Sensation: Measuring the Effects of a Human-to-Human Social Touch Based Controller on the Player Experience

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ABSTRACT
We observe an increasing interest on usage of full-body interaction in games. However, human-to-human social touch interaction has not been implemented as a sophisticated gaming apparatus. To address this, we designed the Sensation, a device for detecting touch patterns between players, and introduce the game, Shape Destroy, which is a collaborative game designed to be played with social touch. To understand if usage of social touch has a meaningful contribution to the overall player experience in collaborative games we conducted a user study with 30 participants. Participants played the same game using i) the Sensation and ii) a gamepad, and completed a set of questionnaires aimed at measuring the immersion levels. As a result, the collected data and our observations indicated an increase in *general, shared, ludic* and *affective involvement* with significant differences. Thus, human-to-human touch can be considered a promising control method for collaborative physical games.

Author Keywords
Social touch; human-to-human interaction; gaming; controller; control apparatus; pervasive games; physical games; SFCS; Touché; game design; game research; embodied interaction; exertion games; exergames.

ACM Classification Keywords
H.5.2 Evaluation/methodology - Input devices and strategies - Interaction styles

INTRODUCTION
The new generation of digital games offer instinctive machine-human interaction with the use of natural user interfaces such as gestural control systems. However, human-to-human social touch, any kind of touch which occurs between people [17], as a detailed game control apparatus has not been implemented and its effects on player experience has not been investigated. This study proposes that the immersion experience felt by a user might be increased if human-to-human social touch can be implemented as a control apparatus for gaming. The proposed system could be a viable alternative for pervasive and computer augmented physical gaming.

Some of the new generation games offer various gestures with the use of either touch screens or other kinds of motion tracking methods. For example, numerous games made for both Android[5] and iOS[6] use different touching gestures and gyroscopic gestures for controlling the games. The Wii Game Console[7], introduced by Nintendo, is equipped with motion capture and a gyroscopic device, allowing players to move naturally rather than hitting buttons while playing games like baseball, tennis etc. Similarly, Sony Playstation's[8] latest controller includes a touchpad and gyroscope, as well as buttons. Moreover, Microsoft's method of involving players with full-body interaction, Kinect[9], uses camera based tracking. These sensing devices increase the players' engagement via natural movements, and through increasing the invisibility of machine-human interaction which can be provided flawlessly with human-to-human touch.

While these recent devices suggest game designers' endeavors for more instinctive interaction, human-to-human social touch (HHST) as a control mechanism has room to expand. Among these methods, social touch may take a step further and create a rich experience for collaborative or competitive co-located multiplayer games by letting players interact with each other physically. In addition, the invisibility of controls, instead of traditional machine-human interaction methods, are needed to intensify the immersion experience [4]. Immersion refers to the feeling of being absorbed and surrounded by media on such a level that the connection to the real world weakens as the bond to the virtual world strengthens [4]. From this perspective, total

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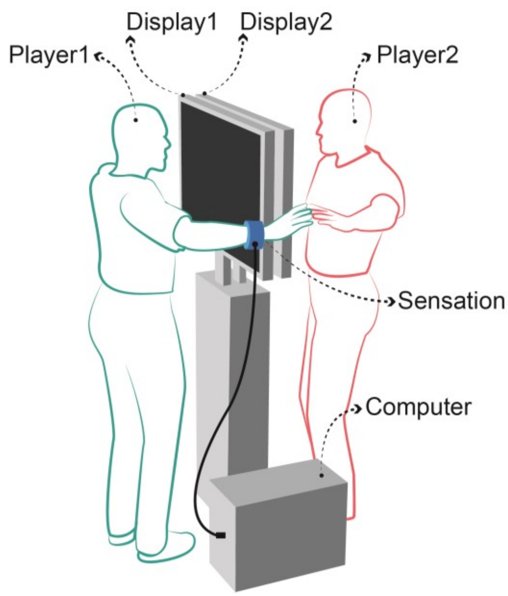

Figure 1: Gaming environment designed for the Sensation

immersion is more likely to be achieved through human-human interaction.

In this study, we introduce and explore a novel interaction technique for collaborative game play, human-to-human social touch, through the use of *the Sensation*, which is a device for sensing different touch patterns between two players. We used the Sensation with a specifically designed collaborative game, Shape Destroy, and conducted a user study with 30 participants to see how using HHST affected the gaming experience. To achieve these goals, we set an interactive environment which allows players to play games via social touch in a face-to-face position (Figure 1). This environment is based on our previous research in which we introduced HHST as a controller concept for gaming for the first time [5]. We used this environment to conduct the user study which compared the difference in the experience between social touch, *Sensation,* and a conventional gamepad in a specifically designed collaborative game. The game, *Shape Destroy*, which was used during our study was also a modified version of the game Worm Hole [5], specifically designed by experts for such environments. Calleja's *Player Involvement Model* [6] was used to explicitly qualify the effect of HHST on the immersion level. We believe that utilization of social touch will contribute to the collaborative gaming experience by increasing 1) kinesthetic, 2) shared, 3) ludic and 4) affective involvement which in turn will boost the 5) overall immersive experience of the players.

BACKGROUND AND RELATED WORK

Human to Human Interaction in Games

In digital PC and console games, there are many strict guidelines and rules which inhibit spontaneity [25]. Online games try to increase spontaneity by providing players a chance to communicate with real players, but they cannot be compared with the feeling of playing the game face-to-face [25]. Using social touch in digital games can break these barriers and may help to bring a new approach for the control of pervasive games. Several research projects were conducted on human-to-human interaction in games like Human Pacman [7], Pirates! [2], Pass the Bomb [31], i-Dentity [11] JS Joust [36]. The aim of these experiments is to transfer the game boards of digital media to the real world [2,7] and make the physical existence of players affect the game world or build game rules upon it. As a result of co-located multiplayer game play, social touch occurs as a resultant effect. However, none of these games solely focus on social touch as a control apparatus.

