial example of an Exertion Interface. It is a carpet-like mat with three embedded sensors that measure the position of a user's feet to control a virtual soccer player. Another soccer game is Kick and Kick [6], where you kick a real ball on a screen against a virtual goalie, both games allow only single user play. Dance Dance Revolution [7] is a physical arcade game, which can be played in teams of two. With Dance Dance Revolution, players step on lighted platforms in time with the music as they try to match the dancing instructions on the screen. However, both players have to be in the same physical location.

ImpactTV [8] is a fun-oriented interface where you throw a basketball at the TV if you want to watch basketball; the physical part of the interaction plays an essential role in making it entertaining. VIRKU is a Virtual Fitness Center [9] that combines exercise equipment with an Internet based fitness monitoring system. Walk the Dog [10] requires the player to use a treadmill in order to walk a virtual dog on a screen.

The idea of a table-tennis racket as an athletic interface is described by the authors of PingPongPlus [11], who developed a virtually augmented ping-pong table. Another example is AR^2 [12], an augmented reality air-hockey table with a virtual puck. The two players wear head-mounted displays to see a virtual puck on the table in front of them. KiRo [13] is a robotic foosball table, where robotic arms control one set of handlebars, replacing the other player. Such a system could be extended to allow playing over a distance: two coupled versions of the table could be networked, and the sensors on the human player's handles could measure the movements and transmit them as input for the distant robot, allowing two users to play against each other without being in the same location.

An early attempt of a networked sport is Telephonic Arm Wrestling [14], in which you arm-wrestle your opponent over a phone-line. A group physical activity is the Virtual Tug-of-War [15] [16], where two teams of high-school students were involved in a tug-of-war at schools 13 miles apart from each other. NetGym [17] describes two physically separated exercise bicycles in a virtually connected gym in which a cyclist cycles with an avatar representing the remote user. If they move too far away from each other, they basically cycle alone. Snowwars [18] is a networked physical game, which simulates a snowball fight using virtual reality technology and guns that shoot tennis balls at the remote player. More networked physical games are reported by Mueller [19].

Most of these examples address the issue of providing an interface that is fun to use. They also often cause the players to exert themselves, and some of them offer remote interactions. However, not many combine these features in one system, and we do not know of any tests of their effectiveness in supporting social interaction.

ASKING USERS

In order to gain more empirical validation of the theoretical framework developed on the impact of social games on bonding experiences, we conducted a survey. With an informal questionnaire, which was sent out to all employees of our research lab, we wanted to know if the purchase of a pool-table, a ping-pong table and a foosball table actually influenced the social climate within the organization. Having participants judge their own behavior is not without its problems and the results should always be treated with caution. However, we were not only interested in the facts about the use of these games, but also sought inspiration from the thoughts of the players. 32 recipients responded, an excerpt of the results can be seen in Figure 1 and 2.

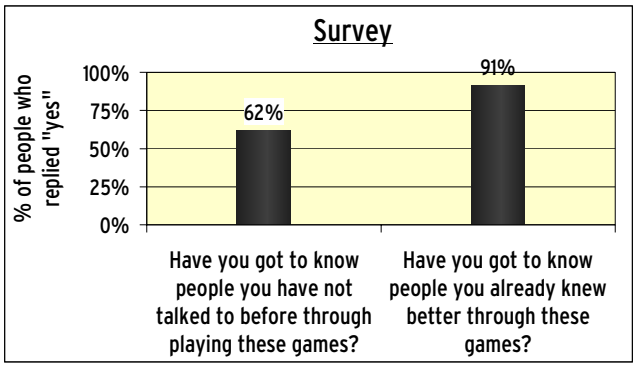

Figure 1: Survey results (excerpt)

