Public DisPLAY:
Social Games on Interactive Public Screens

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ABSTRACT
In this paper we introduce, examine, and reflect on player and spectator interaction, socialization, and engagement with two gesture-based multiplayer games deployed on two sensor-enabled and networked semi-public campus displays. One within a transitory corridor, the other in an open plan combined study area and student services space. Our results show that sensor placement and installation contexts of the display, as well as how players are introduced to the interaction techniques of the game, affect the screens' capacity to support social play. We subsequently offer concrete recommendations on how public display games can be built to encourage social play between two to four participants, limit social embarrassment, and encourage spectators to become active players. In doing so, we extend prior work that has primarily focused on single-user or crowd-based interaction.

Author Keywords
Public displays; bodily play; gestural interaction;

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
The interactive digital display is becoming, and arguably already is, ubiquitous within the public arena. The way in which people engage, react, and play with these screens is an ongoing concern for theorists, HCI researchers, and developers. A popular way of exploring the social use of displays is through games that encourage engagement by members of the public. Previous studies have made recommendations on capturing users' attention and encouraging engagement with a public display (Beyer, Binder et al. 2014) as well as on best practices for making users comfortable interacting in public (Brignull and Rogers 2003). There are, however, unanswered questions regarding how different interaction techniques limit or encourage social engagement between players, how comfortable spectators feel in transitioning to playing (if at all), as well as how this affects the social experience and social embarrassment of current players.

We study how natural user interfaces (NUI) afford different kinds of social play in the context of a public display, where notions of gestural excess (Simon 2009) and public embarrassment (Brignull and Rogers 2003) collide with the 'honey-pot effect' of public play (Wouters, Downs et al. 2016). In this paper, we present two case studies of games on public displays. The first, *Masquerade*, is a full body game that requires players to move and contort their entire body into poses set by previous players. The second, *SocialNUIz* is a multiplayer quiz game which uses the PathSync (Carter, Velloso et al. 2016) technique for hidden gestural interaction. Each game was simultaneously deployed in two different social contexts. We present each study in turn, interrogating the types of play afforded by the different NUI techniques and social context. We then compare the two deployments to draw broader insights and recommendations for social games on interactive public screens.

Our paper contributes instances and general design implications of two core concepts, social embarrassment and spectatorship, both central to the design of public display interaction and play. First, we demonstrate different ways in which the interaction techniques in the games can help ameliorate the inherent social embarrassment and anxiety of public display interaction. Second, we argue that by sensing all users in front of it, the Kinect functionally disallows some forms of spectatorship, instead considering spectators as players (Downs, Vetere et al. 2014). Together with the honey pot effect (Wouters, Downs et al. 2016), we show this to be an extremely successful way to encourage social play by nudging users to step across the divide of *observation* to *interaction*. We further confirm and extend findings of earlier work on interaction with public screens, regarding the prevalence of display blindness within public spaces (Müller, Wilmsmann et al. 2009, Tomitsch, Ackad et al. 2014), the effect of the social context on the nature of the interaction (Brignull and Rogers 2003), and the changes in use patterns over time (Memarovic, Clinch et al. 2015). From these contributions, confirmations, and reflections, we offer recommendations and lessons for future work on social games on interactive public screens.

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RELATED WORK

Historically video games were exclusively played in the public setting in the form of arcade machines (Velloso, Oechsner et al. 2015), but gradually moved to the home through consoles and personal computers. More recently with the widespread availability of interactive public screens they became testbeds for new interaction techniques (Brynskov, Dalsgaard et al. 2009, Fischer, Zollner et al. 2013, Velloso, Oechsner et al. 2015) and the center of a new research agenda on multi-user engagement with public displays (Brignull and Rogers 2003, Beyer, Binder et al. 2014, Hespanhol, Tomitsch et al. 2015), ubiquitous (Storz, Friday et al. 2006, Terrenghi, Quigley et al. 2009) and pervasive displays (Mitchell and Race 2006, Alt, Bial et al. 2011).

Play in public settings is substantially different to play in private settings. Therefore, to better understand and design for social play on public screens we first examine three inherent properties of this platform: social embarrassment, spectatorship in social play, and display blindness.

