Touchomatic: Interpersonal Touch Gaming In The Wild

Joe Marshall
Mixed Reality Lab, School of Computer Science
University of Nottingham, UK
joe.marshall@nottingham.ac.uk

Paul Tennent
Mixed Reality Lab, School of Computer Science
University of Nottingham, UK
paul.tennent@nottingham.ac.uk

ABSTRACT
Direct touch between people is a key element of social behaviour. Recently a number of researchers have explored games which sense aspects of such interpersonal touch to control interaction with a multiplayer computer game. In this paper, we describe a long term, in-the-wild study of a two-player arcade game which is controlled by gentle touching between the body parts of two players. We ran the game in a public videogame arcade for a year, and present a thematic analysis of 27 hours of gameplay session videos, organized under three top level themes: control of the system, interpersonal interaction within the game, and social interaction around the game. In addition, we provide a quantitative analysis of observed demographic differences in interpersonal touch behaviour. Finally, we use these results to present four design recommendations for use of interpersonal touch in games.

Author Keywords
Interpersonal touch; game; in the wild; arcade.

ACM Classification Keywords
H.5.2. *Input devices and strategies*

INTRODUCTION
Touch between people is a key part of social communication, being part of everything from early bonds of caring touch between parent and child, to the many uses of touch in later life, communicating friendship, aggression, physical attraction and physical competition [39]. However, as Marshall et al. [25] note, interpersonal touch is largely unused in computer entertainment, with most games designed for some form of 'parallel play', where all interaction between multiple players is mediated via computer systems and increasingly via remote network connections.

In this paper, we present a study of a two-player game which senses nuances of pressure in gentle interpersonal touch in order to provide control to an airship flying through a mountainous landscape. To achieve a high score in the game, players must collaborate and negotiate to adjust their touching behaviour in order to fly the airship accurately. We believe this kind of gentle, extended touch interaction has the potential to arouse strong affective responses in players which are qualitatively different to those in previous interpersonal touch games which focus on extreme force [25] or the use of touch patterns as discrete individual inputs directly analogous to gamepad buttons [6].

Psychological and sociological research on interpersonal touch (e.g. [11,31,32]) often occurs in naturalistic environments, with the view taken that social and affective elements of interpersonal touch are unrealistically affected by laboratory settings [32]. In concordance with this work, we ran a long-term study of our game in a real-world videogame arcade, without researcher intervention. This year-long study provided us with a large amount of video recordings and gameplay logs which enable us to reach a deep understanding of how people play our game.

We analyse these video recordings and apply a thematic analysis [5] methodology, providing insight into player behaviour in the form of a set of explanatory codes arranged in three top-level themes:

- How players control touch sensing hardware.
- How players behave towards each other.
- How people around the players affect the game.

We follow this with a brief statistical analysis of how demographic variables (visually estimated age and gender) relate to higher or lower levels of some behaviours, for example showing that male/male pairs are less likely to show physical affection than pairs involving female players. These results are largely consistent with psychological research on interpersonal touch, so to us as game designers and researchers, they demonstrate that demographic variables have a real effect on players' experience of interpersonal touch.

We conclude with a discussion of what these results mean for the design of interpersonal touch games, in the form of 4 recommendations for game designers. In summary, the contributions of this paper are:

- Design of an **interpersonal touch game**.
- A **year-long in-the wild study** of our touch game.
- **3 themes** relating to how players play the game.
- **4 recommendations** discussing how to design interpersonal touch games.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.
DIS 2017, June 10-14, 2017, Edinburgh, United Kingdom
Copyright is held by the owner/author(s). Publication rights licensed to ACM.
ACM 978-1-4503-4922-2/17/06…$15.00
DOI: http://dx.doi.org/10.1145/3064663.3064727

PRIOR WORK

Experiences of social and affective interpersonal touch have been studied in a wide range of areas, both within HCI, and in wider social and psychological research fields.

Social Touch Gaming, HCI and Art

A small number of projects have directly explored interpersonal touch in entertainment situations. In particular, two projects explore the detection of hand to hand touch - gaming system *Sensation* [6] uses capacitive sensing to detect two person touch gestures, such as 'bro-fist' & '1 finger touch', which control a game in which players make the gestures together. *Enhancedtouch* uses bracelets which detect and measure human to human touch times [38], which are used to measure touch behaviours in games for children with autistic spectrum disorders. Performance work *Mediated Body* [17] also uses interpersonal touch sensing, with a private light and sound show controlled by touch between a performer and an audience member.

Several systems do not detect touch, but rather encourage forms of social touching: *Musical Embrace* [18] is controlled by a cushion between two players who hug to control a 3d game, creating a deliberately 'uncomfortable interaction' [4]. *Balance of Power* [25], encourages people to brutally force opposing players to move. *B.U.T.T.O.N* [41] gives players instructions such as 'the last player to let go of their controller button wins', designed to encourage players to use imaginative 'Brutally Unfair Tactics' for example to grab controllers off other players; similarly *Intangle* [13] uses shared controllers and instructions which encourage physical social interactions between players.

A key element of *Balance of Power* and *B.U.T.T.O.N.* which we aim to replicate here is that they create a system of rules and rewards but do not enforce particular mechanisms or specify player movements for game outcomes. We believe (after Gaver et al. [14]) that such deliberate use of ambiguity and lack of instructions inspires people to imaginatively explore the range of physical actions which will make a system respond in a desired fashion. In this research however, by creating something which responds to a wide range of inputs, we aim to make something which allows and responds to subtle differences in touch and gradation of control, in contrast to the extreme brutality of *Balance of Power* [25], the simple joypad sensing of *B.U.T.T.O.N.* [41], or the discrete gestures used by '*Sensation*' [6].

Mediated and Computer Generated Social Touch

Many HCI projects explore use of networked computer systems to create experiences of touch between remotely situated participants to communicate or induce affect. For example *move.me* [35] involved a pillow which senses pressure and actuates a remote pillow, aiming to allow remote intimacy. *Poultry Internet* even allows animal owners to stroke their pets remotely [8]. There is also work on the generation of synthetic social touch cues, such as *tactile jacket* [22], which generates tactile affective cues to accompany movies, and robots which aim to touch socially. While we focus here however on direct human-to-human touch, interested readers may wish to read van Erp and Toet's comprehensive review of social touch in HCI [10].