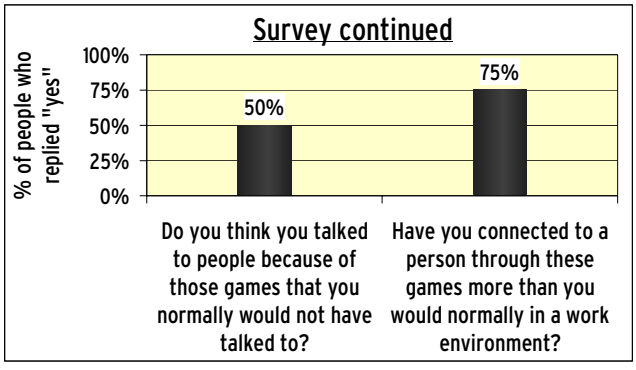

Figure 2: Survey results continued

62% of all players have met other people they have not talked to before through playing these kinds of games. One respondent said that these activities allowed him to speak to people he would normally not have talked to as they give him something to converse about which is non-business related, because "you don't want to talk about work". Although it is hard to measure how the growth of the social network would have differed if the organization had not had those games, the fact that 91% of the employees who played the games said it helped them to get to know people better seems to be a pointer in the right direction, which we used as motivation for our work.

The "physical element" of the games was often mentioned by the respondents. It is "important in breaking down barriers. It also has possibilities for laughter not offered by other games - you can't really screw up in a funny way playing chess." "Pool leaves more room for conversation, but the table tennis loosens you up more so to speak - it's a more "expressive" sort of game (e.g. you can hammer the ball wildly at your opponent if you so wish)." The respondents favored having a "quick game" as a stress reliever and "power break", and value the fact that they are not restrained or "cerebral" and everybody takes them very casually. One respondent summarized it remarkably: "In this room, you can see other sides of people, not the researchers, but the human beings, if not animals, that laugh, move around, jump, scream."

BREAKOUT FOR TWO

In order to test our hypothesis, we used these findings to develop a system which allows two players in remote locations to play sports together. As an example of an Exertion Interface, it requires physical effort to play and encourages mastering specific skills. Furthermore, the design aims to make it fun to play and also to support interactions between the players.

Decision on a Ball Sport

We decided to model our system on a proven Exertion Interface: the use of a ball in sports. Players kick, throw, bat, balance, strike, hurl, pass, dribble and shoot a ball in a vast range of sports. Games like tennis or volleyball have the players on two different parts of the field, allowing only the ball to cross the boundary or net. Based on these examples, we decided to create a game which keeps distinct parts of the field for each player, supporting the goal of a functional long-distance game.

Figure 3: Breakout for Two

Design Goals

We decided on the following design goals for the game:

- playable over a distance

- facilitates exertion
- allows the players to communicate with each other
- involves mastering the skill of handling a ball
- is fun to play

Our prototype sports game is a cross between soccer, tennis, and the popular computer game "Breakout", which can be played by two players over a distance. For this reason, we call it "Breakout for Two" (Figure 3).

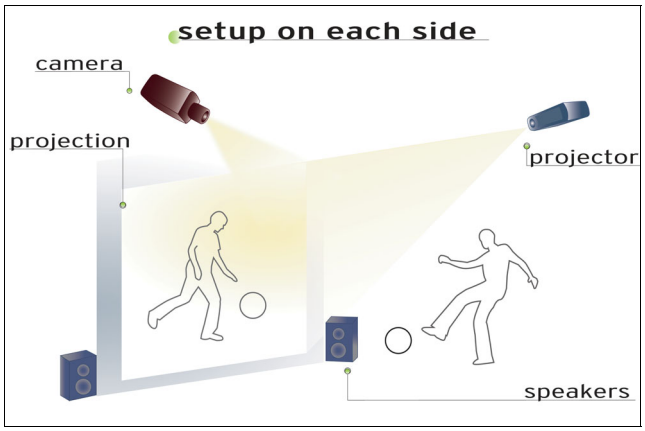

Figure 4: The setup

The players, who can be miles apart from each other, both throw or kick a ball against a local, physical wall. On each wall is a projection of the remote player, enabling the participants to interact with each other through a life-sized video and audio connection (Figure 4). The experience is much like being on a tennis court – each player occupies his/her part of the field and the wall represents the net or boundary between the players, over which they can communicate. The two players can talk to and see each other at all times. This setup facilitates the social interaction and encourages conversations such as challenging the other person or discussing winning strategies. For the players it feels like they are separated by a glass window, which splits the two parts of the field, similar to the ClearBoard [20]. They still hit the ball in the direction of the other player, but it comes back, bouncing off the wall.