Several studies on games have focused on the body contact of players. *Musical Embrace* [16] is a study which employs social touch in a more similar way to our study. It facilitates a hug between two players by making them hug a pillow together. Another study, *intangle* [10], investigates the different levels of body contact and social boundaries in a gaming context. These studies, however, do not concentrate on different kinds of touch patterns, either. Moreover, their concern is social interpretations and design inspirations resulting from human-human interaction, while our focus is on player experience presented by the game and the interactive environment.

In our previous study, we investigated social touch in the context of gaming and gained insights about its use in digital games. This study proposed a conceptual environment called DubTouch, which used a double-sided display and let players play the game by touching each other's hands in a face-to-face position. According to this study, user preferences addressed that touch patterns can be categorized into six groups: *Direct Manipulation*, *Two Hand*, *Hand Posture*, *Two Users*, *Physical Impact*, and *3D Space* [5]. Moreover, this study also introduced two games which are specifically designed for this interactive environment which are called *Worm Hole* and *d-Coder*. Although this research offered many predictions about touch patterns that can be used in the games, it did not investigate the effects of social touch on player experience since it was a study done on a conceptual environment without a working prototype. Nevertheless, we used the insights from this work in the implementation of the game, the organization of the environment and the selection of touch patterns.

Our investigation into the use of social-touch in games shows that physical interactions of players is considered an important subject for games. However, different types of social touch between players, although described in our previous work, was not implemented as a control apparatus for gaming. Different from the previous work, our study focuses on introducing a novel control method which is based on social touch patterns and understand how it contributes to player experience.

Social Touch in HCI

Social touch is a general term used for any touch interaction between at least two people. It includes all touch patterns like shaking hands, hugging, and bumping fists. People use social touch in daily life for communication, and every touch has a symbolic meaning [17]. For example, touching someone's shoulder signals that you want to have a conversation with the receiver of the touch. Furthermore, social touch also employs the transfer of specific emotions between people. The previous study shows that specific touch patterns are capable of delivering emotions like love, fear or melancholy between people [5].

There are several studies about the interpretation of social touch. Haans & IJsselsteijn created six categories according to their interpretations: *positive affection, control, playful, ritualistic, task related and accidental touches* [13]. Another study organized the phenomena into three groups*: simple touch, protracted touch, and dynamic touch* [17]. In both of the definitions, people must be in each other's proximity for social touch to occur. These classifications refer to different kinds of touches in the manner of touch duration, touch surface or body area. For example, simple touch refers to touches only for specific parts of the body such as hands or arms. Protracted touch refers to continuous contact of skin with pressure, while dynamic touch specifies a touch with a repetitive character; for example stroking.

We believe that even if not considered in the context of gaming, usage of social touch in other areas of HCI is related to our work. The TaSST is one of the projects which is capable of generating different kinds of touches with the use of haptic motors [17]. Another study focuses on how mediated social touch alters the experience in a social presence environment [30]. *Emobaloon* considers touches like *Stroking or Hugging* as input and examines its effects on the user through the use of an interactive balloon [29]. Several other studies investigate the directions and capabilities of social touch for possible applications in HCI through extensive research or implementations of interactive systems [9,13,23,28,33]. Application of mediated social touch to digital games is possible, nevertheless, our interest is to attain the genuine social touch between people who are co-located.

Apart from the mediated touch, a spotlight has been held on interpersonal touch by numerous projects. *Enhanced Touch, Touch-Shake* and *Touching a Stranger* employ a similar system to ours by providing face-to-face interaction between users [15,18,38]. *Enhanced Touch* provides a playful interaction between users via a bracelet, while *Touch-Shake* investigates the interaction of users in face-to-face position via different kinds of touches through the use of a hand-held device. *Touching a Stranger* introduces a wearable vest, which grants auditory and visual feedback when someone or something touches different parts of the wearer's body.

Research in social touch indicates that it is capable of transferring messages and feelings among people. Moreover, different kinds of patterns can be interpreted in different manners; thereby we believe that these different meanings can refer to different actions while increasing the bond and communication between players.

Immersion

Even though there is an ongoing discussion about the meaning of immersion, it can be defined as "the sensation of being surrounded by a completely other reality that takes over all of our attention, our whole perceptual apparatus" [27]. More specifically, the prevalent definition of immersion in gaming offered by Brown and Cairns is the degree of involvement that moves along the path of time [4].

According to Brown and Cairns, who conducted experiments on gaming immersion, there are three levels of immersion: engagement, engrossment and total immersion. Total immersion is the presence in the most basic words. When one attains the total immersion level, he is cut off from reality and feels himself in a virtual world. The game becomes all that matters [4]. To become totally immersed one must first become engrossed. Engrossment is the middle step from engagement to total immersion, where the barrier is game construction [4]. If achieved, emotions are directly affected by the game. Brown and Cairns claimed that engagement and enjoyment is not possible if usability and control problems exist. Invisibility of the controls is an important aspect for all levels of immersion, but is vital for total immersion. Therefore, there needs to be an invisibility of controls for total immersion [4].

Ermi and Mäyrä, who have also conducted experiments on gameplay experience and immersion, identified immersion differently. According to them, there are three different immersion dimensions, all having different aspects. These are sensory, challenge-based and imaginative immersions [8]. These three immersions can mix or overlap in many ways and together create a gameplay the player wants. The first dimension, sensory immersion, relates to the audiovisual aspect of games. The second dimension, challenge-based immersion, can be related to motor skill, mental skill or both. Lastly, imaginative immersion means that the player is able to use her/his imagination, empathizes with the character, or enjoys the fantasy of the game and feels absorbed by its story. Although this definition investigates the game immersion considering its ludic, artistic and narrative properties, it does not offer an obvious hypothesis about the game control interface, therefore does not provide a strong base for our study.