Social Embarrassment

The act of interacting with a public display immediately opens up any user to the possibility of failure. They may misunderstand the technique for interaction, fail to complete a task given by the display, or may just not be physically or mentally able to interact correctly. As Goffman suggests, all interaction contains within it the possibility of failure (1971), and this fear of failing has been defined as 'social embarrassment' by Rogers and Brignull (2002). This has been examined by a number of theorists for its effect on user confidence when interacting in public spaces (Brignull and Rogers 2003, Schroeter, Foth et al. 2012, Hespanhol and Tomitsch 2015).

Social embarrassment is also associated with "social pressure" (Beyer, Binder et al. 2014) and "evaluation apprehension" (Mathew, Rogers et al. 2011). In the presence of spectators, the user is overcome by a responsibility to teach them how to interact with the system, leading to pressure to act appropriately and to exhibit good performance. This is similar to the evaluation apprehension documented by O'Hara et al. (2008) and Matthew et al. (2011) in which users are overcome with a fear that their performance or interaction is being judged by others. This pressure has also been documented within more traditional gaming contexts such as arcades (Kimble and Rezabek 1992) where the act of 'choking' defines a player's failure to reach their usual level of mastery due to the audience. The arcade, however, unlike other public spaces, involves a specific audience who have travelled to play and watch others, leading the watched player to accept a performative role by playing in that context (Lin and Sun 2011).

Designers and researchers have offered recommendations in designing interactions to minimize social embarrassment. They suggest that players be eased into interacting with a system and are given a chance to cross between spectatorship and participation and back again at will (Brignull and Rogers 2003). To allow this transition, Hespanhol et al. suggest using intuitive gestures to allow interaction to happen "almost subconsciously" (2015), removing some of the social embarrassment of interaction. Wouters et al., are more specific, discussing "audience flows" (2016) to document the "activation loop" of spectators flowing into a more active participant role before dropping out and sharing their experience with spectators. Spectators are then prompted to interact producing a continuing flow of participants due to subliminal encouragement and normalization.

Spectatorship in Social Play

The public space where interactive displays are installed can lead to users feeling uncomfortable using certain techniques or playing certain games. This can cause users to either stop playing if they encounter barriers to entry (failing to use a gestural technique to select an option), or else refuse to engage at all, instead choosing to spectate or move away from the display. If they don't move away, they may then choose to play after ascertaining the 'correct' way to interact from watching others or after becoming comfortable amongst other participants. This accrual of further interactors with a display once a certain number of users are already interacting or within the vicinity—the honeypot effect—has been documented in many public installations, interactive and static, large (Brignull and Rogers 2003) and small screens (Mitchell and Race 2006).

Previous research on social engagement and the honey pot effect in public installations has shown that strangers are more likely to choose to interact with others if they are working toward a common goal in which they are not directly engaging with other participants (Wouters, Downs et al. 2016). The screen or other digital artifact being collectively controlled or interacted with by participants acts as a catalyst for a shared 'together but apart' social experience. This extends to social play in co-located games where the audience can have a strong effect on possible social embarrassment or 'choking'. Kappen et al. reflect further on the audience's effect on the performance of multiple players co-located in the same space (2014) and found that overall players preferred an audience who was supportive (cheering, etc.) of their gameplay, even as they acknowledge the distracting effect it had on their gameplay. The way an audience is positioned and their engagement with players has a great effect on gameplay. This paper continues this exploration of the effects of the audience as well as how the context in which a game is played negates or enhances player engagement and social play amongst participants.

Failure to Interact

As has been noted in the literature many of these deployments are of short duration (Ojala, Kukka et al. 2010, Memarovic, Clinch et al. 2015), days rather than months, and this has a direct implication for the amount of data that can be collected. Display blindness, the lack of user interaction due to a user not understanding a screen is interactive as well as the attrition of user interaction and interest over time due to continued exposure, has been documented during installations in public spaces (Huang, Koster et al. 2008, Müller, Wilmsmann et al. 2009, Houben and Weichel 2013, Memarovic, Clinch et al. 2015), even within shorter term installs. This leads to questions around display blindness in long term installs especially within contexts that are likely to have recurrent use by the same people over long periods of time, such as an often used path to workplaces, classes or recreational locations.