Figure 5: Semi-transparent blocks overlaying the video

8 semi-transparent blocks are overlaid on the video stream, which each player has to strike in order to score (Figure 5). These virtual blocks are connected over the network, meaning they are shared between the locations. If one of the two players strikes any of them once, they "crack". If that block is hit again, it cracks more. On the third hit, the block "breaks" and disappears. This analogy was chosen to portray the idea of "breaking through" to the other person on the remote end. The player would only receive a point if the block breaks. This scoring theme creates an entertaining and interesting game because the players can watch what the other player is doing, waiting for her/him to hit a block for the second time, so they can then snatch the point by hitting it for the third and final time. In order to avoid a purely tactical game and encourage intense physical activity, an impact-intensity measurement component was added. If the player hits the block hard, it would not only crack a little, it would crack twice. A really hard strike could even break the block completely in one go. For this, the impact intensity was measured and mapped onto a three-point scale. The harder the player hits a block, the more it cracks.

IMPLEMENTATION

The implementation of Breakout for Two went through several iterations, based on user feedback from about 100 players. Breakout for Two was in use in the laboratory and was played by employees, friends and visitors before being exposed to further experiments.

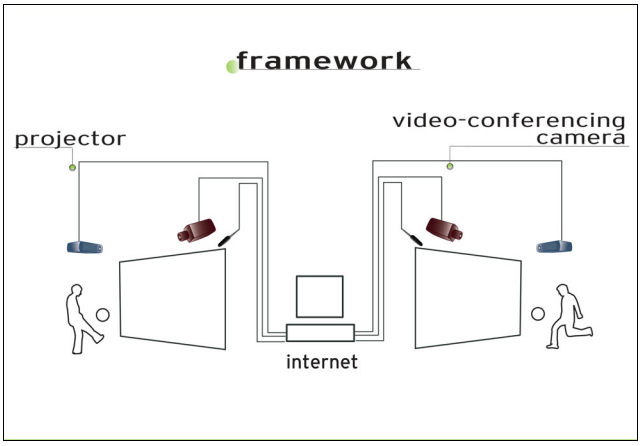

Figure 6: The framework

The Breakout for Two system consists of three components: the video-conference between the players, the detection engine to identify the impact of the ball, and the networking software. The impact data of where, when and how hard the ball hit the wall is transmitted over TCP/IP, and, along with the UDP video-conferencing information, synchronized with the other end (Figure 6).

BALL DETECTION TECHNOLOGY

Audio Solution

Microphones that are attached behind the wall are coupled with a real-time multi-channel signal analysis engine to determine where the ball strikes the wall. We used 8 microphones that are spread at equal distances, forming a grid of detection "panels". The ball is thrown at the wall from the other side and the sound travels through the wall to these microphones. The shorter the time it takes for the

sound of the impact to travel to a particular microphone, the closer the impact was to this microphone.

Video Solution

Impact detection using sound requires the construction of a solid wooden wall with distinct sound characteristics. The goal was to be able to use any existing, concrete wall, therefore, a second version of the system was built.

Vision detection using two cameras is deployed to create a more mobile system. Two cameras continuously capture a narrow area just in front of the wall, about 5 feet in depth. One camera is mounted to the side of the wall, detecting the vertical dimension of any object entering this area. The other camera mounted on top, facing down, measures the horizontal component of a ball striking the wall. This video tracking of the ball allowed us to even play fast ball games such as tennis. Technical details for both systems can be found in [19].

EVALUATION

Participants

56 volunteers were recruited through flyers and email postings at local universities, sports clubs and youth hostels. None of them knew about the study beforehand nor had they any prior experience with the system. The volunteers were matched up randomly in teams of two and no pair of participants knew each other prior to the experiment.

Experimental Design

The experiment followed a between groups design. There were two conditions, exertion and non-exertion, and the participants played either the exertion game or a non-exertion version of the game using a traditional keyboard interface.

Measures

Questionnaire

After the participants played the game, they were presented with a questionnaire, containing 60 items. It was designed to gain insights into how well the participants got to know one another, and how the system could be improved.

Several questions were adapted from questionnaires based on similar work to provide consistency and allow for comparisons: Krampen [21] developed a questionnaire regarding the participant's general attitude towards trust, based on the work of Rotter [22]. A subset was incorporated into the questionnaire, similar to the approach by Hirsig [23], because a person's general attitude towards trust probably influences how she/he approaches strangers and characterizes any first encounter. It therefore makes sense to compare this to the way the participant acts in the experiment.