While these definitions do not administer arguments about embodiment in games, experiments conducted by Berthouze, Kim and Patel clearly show a positive correlation between body movement and engagement [1]. Moreover, Isbister et al. pointed out that, as the body movement and effort put in a game increase, perceived fun also rises [19]. Thus, the more one moves, the more effort one exerts and the more immersed one becomes. In addition, the experiments show a contrast against the predominant view that immersion can only be achieved in a virtual reality environment. With increasing body movements, immersion is achievable with less virtual reality than previously thought [1].

In conclusion, previous work showed that total immersion can take place with more body movement and less machine-human interaction. We believe that social touch interaction can increase immersion by providing invisible controls and engaging players with bodily interactions.

PLAYER INVOLVEMENT MODEL

To overcome the ambiguity about the definitions of immersion, Calleja investigated immersion as a multidimensional concept, and introduced *the player involvement model* [6]. The model categorizes involvement into six dimensions and investigates immersion considering the players' perception about games in many different aspects which are adaptable to different types of game play styles. The experiment conducted by Herrewijn, Poels, and Calleja shows a positive correlation between player involvement model and immersion [14]. Furthermore, we believe that the involvement model is very useful for examining social touch as it separately focuses on social, kinesthetic, ludic and affective experiences. Therefore, our study takes the Player Involvement Model as a base for investigating the player experience. Dimensions of the player involvement introduced in that model are kinesthetic, shared, ludic, spatial, narrative and affective involvement [6]. In our research, we excluded spatial and narrative involvement and focused only on *kinesthetic, shared*, ludic and affective involvement since the game, Shape Destroy*,* does not include a gameplay that consists of characters, environment or story. Our reason for designing Shape Destroy is that a quite similar game was developed by professional game developers for a similar conceptual gaming environment in a previous research [5]. Details of the dimensions on which we base our study are listed below:

Kinesthetic Involvement: This involvement is related to all kinds of avatar or other game object controls in digital games. Calleja states, "This dimension of involvement requires more conscious attention when the controls make themselves present…" [6] meaning that the controller has a significant effect on this dimension, since it forms the communication between the game and the player. For example, Kinect and Wii controllers, which grant players to use their body for interaction, are thought to increase Kinesthetic involvement by providing the feeling of presence in the game environment. In other types of controllers like a gamepad, presence can be achieved by making it invisible to players. We contemplate this dimension as an important one, since our main contribution in this paper is to investigate the effects of a novel control method in digital games.

Shared Involvement: This dimension occurs when the same game is played with others. It can be achieved by split-screen multiplayer games like Mortal Kombat [32] or with online multiplayer games like World of Warcraft [3]. In both cases, players share the same game environment and react to same events. Players establish social bonds in those games, and these social bonds can sometimes be stronger than other types of communication like chatting [6]. Both the collaborative and competitive types of interaction between players have effects on the Shared Involvement. By design, shared involvement is the essence of our gaming environment since we believe that human to human social touch will create a strong attachment between players bolstering their shared involvement.

Ludic Involvement: Ludic involvement focuses on one of the most crucial differences between games and other digital entertainments like cinema and music: choices made by the player related to the game environment [6]. These choices can be made to achieve the goal of the game or just to enjoy the game. For the occurrence of the ludic involvement, players must feel like they control the game, and the flow of the game is affected by their decisions. Since we changed the control method, the perception of the game by players may change, too. Thus, it can change the level of ludic involvement.

Affective Involvement: During and after the gameplay, players give various kinds of emotional responses to the game. Feeling positive, irritated, victorious or bored can be examples of such emotions. We believe that Sensation will provide a boost in *Affective Involvement* since players' feelings and emotional responses will change when human-to-human touch, which is capable of expressing specific emotions, is involved in the process.

SENSATION

We developed Sensation as a device that is capable of detecting different kinds of touches, *touch patterns*, between players. The current version of the prototype is connected to a power supply and to a PC over the USB. Therefore, this prototype does not provide a wireless connection, although one is planned for future versions. Nevertheless, the cables attached are long enough to provide players freedom of movement.

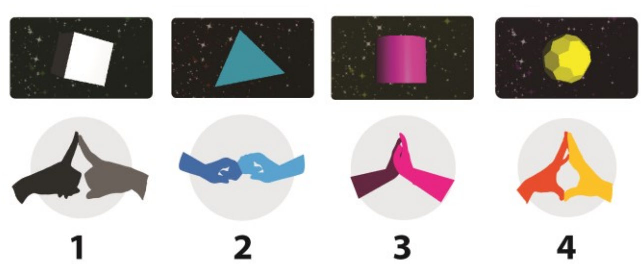

Figure 2: 1) 1-Finger 2) Bro-fist 3) Palm Touch 4) 4-Finger

In our current system, one of the players wears the Sensation on her/his arm. When worn, Sensation can detect several types of touch patterns by making use of changes in capacitance as two players touch each other. A simple calibration interface is implemented for players to map touch patterns to different actions. Therefore, players need to go under a brief calibration process in order to make device recognize different touch patterns that they defined.

Game: Shape Destroy

Shape Destroy is a two-player game based on social touch. It is played on a double-sided display, with players standing and facing each other and the screens in between them. The aim of the players is to destroy the four different objects in the shapes of cube, pyramid, cylinder and polyhedron. This game is based on a game which was designed in an expert workshop in our previous study [5].