Huang, et. al. examined forty-six large digital displays over twenty-four sites and offered recommendations for installation of public displays. These included offering minimal but enticing information to draw in users, positioning displays at eye level, using dynamic content to hold a user's attention, aiming to augment the physical context around the display to draw attention, and considering the size of display and how it can change how comfortable users feel in interacting with it (Huang, Koster et al. 2008). These recommendations are reflected in other papers examining screens, which consistently find that careful consideration of the context of the installation and using techniques to catch the eye of passersby are integral to encouraging interaction (Houben and Weichel 2013, Beyer, Binder et al. 2014). Huang et al.'s work did not however examine displays in which users could interact with the display, using interaction instead to mean that users stopped and consumed the non-user-modifiable information displayed.

This paper thus also offers a longer view of user engagement over an eleven-month period to map the longer term ebbs and flows of user interaction. Along with this, the social and co-located games installed on our displays allow us to map (1) how players socialized with each other through playing games on these screens, (2) how different installation contexts affect how comfortable players feel engaging with the games and (3) how spectating by passing people effect the social embarrassment of players.

CAMPUS DISPLAYS

Our Campus Displays are two public interactive displays installed in different locations on the university campus. They form a test bed for new interaction techniques and theories, and allow rapid development and deployment to a pre-existing audience. Each display is augmented with Microsoft Kinect sensors and a computer. One screen is in a shared study space/student service area outside of one of the University libraries (Figure 1), the other is within a corridor between buildings widely used as an access point by various student and academic cohorts (Figure 2). These two locations thus provide contrasting spaces for examining the role of public space in the usage and play on such screens. The displays have been installed since May 2015.

Each deployment consists of a 42" screen with a mini-pc (5 cm x 10 cm x 11cm) running Windows 8.1 in a kiosk mode. This computer controls the boot up/shutdown (at 7am/7pm) and relaunches the game currently deployed if disrupted. Each PC is connected through a wired cable to the University network allowing for internet connectivity, cloud storage and sharing between screens of collected data and metrics.

The Kinect sensor was used within the Campus Displays as it provides an implementation of a range of technologies within the one easily installed device. These include an RGB camera for taking images or displaying a camera-eye view, an infrared camera to detect people and objects in a 3D space, and a directional microphone. Along with this robust set of technologies, the Kinect SDK offers skeleton tracking including individual joint positions for up to 6 people within the sensor zone, inbuilt detection for a range of hand and arm gestures and a range of other quality-of-life functions. This allowed researchers to concentrate on developing the games and interaction techniques rather than working with low level APIs or sensor data.

MASQUERADE

The first game developed for the Campus Displays was *Masquerade*, a social game which uses full-body postures as an interaction technique. *Masquerade* challenges players to match the poses shown on the display with their own bodies – awarding points for how closely the players manage to align with the pose they are mirroring. *Masquerade* was developed to examine (1) the effect that different types of attract screens had on user engagement and (2) how the honeypot effect may decrease or increase social embarrassment and socializing amongst participants. We outline the design of the game and the results gathered during deployment.

Game Design

The game uses the Kinect skeleton tracking API to compare the body of a player with a stick-figure skeleton or image of another person shown on the screen with points being awarded to the player based on the similarity of the player's pose to that shown on the screen. Multiple skeletons were sometimes shown on the screen with the number of skeletons being equal to, or more than, the current amount of players standing within the Kinect sensor area (up to a total of six).

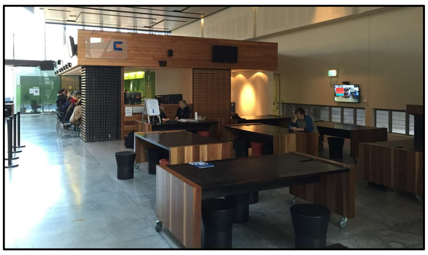

Figure 1. Display 1 (right wall) installed in study space.

Figure 2. Display 2 (right wall) installed in a corridor space.