Social and Psychological Interpersonal Touch Research

Touch between people is interesting for game design because: "*tactile sensations elicited under ecologically-valid conditions that involve interpersonal interaction can have surprisingly powerful effects on people's behaviors and emotions* " [12]. Social and psychology work relating to touch also provides several useful insights into both how we experience touch, and what the potential effects of touch might be. Touch can be used in a discriminative nature, for feeling our surroundings, and can have strong emotional effects on those touched, both positive and negative [26]. Touch has also been shown to communicate emotion between two people [16], and alter social situations, such as tipping in restaurants [37] or selling second-hand cars [9].

How and where people are touched on their body is also important – with a key distinction being between hairy and non-hairy parts of the skin, with hairy skin often linked to more pleasurable touch sensations [26], although recent research suggests combinations of hairy and non-hairy touch can also be pleasurable [23]. Touch is also deeply social and interacts with many factors beyond the pure physical nature of contact – for example studies have shown differences in how effectively people in relationships can communicate emotions compared to strangers [40] and touch actions which would be identified as loving within an intimate relationship, are perceived as harassment within a working environment [21]. Touch can create different effects depending on the gender of the person giving [11] and receiving the touch [37]; a relevant corollary of this work is that in many touch situations there is a clear directionality as to who is doing the touching which is clearly relevant to gaming situations. Further to this, we note that cultural aspects of social behaviour also affect touch, with cultures often described as 'non-contact' (e.g. UK, USA) or 'contact' (e.g. Italy, Spain, Latin America) [15] depending on whether people from those cultures are comfortable with high levels interpersonal touch in general. As well as affecting underlying rates of touching, cultural differences intersect with other factors, affecting for example how comfortable people are with same sex touching or in what relationships they would consider kissing to be appropriate in [34:168].

As well as considering study results, social science research into touch is key to the design of our study. Social touch research often involves naturalistic studies, for example studying the effects of touching on positive appraisal of those doing the touching, done in a real library during checking out of a book [11], and study of touching by real waitresses in restaurant situations [37]. We take particular inspiration from Remland et al's work on proxemics and touch in different countries, which used video-recording of large numbers of subject interactions in situations chosen to be naturalistic and representative of the culture of the countries studied [31,32].

Figure 1. Touchomatic Arcade Cabinet

THE TOUCHOMATIC HARDWARE

The *Touchomatic* arcade cabinet is built around a standard two player sized arcade cabinet containing a standard PC and monitor, webcam, speakers, and a lighting board and LEDs to make the game name at the top of the cabinet flash pretty colours during the game. Instead of the joysticks, the control board contains just two large metal handles with arrows saying 'Player 1' and 'Player 2' next to each handle. An Arduino is connected to each handle using the circuit shown in Figure 2. All source code is linked at the end of the paper. The Arduino gathers data at 100hz using two types of sensing:

Capacitive Person Sensing:

Capacitive sensing is used to detect if anyone is holding each handle. This uses charge / release capacitive sensing on a single Arduino Analog pin connected directly to the handle (i.e. pin 3 or 4 on the diagram). Pins 1 & 2 are set as inputs which are for practical purposes disconnected. The sampling pin is first set as output and held low to discharge any residual charge. Then it is set to input mode and pulled high using the Arduino's built in pull-up resistor. The time this takes to return to 5v is proportional to the capacitance attached to the handle. The pin is sampled repeatedly to estimate speed of return of the pin voltage and hence the capacitive load. When a large capacitance is detected, the system reports that a person is touching the handle.

Resistive Circuit Sensing

Resistive sensing is used to detect whether and how strongly the two players are touching each other's skin. In resistive mode, pins 1 and 2 are set to zero to provide a weak pull-down resistor. The system then generates an oscillating signal on pin 3, by outputting a series of 1 and 0s, whilst reading from pin 4. The oscillating signal is received on pin 4 at a strength which varies depending on the overall resistance between the two player handles. Rather than measure the oscillating signal directly, we measure the variance of the received signal; this negates issues with delays caused by capacitance. For a given touch pose, such as finger to finger, resistance decreases as touch strength increases; this allows for detection of a smooth range of touch strengths (our system reports 512 different strengths).

After the each measurement cycle, Pins 3 and 4 are swapped and the same measurement is applied, to measure this resistance in the other direction. This should not in theory make any difference to measured resistance, but in practice it does, presumably due to differences in internal Arduino measurement circuitry; by swapping the direction of the sensing each measurement cycle, we ensure that the game is as symmetrical as possible.

The respective types of sensing are switched between at approximately 200hz, giving a full data rate of up 100hz.

Sensor Processing

The raw data from the two sensors gives us two basic pieces of information:

1) Is there a person or people holding each handle?
2) What is the resistance between the handles?

The raw sensor data is processed to obtain two further items of data, firstly by detecting moments where capacitive sensing detects a person touching both handles, yet resistive sensing does not detect a circuit, we can detect that there are indeed two people touching the handles, rather than one person touching both handles. We use this to enforce two person play in our games. Secondly, by sensing moments of no-touch followed by short moments of touch, we sense a high five gesture which is used for starting games etc.

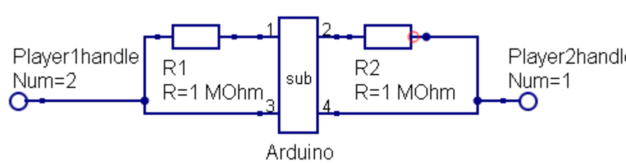

Figure 2. Touch-O-Matic Sensing Circuit

Figure 1. Two players of Astonishing Airship Adventures and game screen

ASTONISHING AIRSHIP ADVENTURES

We built a game called *Astonishing Airship Adventures* (*AAA*, Figure 3) to test *Touchomatic*, it is presented in sepia tone, with accompanying 1920s jazz music to match the bare wood aesthetic of the arcade cabinet. In *AAA*, players control an airship which is flying over a barren landscape. They must fly close to the ground to collect coins, whilst avoiding crashing. The balloon's height is controlled by the touch interaction, with stronger contact increasing the onscreen throttle gauge and making the ship fly higher. A new level occurs every 20 seconds – on higher levels the scenery becomes increasingly hilly (see Figure 5), making it harder to fly low and score, and more likely that players will crash.