Each shape can be destroyed by either a certain button (with a gamepad) or a touch pattern (with the Sensation). Touch patterns of the game are very similar to the ones designed in the expert workshop in our previous work, Dubtouch [5]: one finger touch, fist, firm grip, and hand touch. We made minor modifications by adapting them to this version of the Sensation (Figure 2). Therefore, the patterns we used were finger touch, bro-fist, palm touch and 4-finger. Palm touch pattern required a hold for several seconds. These gestures fall into Two Users and Hand Posture categories which were found to be both intuitive and exclusive touch patterns [5].

The process of the game is shown in Figure 3. In the 1st step, only the 1st player sees the shape and both players perform the required touch pattern. The 2nd player needs to guess the touch pattern by looking at the hand of the 1st player. In the 2nd step, the roles of the 1st and 2nd players are exchanged. In the game, only one participant sees a randomly created object at a time in her/his own screen, alternating each round. The goal is to destroy the objects by pushing the same button (with a gamepad) or applying a complementary touch pattern

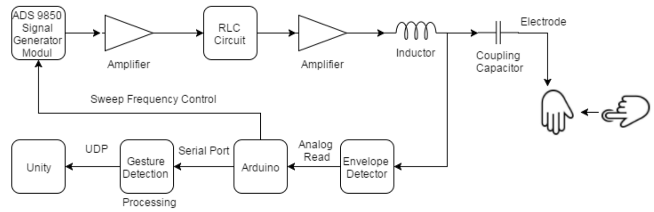

Figure 4: Sensation and its communication with unity.

(with the Sensation) that relies on the contribution of both players. The players need to cooperate and when a shape appears on one participant's screen, the player who can see it will try to describe a complementary pattern or show the button to the other player without speaking.

Technical Information

Sensation, which was developed to detect human-to-human touch patterns, is based on the Swept Frequency Capacitive Sensing technology (Figure 4) behind the Touché developed by Disney Research [35]. Capacitive Touch sensors, used in many display technologies, utilize single frequency capacitive touch sensing. This technology uses a single frequency periodic signal to create oscillations on an electrode. Once the touch event occurs, a capacitive link is formed between the human body and the electrode. Charge flows through the human body and brings about a change in the obtained signal. However, the sensor only detects whether the touch event occurs due to the change in the signal (Figure 4).

Unlike single frequency capacitive sensing which provides binary info, swept frequency capacitive sensing allows us to detect touch patterns. The electrode is a conductive material and is excited by a chirp signal in a certain frequency range; then the frequency response of the system is analyzed. The magnitude of the frequency response of the system reaches its maximum at the resonant frequency and the resonant frequency is directly proportional to system's total capacitance. The capacitive link changes the resonant

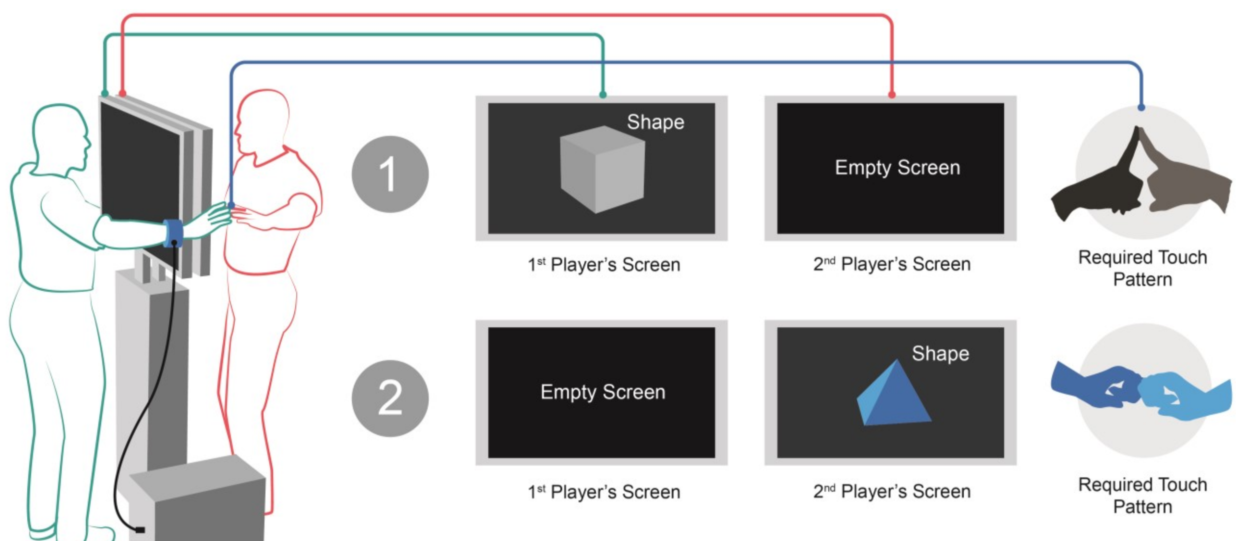

Figure 3: 2-step Gameplay loop for Shape Destroy

frequency of the system; in other words, shifts the frequency response. Thus, even the tiny shifts in the frequency response become detectable thanks to utilization of the swept frequency.

Human skin is a conductive surface, approximately 1MΩ (as found by our experiments) and can form a capacitive link nearly 200 pF [21]. The quantity of that capacitive link has values between 150-250 pF when a touch occurs between two people, proportional to the touch surface. According to these values, we designed the Sensation circuit to detect the effect of a small change on the total capacitance. The circuit design consists of a RLC circuit for bias resonant frequency ~100 kHz, a coupling capacitor for the capacitive link, an envelope detector circuit for detection of the return signal, AD9850 signal generator module and Arduino Uno as a microcontroller. The RLC circuit is excited with a swept frequency sinusoidal wave generated by AD9850, and the signal returned from the envelope detector is used for the detection of the touch area.