The questions were presented in a random order to minimize a sequence effect. They were also partially negatively formulated, in order to avoid repetitive response patterns, but were inverted again for the analysis (marked with an 'n'). To avoid the Halo effect, elaborative instructions were given asking each participant to pay special attention to the different contexts posed by each question, as suggested by Rotter [22]. The questions were to be answered on a scale from 1 to 5, ranging from "strongly agree" to "strongly disagree"; this Likert [24] scale was used to provide consistency along similar questionnaires [21] [23] and to allow for comparisons.

Interviews

Following the questionnaire, both players were accompanied to a different room, where they met for the first time in person. They had some time to introduce themselves before they were interviewed together and videotaped answering open-ended questions about their experience. They were asked to answer them in an informal style and freely discuss them with the observer.

Task

Exertion Game

The participants in the exertion group were introduced to the Breakout for Two game. The players were encouraged to play one practice round to become familiar with the system, and then play at least "a couple of" games.

Non-Exertion Game

The same game that was developed for the Exertion Interface was used, except the input method was modified so it could be played with a keyboard interface, but still using the same life-size screen. The players hit a ball against a wall; however, in this version, they hit a virtual ball with a virtual foot, overlaid again on the video-conference. The player controls the intensity, the direction and spin with a keyboard interface, and the ball follows simulated physics in a virtual 3D environment to recreate a realistic experience. The input method used to apply force and direction to a virtual ball with a keyboard interface is similar to the one used in many golf and other sports simulations. The intensity of the swing is controlled by a key hit at a specific time during a continuous movement of the virtual player swinging his/her club.

Procedure

The participants were introduced to the game and also told that their performance was not being measured, but that the goal of the experiment was to hear about their thoughts on the system and to see how much they enjoyed it. After the participants played the exertion or non-exertion game, they were asked to fill out a questionnaire. Subsequently, both participants were brought into the same room where they were interviewed together.

RESULTS

The questionnaire revealed many statistically significant findings between the exertion and non-exertion group. We concentrate here on the main conclusions regarding social interaction and more details are reported by Mueller [19].

The participants showed no statistically significant difference in education, video-conference experience and general attitude towards technology and trust between the two groups. All t-tests are two-sample and assume equal variances, unless otherwise noted.

Social Bond

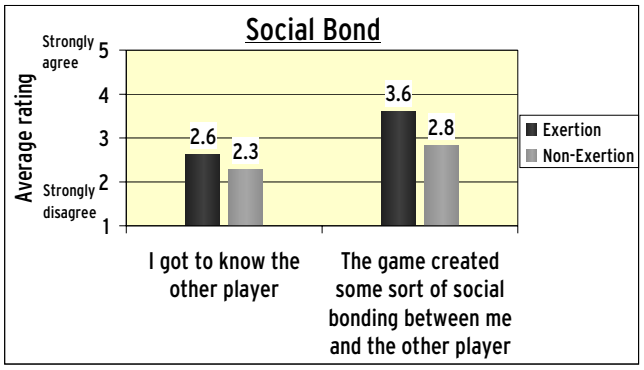

Figure 7: Exertion players perceived stronger bonding

The exertion group answered the question "I got to know the other player" with a significantly higher rating than the non-exertion group ($t=-1.94$, $p<0.05$, one tail) (Figure 7). Additionally, the players of the exertion group believed that the game created a much stronger social bond between them than the non-exertion players ($t=-2.73$, $p<0.05$, unequal variances, two tail). This finding was reinforced by the interviews, where the players who rated the question higher showed much more knowledge about their partner, not necessarily on facts, but on characteristics; for instance, on how competitive the other player is.

Friendship

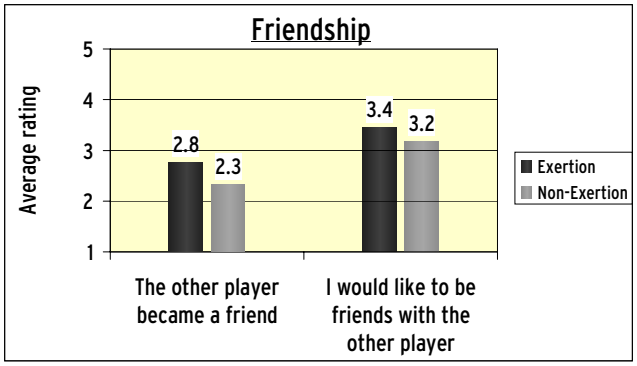

Figure 8: Exertion players believed to be closer friends

The exertion players felt they became better friends than the non-exertion players ($t=2.50$, $p<0.01$, one tail) (Figure 8). There was also a trend that they wanted to become friends more strongly (if they were not already) ($t=-1.57$, $p=0.061$, one tail).