Design Choices

When building *AAA*, we made several deliberate design choices to best support the Touchomatic:

- With the exception of text, the game and arcade cabinet is entirely symmetrical, the balloon flies away from the players and is directly between them. This was important as we wished to remove any cues that would imply one player was more important than the other player.
- The game is entirely controlled by touch, including starting the game, and consenting to the research video recording. We did not want players to be required to interact in any way other than interpersonal touching.
- The game starts off extremely easy, and gets difficult quite slowly, because we wanted to observe people playing for significant lengths of time, and wanted them to be able to explore the unfamiliar touch interaction without too much pressure to begin with.
- To encourage people to use the control in a nuanced way, getting a high score requires using detailed control interactions to fly very low.

Game Trajectory

Because the game must run unattended, we designed an overall experience for the pairs of players with all instructions coming from the game itself via a tutorial level.

Figure 4. Title screen

Figure 5. On higher levels, the terrain becomes more rugged.

The initial title screen begins with an instruction that two players must grab a handle each to play (Figure 4). Once the system detects both handles are touched, it checks that there is no connection between the two; this makes sure that it is two people, rather than just one person touching both handles. It then changes the text to "High five to play". Next, a video recording consent screen is shown, this shows the video camera image and notifies players that games are recorded, and to high five if they are happy to continue. The game starts with the airship landed and the instruction 'touch each other to fly'. As soon as the players touch, the ship takes off, and further instructions are shown ('the harder you touch the higher you fly' etc.). The player cannot crash in this section and can experiment with flight controls. After 10 seconds of instructions, the game proper begins and players can fly until they crash or run out of fuel. On achieving a high score, players are again shown the camera video, and a photo to be shown on the high score chart is captured when they do a high five.

STUDY

We installed *Touchomatic* at National Videogame Arcade (NVA), Nottingham, a public gaming arcade which showcases a wide range of classic and experimental gaming machines. Entry to NVA is by paid ticket, with game machines set to free-to-play. It is open 3 days a week normally and all week in school holidays.

This setting allowed us to study *Touchomatic* in the wild, in a real world setting, surrounded by other gaming machines, for example in the first half of the year, *Touchomatic* was installed in between the classic fighting game *Street Fighter II* [7] and Nintendo's *Duck Hunt* [27], and towards the end, when the arcade was reorganized, it was moved to be next to an early *Tetris* [29] arcade machine.

We left *Touchomatic* running for a full year, recording video of players, screen capture, and logs including data such as state of the touch input, score, level and player position. For privacy, we did not record player audio. In addition to venue consents and signage explaining that public video recording occurs in the arcade, players were specifically informed of *Touchomatic*'s video recording each time the game began, with a screen notifying that the game is recorded, showing them the view from the camera, and asking them to high five if they are happy to be recorded.

We had access 3 times over the year to maintain the machine and retrieve data, in between maintenance was performed by the arcade's in house team, who have significant experience of keeping game machines in playable state.

After running the game for a year, we retrieved all data from the game machine and performed a thematic analysis [5] on the data to explore how people actually played the game in this real world, in the wild setting.

Data availability and Ethical Approval

This study was approved by the School of [XXX] at the University of [XXX]. Video data from the *Touchomatic* is personally identifiable data which we do not have consent to share. Images shown here are blurred for privacy. Our coding dataset is included as supplementary materials.

Dataset Processing and Analysis

During the game's run, we had limited access to the machine, and maintenance was performed locally by the arcade staff. Their only priority was to keep the game itself working, for example by fixing loose game handles, replacing speakers which had been poked by children, cleaning screens etc. They were not interested in the game camera or network connection of the game. Because of this, there were some points in time were the camera was forcibly removed or where video capture software on the system failed, which we were unable to diagnose or fix for an extended period of time.

Players played a total of 3412 games, over 157 hours. We checked all the videos to recover games with full datasets including video. This gave us 93 hours of gameplay. For the purposes of practical analysis, we chose to analyse 500 games (27 hours of video) taken from the earliest and latest sets of games in the dataset; we did not observe any difference between early and late gameplay, probably due to the visitor attraction nature of the arcade meaning that there are few regular players, so most players will be experiencing the game on only one day, so we treat this as a single dataset representing typical play of *Touchomatic*.

From our initial set of 500 games, we initially briefly watched each video to check whether the gameplay video was usable, specifically noting whether: a) both players are visible, and b) the touch between players is visible. This gave us a set of 347 videos in which gameplay and players are visible. We also annotated each video with estimated demographic data, including a) estimated age for each player, as child (<12), teen (12-20), or adult (20+), and b) presenting gender of each player, male / female / uncertain.

Treating each gameplay video as a unit of assessment, we then analysed videos to identify player actions observed in the data and assign (potentially multiple) codes to each unit. We split this work between two researchers, who initially each independently watched half of the dataset and assigned their own set of codes describing actions of players in the games. We combined the two sets of codes and developed a shared code set around a set of themes, which we applied to the full dataset for the analysis described below.

DEMOGRAPHICS

Our dataset included 435 male players (63%), and 255 female (37%), 4 players were of uncertain gender. There were 179 same gender pairs, and 167 pairs of opposite gender players. We estimated 143 players (21%) were children, 195 (28%) teenagers and 353 (51%) were adults.

THEMATIC ANALYSIS

Our codes split into the three themes shown in Figure 6:

- Methods people use to **control** the touch sensing.
- **Interpersonal** interaction between players.
- **Social** interaction with people outside the game.

We describe these in the sections below. This is a primarily qualitative analysis, however where we make assertions of between-group differences relating to our codes, we apply appropriate statistical tests.

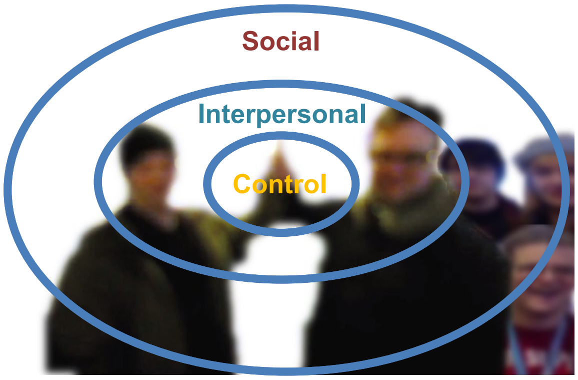

Figure 6. The three themes from our analysis

Theme 1: Methods to control the touch sensing

This theme relates to ways in which players move their hands and other body parts in order to actuate the touch sensing controls of *Touchomatic*. 358 of the 844 coded units are accounted for by this theme.