USER STUDY

We utilized a 6-step user test to compare immersion level differences between a conventional controller, a gamepad, and a touch pattern based controller, Sensation. A total of 30 participants played Shape Destroy both with a gamepad and with the Sensation and completed a set of questionnaires. We divided participants into two groups, group A and B, equally swapping the orders of control methods respectively. Group A played the game first with *a gamepad* and later with the *Sensation* while Group B used the *Sensation* first and a gamepad second. This process aimed at minimizing the *"learning effect"* on test results.

The steps of the user study were as follows (Figure 5): 1) fill out the Immersive Tendency Questionnaire (ITQ), 2) play the game with *Gamepad (A)/Sensation (B),* 3) fill out the Immersive Experience Questionnaire (IEQ) for the 1st gameplay session, 4) play the game with *Sensation (A)/Gamepad (B),* 5) fill out the IEQ for the 2nd gameplay session and 6) fill out the Experience Comparison Test. We used an environment similar to *DubTouch* and used the game *Shape Destroy.* Each session lasted for approximately 45 minutes.

Participants

Thirty participants (19 Male, 11 Female, M_{age}=21.4, SD_{age}=1.99) attended the experiment. Of these participants, 21 expressed that they allocated *0-3 hours* of their time a week for playing games while 9 of them allocated more than *3 hours*. Seven participants were involved only with *mobile games*, 12 with only *PC or Console games,* 7 played both PC/Console and Mobile games. Three of the participants indicated they were not into playing games on PC/Console nor on a Mobile Platform.

None of the participants had prior knowledge about the game and the study, so that all began at the same experience level. Group A had *16 participants* while Group B had *14 participants*. Each couple played the game in 5-minute-long sessions consecutively after a tutorial phase with each controller.

Questionnaire

Herrewjin, Poels and Calleja investigated the relationship between immersion and player involvement [14] and developed a comprehensive questionnaire which was compatible with the player involvement model. This questionnaire was prepared by combining several authenticated questionnaires: The Presence Questionnaire [37], The Immersion Scale [20], The Narrative Engagement Scale [12], The Self-Assessment Manikin [22], and The Game Experience Questionnaire [34].

The questions gathered from these studies are categorized as *General Involvement, Immersion, Kinesthetic Involvement, Spatial Involvement, Shared Involvement, Narrative Involvement, Ludic Involvement and Affective Involvement.* Other than these dimensions in the player involvement model, this questionnaire includes questions which measured *General Immersion* and *General Involvement*. *General Immersion* stands for presence related experiences while

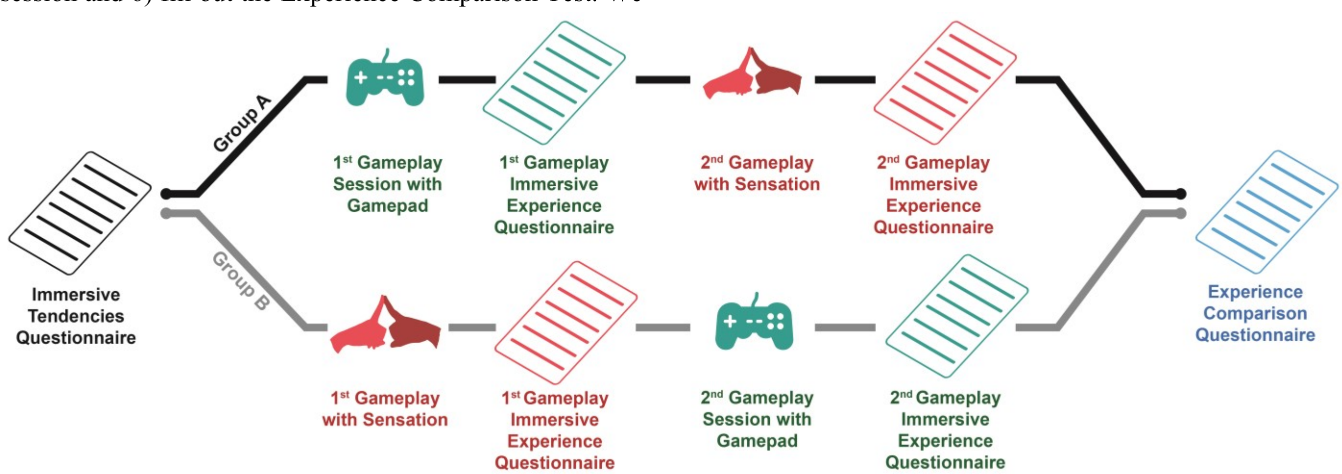

Figure 5: Structure of the User Study

General Involvement refers to absorption by the game which can be defined as the "game's capability of holding one's attention".

We selected the questions from this questionnaire to build two different questionnaires (the Immersion Experience Questionnaire, and the Experience Comparison Questionnaire) for our experiment. We chose questions which aimed at measuring general involvement, kinesthetic involvement, ludic involvement, shared involvement and affective involvement. Since the game had no story or characters, questionnaires did not include any questions about spatial and narrative involvement. Moreover, we did not include the questions for general immersion since these questions are based on presence, which requires a game world that players can feel in the shoes of their avatars.

RESULTS

Repeated Measures ANOVAs were used to analyze the difference between a gamepad and the Sensation for each immersion sub-category. The order of playing with a gamepad and the Sensation was the independent variable in these analyses. Results showed that *Order* did not have a significant relation with how subjects performed using a gamepad or the Sensation for all categories, $ps > .05$. However, there was an effect of playing on Gamepad vs. Sensation for all subcategories ($ps < .05$) except *Kinesthetic* and *Challenge*. Finally, no interactions between order and the type of play were found in any of the categories, ($ps > .05$); except *for the General Involvement* category, ($p < .05$).