Before a player has engaged with the display it shows the 'attract screen'. This screen shows the current high score attained by both this and the other Campus Display screen and a black bar on the right side encourages possible players to 'Come closer'. These scores are overlaid on either a live view of the Kinect camera's current view or a black screen. When a player enters into the sensor area one of three possible visualizations are shown, either the live view of the camera continues (in which the player can now see themselves), a stick-figure representation of the player appears on the black background, or the live view is overlaid with the stick-figure of the player's skeleton. These were randomly selected and were used to gather data as to which attract screen was more likely to draw in players.

Once a user approaches the display, the 'Come closer' message changes to prompt users to 'Wave to start' along with an animated image of a person undertaking the wave gesture. Once a user successfully waves at the screen the game begins and player(s) are presented with a pose captured from a previous game that they need to mirror. The amount of poses on screen that they must mirror could align with the current amount of players or could possibly include more poses to encourage other people passing to interact with the game. The poses are presented in five possible ways:

- Static RGB image of the previous participants overlaid with the current players stick figure.
- Live RGB image of the current players overlaid by reference skeletons of the previous participants.
- Static skeletons of previous participants on a black screen overlaid with current participants' skeletons.
- Live RGB image and participants' skeletons over which the reference skeletons are overlaid.
- Static reference RGB image and skeleton over which the live participants' skeletons are overlaid.

These five presentation modes were used to test which was most easy for players to align themselves with the reference pose, and to examine player-representation's effect on social embarrassment. Players score points (out of 1000) for aligning their bodies with the pose on screen.

After the score has been displayed, players are shown the live RGB image and given 30 seconds to create a pose reference image for the game's database. Players are scored based on the pose with higher scores being given to poses where there is a larger distance between each of their hands and feet (in order to encourage 'wilder' and therefore interesting poses). Once completed, users see their cumulative score from the two rounds after which they can again use the wave gesture to begin a new round (and cumulative score). Players can walk away from the screen at any time to end the game.

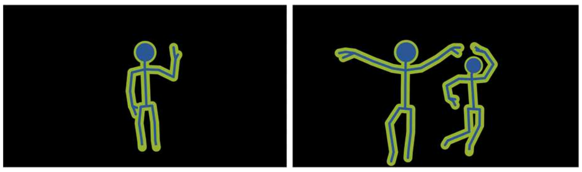

Figure 3. Skeleton data of solo and two player Masquerade.

Interaction Techniques

While the hand-based 'wave to start' gesture is used by the player to begin the game and between rounds; the main game requires players to use their whole body in order to interact and score points. Masquerade's interaction technique, while not an exertion interface as defined by Mueller et, al (2003), does require full body movement to collaborate or compete with one or more participants. These full body interfaces, Marshall suggests (2016), can be understood not just for their ability to promote physical activity but also their ability to improve or produce social interactions amongst participants. Masquerade was built to provoke and curate interaction amongst users through the game's posing challenges which may offer more skeleton poses on screen to emulate than there are currently users interacting with the game. The aim then would be for users to encourage friends or bystanders to help them achieve a higher score.

Results

Masquerade was deployed for a total of 189 days on the two screens and in that time 4,274 sessions were completed. During the first two weeks of deployment we conducted 10 interviews with 14 players. All players interviewed were students of the University who had independently chosen to approach and engage with the game. These players were first observed without their knowledge, then approached once their play time had been completed. Amongst other questions, players were asked about their decision to interact with the game and how comfortable they felt interacting with the game on a scale of 1 (uncomfortable) to 5 (comfortable). We present the quantitative data captured by the sensors over the entire deployment as well as the qualitative data from observations and interviews with players. Overall we found that participants enjoyed the game and reported feeling comfortable (3.8 average) but reflected in their discussion that they would feel more comfortable in a less public space.

Honeypot effect

Of the 846 games with more than one round, players were joined by one or more new players after the first round in 125 cases. 288 games lost a player after the first round and 433 games had the same number of players throughout. The fluctuating number of players throughout these engagements of multiple rounds reflects well on the drop in/drop out engagement which this game aimed to achieve.

While we expected players interviewed would feel felt some level of social embarrassment when playing *Masquerade*, it was surprising that spectators (friends included in interviews who watched play but did not play themselves) also reported feeling awkward and embarrassed as they watched.