Whilst the start-up sequence of Astonishing *Airship Adventures* encourages players to do a high five, i.e. to use palm to palm contact, no direction is given in the rest of the game as to how to touch each other. We saw many examples of player pairs ***experimenting with ways of touching*** (86 units), for example by trying to touch through clothes, or touching heads together. Several pairs explored ***playful methods of touching*** (35 units), such as face touching, and even one pair who played the game by touching their heads together (Figure 7).

The touch detection hardware simply detects the quality of electrical connection between players, which, as long as players maintain the same type of physical connection, relates strongly to the overall pressure between players. The game does not change depending on how this pressure is applied. We observed several different approaches to controlling this pressure: many pairs of players began by adopting an approach of ***reciprocal touching*** (83 units), where both players adjusted their touch pressure at the same time. Pairs often however adjusted their play style to one in which ***one player takes control of the touch pressure*** (53 units), with the other player holding their hand or other body part still, often this involved an element of taking turns as to who was in charge. This was not always a simple negotiation as players did not always agree on who was in charge, we observed several ***moments of physical disagreement*** (22 units) where one player attempts to increase pressure and the other simultaneously moves their hand away to decrease pressure.

Touchomatic is designed to allow smooth, gentle analogue control. However, we noticed several players appeared to find modulating their touch levels difficult. Whilst some of these players simply ***failed to modulate touch pressure*** (14 units) and their airship oscillated wildly up and down, others found a work-around by treating the system as essentially a digital input, using a ***series of repeated taps*** (65 units) of greater or lower frequency depending on how high they wished their airship to go.

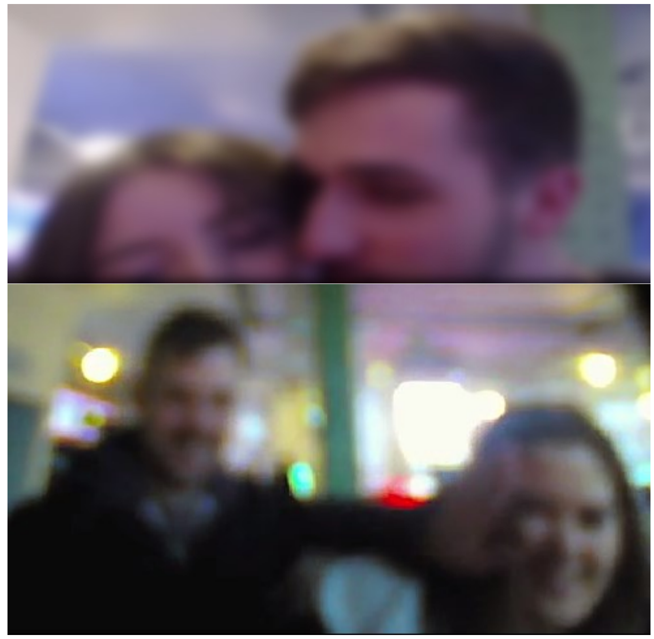

Figure 7. Players Bumping Heads and Touching Faces

Theme 2: Interpersonal interactions between players

This theme is concerned with ways in which players interacted together beyond purely controlling the touch sensing hardware, the 427 units in this theme provide insight into wider aspects of the interpersonal interaction between players.

One element of deploying this game in a real arcade which we had not anticipated or seen in deployments in research settings, was the very high incidence of ***play-fighting and forceful pushing*** (98 units), with players enjoying that they could slap each other in the face to control the game or use pushing the other player to the floor or punching fists together as part of their control strategy.

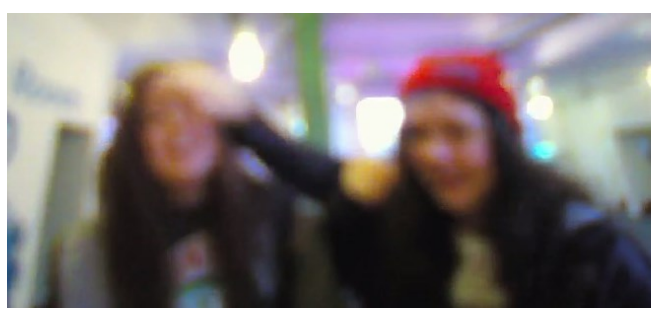

Figure 8. Right player hits left player in face.

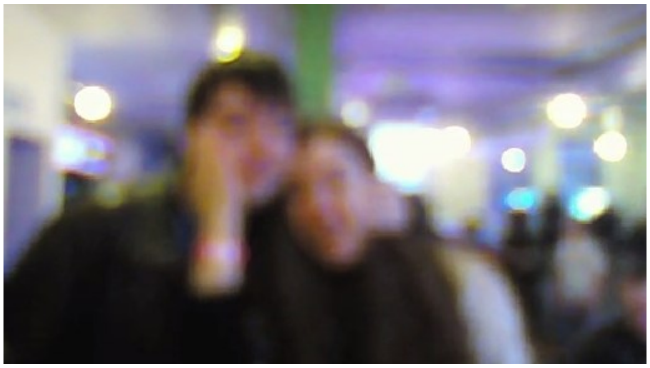

Figure 9. Cuddling heads and faces together to control the game

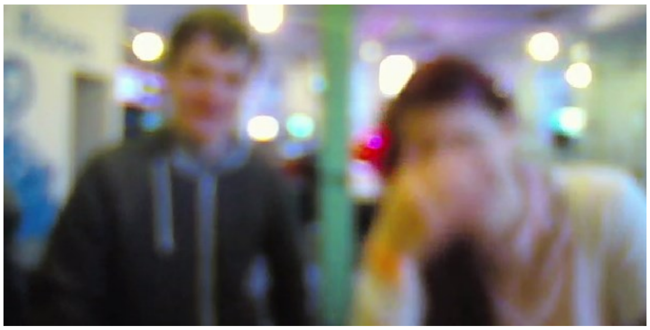

Figure 10. Moment players realise they must touch each other

Players also made another use of interpersonal touch by controlling the system in ways that ***demonstrated affection*** (34 units), such as by hugging, kissing, or stroking the other player (Figure 9). Other players were clearly uncomfortable with the level of intimacy involved in human-to-human touch, and showed ***physical signs of feeling awkward*** (38 units), such as shying away from the other player's touch, refusing to play at all, and facial signs of awkwardness such as extreme grimaces and 'face-palming' as the player reads the instruction to touch the other player (Figure 10).