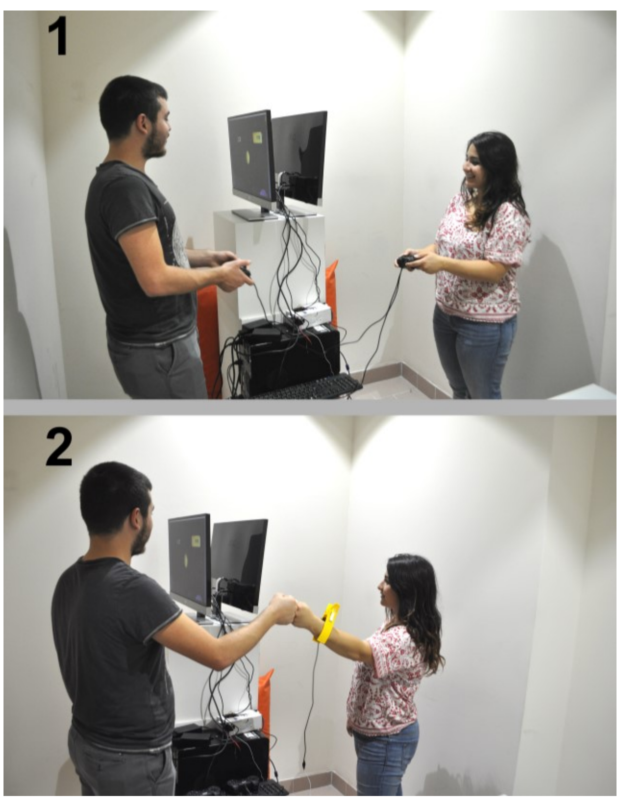

Figure 6: 1) Gameplay session with a gamepad 2) Gameplay session with the Sensation

Overall results presented in *Table 1* showed that the gaming experience provided by the Sensation outrivaled the Gamepad in the means of *General Involvement* ($F(1, 28) = 21.18, p < 0.001, \eta^2 = 0.43$), *Shared Involvement* ($F(1, 28) = 8.75, p < 0.01, \eta^2 = 0.24$), *Ludic Involvement* ($F(1, 28) = 7.00, p < 0.05, \eta^2 = 0.20$), *Competence* ($F(1, 28) = 5.46, p < 0.05, \eta^2 = 0.16$), and *Tension* ($F(1, 28) = 10.11, p < 0.01, \eta^2 = 0.27$), (*Positive* $F(1, 28) = 9.45, p < 0.01, \eta^2 = 0.25$) *and Negative Effect* ($F(1, 28) = 5.43, p < 0.05, \eta^2 = 0.16$). Due to an increase in these dimension, the *overall immersion score* also increased ($F(1, 28) = 8.16, p < 0.01, \eta^2 = 0.23$).

Results indicate that experience in these dimensions is more, (less for *Negative and Tension)*, likely to be provided in the gameplay sessions conducted with the *Sensation*. Nevertheless, the difference in *Kinesthetic Involvement* ($F(1, 28) = 3.52, p > 0.05, \eta^2 = 0.11$) scores does not indicate a strong significance level, meaning that although an inclination towards the Sensation was observable, this tendency is not as strong as expected.

	G.P Mean	G.P SD	Sens. Mean	Sens. SD
General	3.18	0.85646	**3.84*** **	0.69339
Kinesthetic	3.39	0.85592	**3.72**	0.73227
Shared	3.64	0.78381	**4.04** **	0.57988
Ludic	3.30	0.89558	**3.58***	0.76357
Affective Involvement(AI) (Competence)	2.99	1.07829	**3.45***	1.01971
AI (Challenge)	3,01	,53028	**3,10**	,55024
AI (Tension)	**1.84** **	0.74460	1.54	0.51327
AI (Negative)	**1.81***	0.63561	1.56	0.46346
AI (Positive)	3.35	0.93366	**3.70** **	0.89263
Overall	3.52	0.66895	**3.84** **	0.54918

Table 1: Overall Results for Gamepad and Sensation Comparison. G.P. = Gamepad, Sens.= Sensation Note: * p<.05, ** p<.01, *** p<.001

Other than the overall scores, we also analyzed the results of *"Order"* and *"Order Interaction"* values to see whether being in Group A or Group B affected the test results. This analysis aimed at understanding if *learning effect, fatigue* or other factors altered the outcomes. *Order* value referred to whether using controllers in different orders had any meanings on results. Collected *Order* values showed that Order Value did not affect the significance level of the results. The *Order Interaction* value demonstrated the impact level of the order difference for controllers. Outcomes implied that players in Group A seemed inclined towards experiencing *General Involvement* more, compared to Group B ($F(1, 28) = 7.51, p = 0.01, \eta^2 = 0.21$). Our results showed that the experience level in other dimensions did not show difference between the two groups.

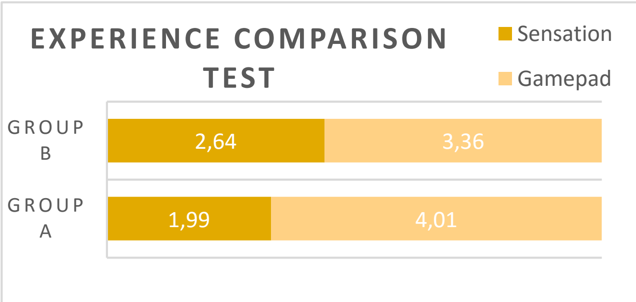

Table 2: Results of the "Experience Comparison Test" Closer scores to 1 indicate participants' preference for Sensation over Gamepad for both groups.