Fun

The exertion group said they had more fun, which is highly significant ($t=-4.11$, $p<0.0005$, two-tail) (Figure 9). This is no surprise if one looks at the comments during the interviews: almost all exertion players confirmed how much fun they had without being asked explicitly.

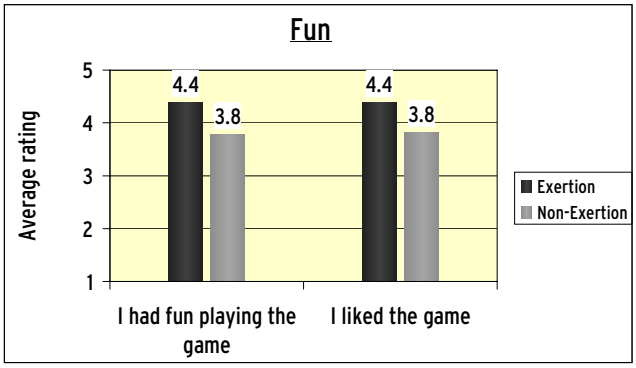

Figure 9: Exertion players said they had more fun

They also said they liked the game more ($t=3.45$, $p<0.005$, two-tail). The non-exertion group played the same game; however, the keyboard-based interaction might require a different kind of game for the players to enjoy. Having the non-exertion group play a commercial computer game could be an alternative, but the interaction modalities would be different, making them a non-viable control group.

Number of Rounds Played

The exertion group played more rounds (average 6.9 rounds, non-exertion group 4.5 rounds), one team even played 17 games. Both systems are perhaps intriguing for the players because of the large projection, which might be one of the reasons the participants played so long.

Video-Conferencing Quality

The difference in perceived quality between the exertion and non-exertion group is very interesting: the exertion group answered, with high significance, more often that the audio quality was sufficient for them ($t=-5.36$, $p<0.000005$, two-tail). Similar results were obtained about the video quality: again, the exertion group said they were happier with it ($t=-3.37$, $p<0.005$, two-tail) (Figure 10).

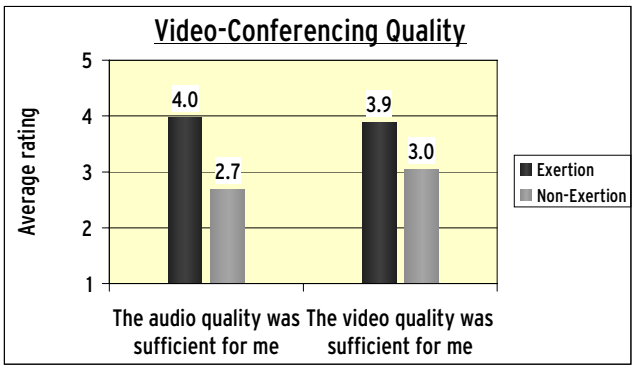

Figure 10: Video-conferencing quality perceived differently

It is important to consider the influence of previous exposure to video-conferencing across the subjects. The question "I am familiar with using video-conferencing" was not significant between groups indicating that the interface influenced the perception of the video-conferencing quality.

These results are surprising, because both groups used the same video-conferencing setup. It seems reasonable to conclude that an Exertion Interface does not require a high video-conferencing quality to the same extent that a non-exertion interface does. Our assumption is that because the sports game allowed the other person's full body to be viewed from various positions, it permitted the players to "read" much more through body language and posture, compensating for deficits in the video-conference quality.