We also observed some distinctly contrasting styles of play – a large number of pairs were observed ***laughing constantly throughout*** (78 units), whereas a small number were observed to have adopted a ***highly focused play style*** (13 units), staring intently on the screen and focusing purely on the game (Figure 11 shows examples of both styles). We suggest that these two behaviours imply two differing conceptions of the computer game itself, by laughing players the game may be seen as stimulating a wider play situation, whereas the more focused players are not interested in what is going on around the game. Those who adopted the focused play style certainly had more success purely in the terms set by the game, lasting for longer before crashing (median=447 seconds) compared to the laughing group (median=143 seconds); a Mann-Whitney test indicated that this difference is significant, $U=159.0$, $p<0.001$

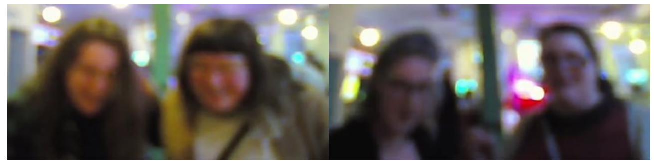

Figure 11. Contrasting play styles: laughing (L) vs focused (R)

One final aspect of social behaviour around the game which was observable in our video data is how players get bored and give up on the game. The difficulty level of the game was deliberately slightly low, plus for players who did not choose to collect coins and aim for a high score, it was possible to fly high for a large number of levels before fuel ran out. Because of this, 34% of players ***gave up playing before they crashed*** (120 units). This was in part made worse by the two player only nature of the game – unlike many arcade games, where if one player leaves, they drop to single player mode, if a player leaves the *Touchomatic*, whilst the single player left can grab both sticks and control it by releasing and touching one stick, much of the fun of the game is lost; evidence for this is seen in our analysis, where if ***one player leaves the game first*** (46 units), the other player is more likely to give up before crashing also, giving up 64% of the time (this difference is significant, Fisher's Exact Test, $p<0.001$).

Theme 3: Social interaction with people outside the game

Our final theme (59 units) relates to ways in which the game situation is affected by and affects people who are not directly involved in the game. Players using *Touchomatic* are often doing something which is visibly odd in a public gaming arcade, which attracts spectators. It was quite common to see situations where ***spectators advised or helped players*** (33 units), for example by physically gesticulating to demonstrate what players should aim to do, or by showing players that they had to keep their hands on the handles. We also saw several situations where a ***spectator enters the game*** (10 units), either taking the place of one of the players, or getting in between the two players to become part of the circuit between them (Figure 12).

The other way in which players interact with others via the game is through the pictures shown in the high score chart which are visible to future players and spectators. We saw that when this happened, players often took some time playing in front of the camera and ***composing their high score pictures*** (16 units), sometimes including bystanders also. Figure 13 shows some examples of high score poses.

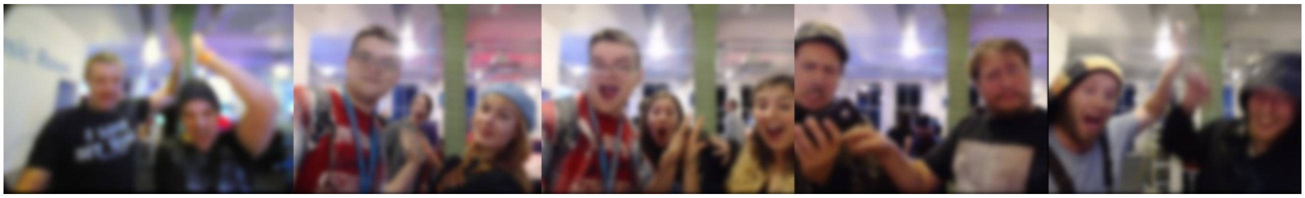

Figure 2. Players pose for high score pictures.

Figure 12. Two players touching a third player's face

DEMOGRAPHIC DIFFERENCES

We analysed our coding results for differences in code distribution relating to our player demographic categories of age and gender. In this section, we present a discussion of codes where we found significant differences across demographic variables. We found no significant differences in distribution of any other codes relating to these variables. Analysis was done using IBM SPSS 22. The dataset and SPSS commands are provided as supplementary material.

Affection and Gender

We found that public displays of affection were strongly influenced by gender with 17% of female/female pairs showing affection towards each other, 14.3% of mixed gender pairs, and only 2.3% of male/male pairs. Chi-square tests for association showed that the difference is significant, $\chi^2(2)=14.976$, $p=0.001$; pairwise tests showed that this was only significant for male/male pairs compared to f/f ($\chi^2(1)=13.448$, $p=0.001$) and mixed pairs ($\chi^2(1)=12.944$, $p<0.001$). No significant difference was found between all female and mixed pairs, $\chi^2(1)=.271$, $p=.603$.

Awkwardness and Gender

All male pairs also showed significantly higher levels of behaviour indicating awkwardness, with 22% of m/m pairs displaying signs of discomfort, in comparison to 2% of f/f pairs and 5% of mixed pairs. Chi square tests again show significant differences between m/m and other pairs, $\chi^2(2)=25.429$, $p<0.001$. Again no significant differences were found between female and mixed pairs.

Play-fighting and Age (but not Gender)

We noted a strong association between *play-fighting and forceful pushing* and age. In pairs consisting of two non-adults, 39% of pairs engaged in some kind of forceful behaviour. Pairs with at least one adult were more restrained, with only 22% of players engaging in fighting play. A chi squared test showed this association to be significant, $\chi^2(1)=8.434$, $p=0.001$. We also found an association between fighting and whether the pairs had the same gender, however a logistic regression demonstrated that this was a side effect of different gender distributions in adult and child populations (with children more likely to play in same-sex pairs); showing significant effect, $p=0.032$ only of whether a pair included a child. We also found no significant differences between all female and all male pairs, child and/or teen pairs showed high incidences of play-fighting whether they were girls or boys.