Table 2 presents the result of the Experience Comparison Test. We analyzed the comparison questionnaire to examine the total immersion level differences between the Sensation and a gamepad. In this questionnaire, participants were asked to select a score near 1 if they enjoyed the *Sensation* more, or to select a score near 5 if they preferred a gamepad, and select 3 if they enjoyed the Sensation and a gamepad equally. The two groups were analyzed separately. The lower mean value indicates that the participants favored the *Sensation* more. Both results show that both groups preferred the Sensation over a gamepad. However, we can see that the comparison questionnaire indicates a significant difference between the results of Group A and Group B, ($t(27) = 2.12$, $p < 0.05$.) We believe that the *learning effect* resulting from the different gameplay order may be the reason.

We also administered an Immersive Tendencies Questionnaire (ITQ) prior to the games to see whether subjects' individual variation in their tendencies to get immersed in activities would have any correlation with their actual immersions in the two game conditions. A correlation analysis showed that there was no significant correlation between the tendency questionnaire and subjects' actual immersion scores, $p > .05$. Therefore, participants' enjoyment is not affected by their immersive tendencies.

DISCUSSION

Player Experience

In the beginning of this study, our hypothesis was "Using social touch as a controller device would increase 1) kinesthetic, 2) shared and 3) ludic involvement 4) affective involvement and 5) increase total immersion level". Our findings show a strong relationship between immersion and social touch in digital games. While *general ($p<0.001$), shared ($p<0.01$), ludic involvement ($p<0.05$) and competence ($p<0.05$), tension ($p<0.01$), negative ($p<0.05$), positive feelings ($p<0.01$)* and *overall immersion ($p<0.01$) score* was ostensibly high in the Sensation, *kinesthetic involvement ($p>0.05$),* although inclined towards the Sensation, did not show a clear increase as expected.

The results show that our hypothesis seems to be verified, in the means of shared, ludic involvement and total immersion, yet the control method does not provide a strong kinesthetic experience which outplays the conventional controls effectively. Nevertheless, we can claim that our aim to provide invisible controls was achieved, since the specific questions[10][11] about this quality specifies an increase for the Sensation ($t(29) = 2.77$, $p < 0.05$). Therefore, we believe that this score can vary greatly for the games where physical interaction feels more natural. Furthermore, compared to a gamepad, using the Sensation is tiring and some of the participants expressed that they were tired during the game which may have affected their experience with kinesthetic involvement. Thus, games that require more ergonomic body position or use fatigue as a feature as proposed in previous research [26] may increase this value.

As we predicted in the hypothesis, an increase in shared involvement provided by the Sensation is observable. Shared involvement refers to how players empathize and feel connected to their game partner. We believe that physical contact between players may facilitate the empathy between players and increase their connectedness to each other compared to the distant position. Therefore, social touch can be an appropriate and novel control method for pervasive games having collaborative mechanics.

Our analysis did not indicate a clear difference between the immersion scores of players whose gaming habits were different. However, during the study we observed that less experienced players tended to enjoy the *Sensation* more. Experienced players still found the Sensation more involving than a gamepad; however, with a smaller difference, when compared to the second group. These facts indicate that rather than replacing traditional controllers, Sensation might attract new players who do not play games often. People who find traditional controllers less stimulating might find the Sensation more interesting.

Comparison Questionnaire demonstrated that Group A enjoyed the Sensation more than Group B. We believe that the *learning effect* can be the reason. None of the participants had prior knowledge or experience about the game that we introduced. Therefore, experience in the 1st gameplay sessions was affected by a learning process. Thus in group B, participants could not engage with the game via Sensation as much as group A.

[10] "I could concentrate on the assigned tasks or required activities rather than on the game controls used to perform those tasks or activities."

[11] "I became unaware that I was even using any game controls."

Different aspects of Human-to-human Social Touch in Games

Results of the study indicated a rise in the player experience with the use of the Sensation. HHST has many aspects which may cause this rise. In this part we will discuss possible reasons for the enhanced experience.

According to our observations, we believe that the main reason for the increase in experience is the varying physical quality of the interaction with players. The palm touch, the 3rd touch pattern, was one of the interactions which let us observe this quality clearly. The physical impact, which was reported as an exclusive touch pattern in our previous work [5], and the protracted contact heightened the collaboration feeling and thereby the fun experience. Moreover, we observed that different characters of touch patterns alter the experience of touching each other. If touch patterns were not varied, same touch interaction would become mundane even if it was in the physical impact category. We observed that players overtly enjoyed switching between touch patterns especially when they had different characteristics. For instance, changing from 1-finger touch, which was in the "Hand Posture" category [5], to bro-fist, appearing in the "Physical Impact", were more exciting compared to changing from 1-finge to 4-finger. Therefore, improving our previous work, we can state that usage of different touch pattern characteristics is preferable for HHST in games.

With the Sensation, the level of ludic involvement felt by players increased. Changing the control mechanism also changed the way players used to reach the goals although the other properties of the game were exactly the same. Most participants concentrated better on their goals while playing with the Sensation, since they were in physical contact with their partner. It was also more intuitive to understand the complementary gesture compared to checking other players' gamepads to see the right button. Thus, their ludic involvement increased significantly as their concentration on game tasks increased. The game pad controls, although they took longer to adapt, did not make the gameplay significantly difficult since we passed the adaptation process in the tutorial section. Overall scores also did not indicate a better performance with the Sensation. However, we observed that the control method also became an enjoyable game while participants tried to explain the right gesture without speaking. Yet, the same effect was not observable for the gamepad since checking the controls become mundane after a while. Therefore, the use of social touch as proposed in our study reveals a new approach to control interfaces by involving these interfaces as a part of the game. The invisibility of the controls is not provided by making them unnoticeable to players but to integrate them as a part of the game. It gets different from pushing a button, which is an action solely done for triggering events in the game, by being transformed into an action which is the part of the game.