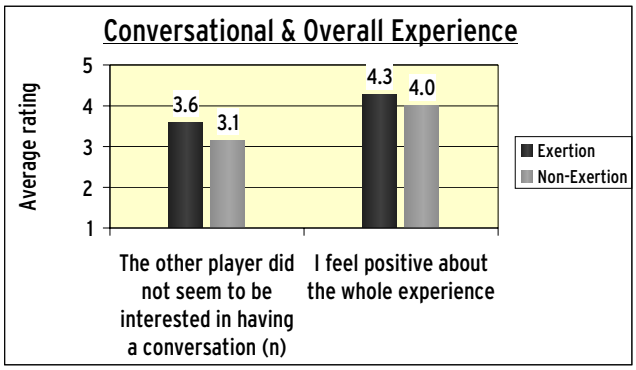

Figure 11: Exertion players rated the experience higher

Conversational

The participants who played the exertion game answered the question "The other player did not seem to be interested in having a conversation (n)" with a much higher ranking than the non-exertion players ($t=1.95$, $p<0.05$, one tail). This statistically significant result suggests that an Exertion Interface not only helps the players to forget about limited video-conferencing quality, but also makes the other player seem more talkative.

Overall Experience

In addition to these findings, the exertion group felt significantly more positive about the experience ($t=1.74$, $p<0.05$, one tail) (Figure 11). Physiologically, physical activity is known to release endorphins which might have put the players in an affective state of arousal, resulting in a more optimistic view of their surroundings.

Interviews

The interviews strengthened these findings. Players in the non-exertion group (ignorant of the exertion condition) mentioned without being asked that some physical activity would have helped them create a closer bond with the other person. The interviews with the people who played the exertion game lasted much longer than the interviews with the non-exertion players, although they were answering the same questions. They seemed to be more comfortable chatting freely and interacted longer, showing a deeper involvement.

Both groups praised the big screen projection and attributed the success of the game to it. As one participant commented: "The exertion would not work if you would play it on a regular screen."

One participant mentioned that he would like to see such a game in a bar, allowing him to play with friends who could not be there. Almost all of the players in the exertion group were very exhausted after the game. Most of them told us that it was much more exhausting than they thought it would be in the beginning. Indeed, the game can be very demanding and fatiguing. The reason for this is because there are no opponents or teammates to wait for and there are no scheduled time-outs. Some players were getting so involved that they were seriously out of breath and their shirts heavily sweaty. We had to put a water-cooler close by, because we got concerned that some participants might become dehydrated.

Physical exercise alone might influence the outcome of experiments, and could be independent from the interaction. The results from the questionnaire and especially the interviews however, showed that the exertion players had a much higher involvement in the interaction during the game, as well as a greater awareness of the other player.

Participants also reported their experiences with playing online games, and drew comparisons. While the non-exertion game could not compete with current state-of-the-art computer games, participants said they would like to see a similar video-conferencing system being deployed in these games. They suggested that being able to see the other player, and playing a game in a layer on top of this, would make the interaction more appealing.

Whether people prefer computer games or physical games depends on the situation and the personality of the player. Not everybody will like participating in a physical game, regardless of whether that game is played over a distance or on the same court. One participant stated: "Computer games are not for everybody, they are certainly not my cup of tea, I prefer sports". Some participants came up with the idea of wanting to play two on two, which turned out to be very engaging.

FUTURE RESEARCH

The demonstrated increased social bonding and perceived connectedness can provide valuable augmentations for experiments such as those done by Rocco [25]. Instead of comparing text-chat with audio- and video-conferencing, a system like Breakout for Two could offer an additional experimental condition. In addition, the measures on social relationships performed here could be easily performed on several other connected physical interfaces, such as the Tug-of-War [15] or Snowwars [18].

CONCLUSION

We have defined an Exertion Interface, and shown that it can provide a valuable augmentation to what current interfaces try to accomplish in terms of social interaction. We demonstrated that distance communication could be improved through the addition of information in another modality, by developing a system that allows sports over a distance. Experiments with the system demonstrated that participants who played sports over a distance reported a significantly greater social bond than players who used a keyboard interface. They said they got to know the other

player better, had more fun, became better friends, and were happier with the transmitted audio and video quality.

The addition of an Exertion Interface to currently available interface designs opens the door to another world of social interfaces. This interface is not designed for a wide range of applications, where traditional keyboard interfaces are much more suitable (e.g. word-processing and programming), but in supporting social interactions, an Exertion Interface is advantageous. This approach moves in the opposite direction to most other current interface design trends, because although it is easy to learn, an Exertion Interface requires skill and strength, and is hard to master.

An Exertion Interface supports people connecting with one another on a social level. Players use the universal language of sports to come together, and they now can do this with people in remote locations.

ACKNOWLEDGEMENTS

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