Cultural Specificity of These Results

We note that whilst these show some interesting results, these are likely to be somewhat dependent on the cultural norms of the UK. Results on awkwardness and demonstrative physical affection are consistent with several studies from varying cultures around the world almost all of which demonstrate lower rates of male/male touching than female/female touching [36:219], which would suggest a likelihood for less comfort with touching amongst male/male pairs. We anticipate that results could be different in other societies as previous studies have demonstrated highly differing attitudes to touch and personal space between countries [12,31], for example studies in Mediterranean cultures have shown far greater social acceptability of touching and physical affection between all-male pairs compared to Northern European cultures [34:168].

DISCUSSION: 4 DESIGN RECOMMENDATIONS FOR INTERPERSONAL TOUCH

In this section, we present a set of design recommendations which distil our experiences and study of *Touchomatic* into practical recommendations for those designing other games which make use of interpersonal touch. Rather than provide a prescriptive how-to guide, we aim to guide designers in taking consideration of what our findings suggest are the most important factors, and provide sets of questions to sensitize designers to each recommendation.

R1: Highlight Controlling Interactions Between Players

In Jennet et al's discussion of the concept of immersion [20], their questionnaire suggests that for a game to be 'immersive' players should forget about the controls and should feel *separated from your real world environment*. Conversely, we believe that one of the key positive things that interpersonal touch has to offer over and above conventional controllers is the actual sensations of touch themselves, and that for such games we need a wider sense of the game environment, which includes the whole play situation. If one forgets about the control system in *Touchomatic*, we have essentially made a 3d version of the classic Flappy Bird game; without an awareness of the real world situation, we would also be unaware of the real world person standing next to us with whom we are touching to play the game. We believe that for this reason measuring immersion in this kind of game makes no sense, and that designing for immersion, i.e. for the interface to disappear, is a bad choice, and that designers should instead aim to highlight the interactions between those controlling, by considering the following questions:

How can we encourage players to focus on their touch senses?
Touchomatic is designed so players stand next to each other, and need to look at the screen. This encourages players to not look at each other while playing the game. Canat et al.'s *Sensation* [6] directly enforces this, by standing players on opposite sides of the screen. We might also consider games in which players are blindfolded, must wear headphones to block their hearing, or where touch occurs out of their sight.

How do we encourage nuanced control?
Touchomatic encourages players to vary their touch pressure gently and smoothly. To play effectively requires players to concentrate and collaborate in order to achieve this. Alternatively, as Canat et al.[6] suggest, we can consider subtleties in other dimensions of touch such as touch contact area shape or point of touch on the body.

How can the game be controlled with limited control dimensions?
The control of *Touchomatic*, is basically a single analogue value. In other touch systems such as [6,38] input is even more limited, being essentially constrained to a small number of discrete poses. There are many game models, especially from early games that fit such controls, from games such as *Pong* [2], which used a single rotary control, to *Flappy Bird* which is controlled by a single 'fly up' button. Many limited control games automate some common actions, for example *Super Mario Run* [28] automatically runs all the time, giving the player control only of 4 jumping actions.

R2: Encourage Interesting and Expressive Touch
For us, a key interest in using interpersonal touch is in the wide range of expressive possibilities which it affords. The following questions aim to help maximize the possibilities of interpersonal touch in games:

How does the game encourage interesting touch behaviour?
We found that a side effect of the way that we used the high-five to start the game was that players instantly understood that the game would respond not just to gentle hand-to-hand touching. We believe this encouraged people to explore a wider range of touch actions.

How can we allow for expressive latitude?
Benford et al discuss how sensing based systems involve ranges of actions that people are expected to perform, actions which can be sensed, and actions which are 'desired' to control an application [3], they argue that the fact some actions people will do cannot be sensed, allows opportunity for 'expressive latitude', where people express themselves in ways not sensed by the interface, in a way analogous to movements that pianists make around a piano keyboard, which the piano does not respond to, but can still be key to the pianists performance. *Touchomatic*'s simple sensing method allows for a wide range of expressive latitude, which we believe allows people to play with an interesting range of touch styles, and allows it to be played by people with highly differing touch preferences.

How does the physical interface support touching?
Touchomatic is deliberately built to be quite narrow, with the two handles approximately 50cm apart. Players typically grab the handle with their outside hand, and touch with the closer hand. This encourages people to stand quite close together and orient their bodies slightly towards each other. It ensures that players are almost always within each other's reach, and can easily reach a wide range of body parts on the other player. However, there are other ways to support touching, for example in *Balance of Power* [25] the freedom given by Kinect's non-contact sensing supports players to touch as each other as forcefully as they wish.

R3: Consider Demographics and Culture.
As we observed in our study, the interaction between players was strongly affected by gender and age effects. These effects are largely not discussed in previous HCI work relating to interpersonal touch interaction, perhaps due to sample size limitations in studies. Our study also showed effects consistent with wider research into the nature of touching in the UK, so although obviously we only studied in a single culture, we would also expect to observe different behaviour if we ran *Touchomatic* in other countries. When designing interpersonal touch gaming, assuming we have some idea of where the game is likely to be played, or by whom, we suggest that designers consider:

What kinds of touch will likely users be comfortable with?
We note that we may, as in *Musical Embrace* [19], actually wish users to experience uncomfortable touch interactions, which, as discussed in [4], can be appropriate as an active design choice.

What kinds of touch are players likely to spontaneously do?
According to Houmel and Flammia [34:168], in some cultures, it is common for greetings between two men to include kisses on the cheek, and seen as rude not to. Whereas in some cultures, even shaking hands is considered excessive contact between people who are not already intimate. We can expect that the level of touching which players perform by default will differ strongly between such cultures, and design accordingly. We also observed children in particular showing far more tendency to take part in play fighting and vigorous contact in our game, something which we might choose to discourage or encourage (as in [25]) if we built a game for a setting with a lot of child players.

How private should games be?

Psychological measures of extroversion show large differences across cultures [24]. Using interpersonal touch games such as *Touchomatic* is a visible and abnormal act. In some cultures it may be appropriate to create a level of privacy for players. Even in the UK, we wonder if we would have observed less awkwardness amongst male/male pairs in an environment which was less open to spectators.

Are there cultural restrictions on player demographics?