A novel character of the Sensation may have an effect on the player preferences between the game pad and the Sensation. The IEQ aims at measuring the experience in many different aspects. If we only measured the effect on the fun experience, the novelty of the Sensation may have had a stronger manipulating effect. However, in this case, we did not observe an increase in Kinesthetic Involvement on which we expect the novelty of the controller to have the biggest effect since this dimension is strongly related with the perception on controllers. Moreover, the game and the way it is played was also novel to players even when they were playing it with a game pad. Therefore, the boost in the immersion level was not caused by the usage of a novel control method but by novel experiences provided by it.

Although this study focused on the effects of social touch on the game experience on an individual basis, different characters of couples playing the game may result in different experiences. For example, some participants who had previous acquaintance indicated that their friendship affected the enjoyment they got. Previous research about the utilization of social touch in HCI verifies that experience [38]. Our observations showed that those players who knew each other well tended to play the game with a more synchronized body language than those who did not. Therefore, further studies may be conducted to understand the effect of acquaintanceship in a gaming environment utilizing social touch.

Game: The Shape Destroy

The game, Shape Destroy, was specifically designed for social touch and face to face positions of players in an expert workshop which was conducted in our previous research [5]. As a sole digital game, Shape Destroy is quite simple. However, we believe that it fits our context where we introduce a novel control method and a completely new way of collaborative interaction. Although the digital properties of Shape Destroy are simple, the face to face positions of players, alternating visibility of displays and no-speaking rule are novel additions to game mechanics. These additions also made the game appropriate to be played with social touch.

Although we believe that Shape Destroy is an appropriate game for the introduction of such system, different kinds of games also have possibilities to be played with social touch. Positions different than face-to-face, like side-to-side, also may prove novel interactions. Moreover, our previous work proved that social touch is capable of conveying emotional messages between players [5] which suggests implementing narrative based games to be played with social touch. In this way, investigation of Spatial and Narrative involvement will also be possible.

As a result of our study, employment of social touch in digital games proved to be a valuable contribution. Results show that social touch increases the general, shared and ludic involvement in the game. Moreover, players felt more positive, competent and less tense towards the *Sensation*. Although kinesthetic involvement scores were prone to *the*

Sensation, they do not show a strong significance as a general control method. However, results show that it provides a much more invisible interaction than a gamepad. Moreover, the player experience study also cast light on different aspects of social touch which should be researched by further studies. The effect of the relationship between players on the experience, how touch patterns specifically alter the experience, different game genres for social touch and different body positions during the gameplay are some of these aspects. Overall, we believe that social touch is proved to be a valuable alternative as a control method for pervasive and physical games and further studies should be conducted to explore this area with more depth.

CONCLUSION

In this study, we introduced a novel controller, the Sensation, which enables players to play games by touching each other by different touch patterns and designed a game, Shape Destroy, drawing on an expert workshop conducted in our previous study [5]. Moreover, we conducted a user study with 30 participants by analyzing four dimensions of the player involvement model [6]: (Kinesthetic, Shared, Ludic Involvement and Affective Involvement) to understand if HHST can add to the collaborative game experience and have potential for further research.

Results of the user study indicated that the overall user experience is improved especially with the boost in *ludic* ($p<0.05$)*, shared* ($p<0.01$)*, general* ($p<0.001$) and *affective involvement (competence* ($p<0.05$)*, tension* ($p<0.01$)*, negative* ($p<0.05$)*, positive feelings* ($p<0.01$)*)*. Due to the rise in these dimensions, the *overall score* ($p<0.01$) of the test also advanced. The increase in *kinesthetic involvement* ($p>0.05$) with the Sensation is lower than what we expected. Although results indicate that invisibility of controls was provided, other dimensions of control should be improved and tested with different game genres and body positions. Therefore, we believe that HHST could be very meaningful as a new controller even in simple games as we used. With this system, it is possible to put social touch into games collaboratively and its contribution to competitive games is open for exploration.

Our observations showed that HHST changes the player experience by letting players physically affect the controller (the other players' hand) and manipulate it. Moreover, non-digital rules like "no talking", can be more easily achieved with social touch. Therefore, we see that new non-digital mechanics, rules and interaction styles can be possible in games with the use of HHST. It is possible to apply these to both collaborative and competitive games along with different game genres.

Results showed that the use of social touch interaction between people in a gaming context is an important alternative considering the growing popularity of full-body utilization in games. Results indicate that social touch can be quite valuable for enhancing collaborative gaming experiences in games designed for full-body engagement.

LIMITATIONS & FUTURE WORK

We have gathered successful results regarding touch experience in gaming, but since we worked with a new technology there were some technical limitations.

The Sensation module works smoothly for games controlled with basic gestures. The available gestures can be increased with the use of different sensors like tendon or sound sensors. Therefore, a wide range of games with different characteristics can be developed.

Capacitive effect due to interaction varies from person to person. Therefore, the Sensation can work after an individual calibration. We plan to improve this feature to make it work for everyone without calibration. Moreover, we are still studying the Sensation device to detect touch patterns between three or more people for multi-player games.

In order to obtain more comprehensive, reliable and extensive results on player experience, usage of psychophysiological methods is also possible [24]. However, experiment setups have a possibility to hinder social experience since additional devices need to be attached to players. Nevertheless, we consider applying these if we can reduce their effects on social experience.

The comparison made in this study included the Sensation and a conventional game pad. However, how social touch alters the player experience when compared to embodied control methods like mid-air gestural interaction which can be provided by game consoles like Xbox with Kinect and Wii will be investigated in further studies.

Our results showed that human-to-human touch is promising for the gaming field; therefore, our work aims to improve the *Sensation* in technical aspects and measure its effects on *Player Experience,* with a wide range of game genres and with objective methods.

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