Interpersonal touch has strong valence in some cultures which will affect who players are able to touch. In many highly religious cultures, there are strong constraints on opposite sex touching [1], and in cultures with a high incidence of homophobia, men are likely not to want to touch other men [33].

R4: Design For Spectators

Two people playing a game by touching each other in public is something out of the ordinary and highly visible, especially if players choose to play with touching in funny places or slapping each other. We suggest designers should explore:

What should be visible to spectators?

Reeves et al. [30] discuss 4 approaches for exposing or hiding interface manipulations and outputs from computer systems to spectators. In *Touchomatic*, we take what Reeves calls an 'expressive' approach, of making sure that both the game and the interactions with the game are highly visible, mainly through our arcade cabinet layout, placement and audio. Performance work *Mediated Body* [17] in contrast uses headphones so that only the direct participants can hear the outputs of the system, whilst making the touch inputs highly visible. This 'suspenseful' approach highlights the touching to attract spectators by making them intrigued as to what is occurring for the participant. We could also envisage that in some games we may wish to make the touching not visible to spectators, a 'secretive' or 'magical' approach, for example if expected player demographics may not wish to be seen to touch in public.

What happens if spectators get involved in the game?

In *Touchomatic*, we observed moments when spectators took part in the game either by physically coming into the electrical loop between the two players, or by swapping places with players. We had not considered in designing *Touchomatic* that players would do this; in future designs we would explicitly consider how to facilitate likely spectator actions and whether they might transition to become additional players or replace existing players during a game. This could also aid with the inherent issue with two player games when one player becomes bored before the other.

CONCLUSIONS AND LIMITATIONS

In this paper, we present a large-scale analysis of hundreds of players through game recordings and logs. This has allowed us to answer the question: *how do people behave when presented with our interpersonal touch game*, and from it to draw wider design lessons.

We note that our approach of large-scale collection of gameplay logs and video allows us only to firmly answer the question of how people behaved. Whilst we believe that this is the most interesting question, we should be clear that with a study like this, we largely cannot evaluate factors such as the quality of our particular game or how much players enjoy playing it, beyond noting that a) players express themselves by laughing and smiling during the game, and b) the arcade have requested that we continue to leave the machine running indefinitely, something that has not been the case for previous research prototypes we have lent to them.

With this work, we have demonstrated that interpersonal touch has many interesting and expressive possibilities for game designers, and is highly practical to deploy in real world gaming environments. Readers wishing to build their own interpersonal touch systems may be interested in our source code and hardware designs. Code for *Astonishing Airship Adventures, Touchomatic* firmware & instructions for building the interface are available at https://github.com/paultennent/Flyer.

ACKNOWLEDGEMENTS

We would like to thank NVA and all our players for their help in this project, and Rich's Bartop Arcades for their work on our custom arcade cabinet. This work was supported by the Engineering and Physical Sciences Research Council (EP/M000877/1).

REFERENCES

1. Peter A Andersen. 2011. Tactile Traditions. In *The Handbook of Touch: Neuroscience, Behavioral, and Health Perspectives*, Matthew J. Hertenstein and Sandra J. Weiss (eds.). Springer, 351–369.
2. Atari. 1972. Pong.
3. Steve Benford, Bill Gaver, Andy Boucher, Brendan Walker, Sarah Pennington, Albrecht Schmidt, Hans Gellersen, Anthony Steed, Holger Schnädelbach, Boriana Koleva, Rob Anastasi, Chris Greenhalgh, Tom Rodden, Jonathan Green, Ahmed Ghali, and Tony Pridmore. 2005. Expected, sensed, and desired. *ACM Transactions on Computer-Human Interaction* 12, 1: 3–30. https://doi.org/10.1145/1057237.1057239
4. Steve Benford, Chris Greenhalgh, Gabriella Giannachi, Brendan Walker, Joe Marshall, and Tom Rodden. 2012. Uncomfortable interactions. *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12*: 2005. https://doi.org/10.1145/2207676.2208347
5. Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2: 77–101. https://doi.org/http://dx.doi.org/10.1191/1478088706qp063oa
6. Mert Canat, Mustafa Ozan Tezcan, Celalettin Yurdakul, Eran Tiza, Buğra Can Sefercik, Idil

Bostan, Oğuz Turan Buruk, Tilbe Göksun, and Oğuzhan Özcan. 2016. Sensation: Measuring the Effects of a Human-to-Human Social Touch Based Controller on the Player Experience. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 3944–3955. https://doi.org/10.1145/2858036.2858418

7. Capcom. 1991. Street Fighter II: The World Warrior.
8. Adrian David Cheok. 2010. *Art and Technology of Entertainment Computing and Communication*. Springer-Verlag London. https://doi.org/10.1007/978-1-84996-137-0
9. Damien Erceau and Nicolas Guéguen. 2007. Tactile contact and evaluation of the toucher. *The Journal of social psychology* 147, 4: 441–444. https://doi.org/10.3200/SOCP.147.4.441-444
10. Jan B. F. van Erp and Alexander Toet. 2015. Social touch in human-computer interaction. *Frontiers in Digital Humanities* 2, 2: 1–14. https://doi.org/10.3389/fdigh.2015.00002
11. J D Fischer, M Rytting, R Heslin, J D Fisher, M Rytting, and R Heslin. 1976. Hands touching hands: affective and evaluative effects of an interpersonal touch. *Sociometry* 39, 4: 416–421. https://doi.org/10.2307/3033506
12. Alberto Gallace and Charles Spence. 2010. The science of interpersonal touch: An overview. *Neuroscience and Biobehavioral Reviews* 34, 2: 246–259. https://doi.org/10.1016/j.neubiorev.2008.10.004
13. Jayden Garner, Gavin Wood, Sandra Danilovic, Jessica Hammer, and Florian Mueller. 2014. Intangle: exploring interpersonal bodily interactions through sharing controllers. In *CHI PLAY '14: Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play*, 413–414. https://doi.org/10.1145/2658537.2661306
14. William W. Gaver, Jacob Beaver, and Steve Benford. 2003. Ambiguity as a resource for design. In *Proceedings of the conference on Human factors in computing systems - CHI '03*, 233. https://doi.org/10.1145/642611.642653
15. Edward Twitchell Hall. 1963. A system for the notation of proxemic behavior. *American Anthropologist 65*, 1003–1026. https://doi.org/10.1525/aa.1963.65.5.02a00020
16. Matthew J Hertenstein, Dacher Keltner, Betsy App, Brittany a Bulleit, and Ariane R Jaskolka. 2006. Touch communicates distinct emotions. *Emotion* 6, 3: 528–533. https://doi.org/10.1037/1528-3542.6.3.528
17. Mads Hobye and Jonas Löwgren. 2011. Touching a stranger: Designing for engaging experience in embodied interaction. *International Journal of Design* 5, 3: 31–48. Retrieved from http://www.ijdesign.org/ojs/index.php/IJDesign/article/view/976
18. Amy Huggard, Anushka De Mel, Jayden Garner, Cagdas "Chad" Toprak, Alan Chatham, and Florian "Floyd" Mueller. 2013. Musical Embrace: Exploring Social Awkwardness in Digital Games. In *Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (UbiComp '13), 725–728. https://doi.org/10.1145/2493432.2493518
19. Amy Huggard, Anushka De Mel, Jayden Garner, Cagdas "Chad" Toprak, Alan Chatham, and Florian "Floyd" Mueller. 2013. Musical embrace. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing - UbiComp '13*, 725. https://doi.org/10.1145/2493432.2493518
20. Charlene Jennett, Anna L. Cox, Paul Cairns, Samira Dhoparee, Andrew Epps, Tim Tijs, and Alison Walton. 2008. Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies* 66, 9: 641–661. https://doi.org/10.1016/j.ijhcs.2008.04.004
21. Josephine W. Lee and Laura K. Guerrero. 2001. Types of touch in cross-sex relationships between coworkers: perceptions of relational and emotional messages, inappropriateness, and sexual harassment. *Journal of Applied Communication Research* 29, 3: 197–220. https://doi.org/10.1080/00909880128110
22. Paul Lemmens, Floris Crompvoets, Dirk Brokken, Jack Van Den Eerenbeemd, and Gert Jan De Vries. 2009. A body-conforming tactile jacket to enrich movie viewing. *Proceedings - 3rd Joint EuroHaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, World Haptics 2009*: 7–12. https://doi.org/10.1109/WHC.2009.4810832
23. Line S. Löken, Mika Evert, and Johan Wessberg. 2011. Pleasantness of touch in human glabrous and hairy skin: Order effects on affective ratings. *Brain Research* 1417: 9–15. https://doi.org/10.1016/j.brainres.2011.08.011
24. Richard Lynn and Terence Martin. 1995. National differences for thirty-seven nations in extraversion, neuroticism, psychoticism and economic, demographic and other correlates. *Personality and Individual Differences* 19, 3: 403–406. https://doi.org/10.1016/0191-8869(95)00054-A
25. Joe Marshall, Conor Linehan, and Adrian Hazzard. 2016. Designing Brutal Multiplayer Video Games. In *CHI '16 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*.

https://doi.org/10.1145/2858036.2858080

26. Francis McGlone, Ake B Vallbo, Hakan Håkan Olausson, Line S Löken, Johan Wessberg, Line Loken, and Johan Wessberg. 2007. Discriminative touch and emotional touch. *Canadian journal of experimental psychology = Revue canadienne de psychologie experimentale* 61, 3: 173–183. https://doi.org/10.1037/cjep2007019

27. Nintendo. 1984. Duck Hunt.

28. Nintendo. 2016. Super Mario Run.

29. Alexey Pajitnov. 1984. Tetris.

30. Stuart Reeves, Steve Benford, Claire O'Malley, and Mike Fraser. 2005. Designing the spectator experience. In *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '05*, 741. https://doi.org/10.1145/1054972.1055074

31. Martin S. Remland, Tricia S. Jones, and Heidi Brinkaman. 1995. Interpersonal Distance, Body Orientation, and Touch- Effects of Culture, Gender, and Age. *Journal of Social Psychology* 135, 3: 281–297. https://doi.org/10.1080/00224545.1995.9713958

32. Martin S. Remland, Tricia S. Jones, and Heidi Brinkman. 1991. Proxemic and haptic behavior in three European countries. *Journal of Nonverbal Behavior* 15, 4: 215–232. https://doi.org/10.1007/BF00986923

33. Neal J. Roese, James M. Olson, Marianne N. Borenstein, Angela Martin, and Alison L. Shores. 1992. Same-sex touching behavior: The moderating role of homophobic attitudes. *Journal of Nonverbal Behavior* 16, 4: 249–259. https://doi.org/10.1007/BF01462005

34. Houman A. Sadri and Madelyn Flammia. 2011. *Intercultural Communication: A New Approach to International Relations and Global Challenges*. Continuum.

35. Thecla Schiphorst, Frank Nack, Michiel Kauwatjoe, Simon De Bakker, Lora Aroyo, Angel Perez Rosillio, Hielke Schut, Norm Jaffe, and Stock. 2007. PillowTalk: can we afford intimacy? *Tei 2007*: 23–30. https://doi.org/10.1145/1226969.1226975

36. Aron Wolfe Siegman and Stanley Feldstein (eds.). 1985. *Multichannel Integrations of Nonverbal Behavior*. Psychology Press.

37. Reneé Stephen and Richard L Zweigenhaft. 1986. The effect on tipping of a waitress touching male and female. *The Journal of Social Psychology* 126, 1: 141–142. https://doi.org/10.1080/00224545.1986.9713586

38. Kenji Suzuki, Taku Hachisu, and Kazuki Iida. 2016. EnhancedTouch: A Smart Bracelet for Enhancing Human- Human Physical Touch. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16*, 1282–1293. https://doi.org/10.1145/2858036.2858439

39. Stephen Thayer. 1982. Social touching. In *Tactual perception: A sourcebook*, William Schiff and Emerson Foulke (eds.). Cambridge University Press, 263–304.

40. Erin H. Thompson and James A. Hampton. 2011. The effect of relationship status on communicating emotions through touch. *Cognition & Emotion* 25, 2: 295–306. https://doi.org/10.1080/02699931.2010.492957

41. Douglas Wilson. 2011. Brutally Unfair Tactics Totally OK Now: On Self-Effacing Games and Unachievements. *Game Studies* 11, 1. Retrieved January 11, 2017 from http://gamestudies.org/1101/articles/wilson