Watching yourself looking 'silly' is easier in groups.

While we presumed that when players produced a new pose for others to mirror we would find, due to social embarrassment, a difference between the amount of one person to two or more people poses, we instead logged a similar number of one and two person poses created (1031/1122 respectively). Due to the nature of the game all poses must be approved by a researcher before they are

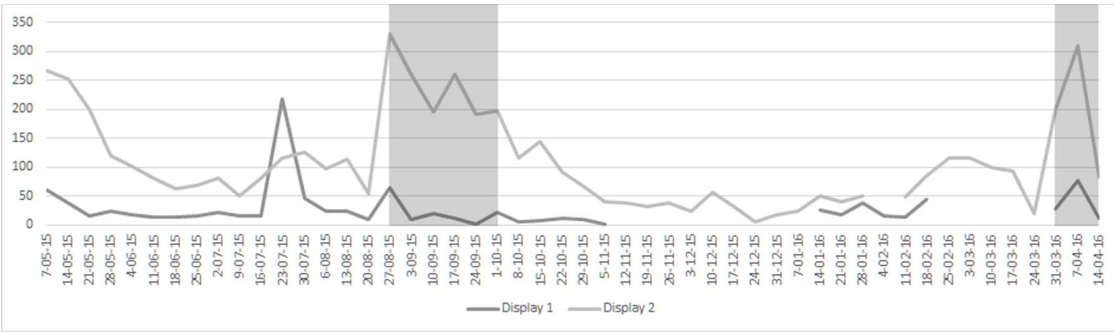

Figure 4. Sessions played on each display by week of Masquerade (unshaded) and SocialNUIz v1 & v2 (consecutive shaded areas).

included in the game—to remove any with unclear skeleton data or offensive imagery. As these poses were approved it became clear that although there was a similar number logged, the poses themselves were quite different. A predominant amount of the single player poses were static poses in which the user either stood straight, watching the camera or limited their body movements to raising of the hands. In comparison, images with two or more player poses are much more dynamic with players throwing arms and legs into the air in order to score further points (Figure). This was quantified through random selection of 80 pose images captured by Masquerade. These images were coded by a researcher as either *static* (containing one or more of the following: limited movement, standing with shoulders facing the screen, hands not raised above head, no feet off the ground) or *active* (based on the following markers: participant(s) are standing side on or turned away from front on view of camera, arms are outstretched above head, foot/feet are off the ground). From this coding we found that 31% of one skeleton poses were considered as *active* while 87% of two skeleton poses were marked as *active*. Similar percentages were seen for three and four-or-more poses (85% and 77% respectively).

Attract screen and Alignment Screens

Across the three different attract screens and five possible visualizations for the mirroring task there were no significant differences as to if possible players began to play or how well they could mirror the poses on screen. As all attract screens did visually change when potential players approached or passed this lack of variability, this confirms Beyer et al. (2014) who also found minimal difference in audience engagement across a range of different attract screen visual styles.

Differences in two or more player games

As can be seen in Figure , over 50% of the sessions played on Display 2 were played by two players versus ~37% on Display 1. Alternatively, more games with three players occurred on Display 1(~19%) versus ~13% on Display 2. This can be explained due to the nature of the two install spaces. As Display 1 was installed within a shared study space where groups meet for project discussions it makes sense that there would be larger groups of players who have a pre-existing relationship and therefore feel comfortable engaging with the display together. Those interviewed described the space as quiet or calm and reported feeling more comfortable there (average 4.5 vs 3.3 for corridor reported feeling of 'comfort').

Display 2 being installed in a transitory space between classes, buildings and cafes drew a larger and more distinct crowd and a larger amount of games played overall. From what is understood of social embarrassment and anxiety as well as what was learned from our interviews, it is clear that solo players were less likely to engage with the screen due to the full body interaction technique (those that did often produced less dynamic poses). The large number of two player games, as shown in the data and via researcher observations of the types of groups who played, can be explained due to this nature of social embarrassment, while the smaller percentage of three or four player games is likely due to the space being transitory and therefore less likely to contain possible players with pre-existing relationships.

Long term deployment shows waves of engagement

On counting the number of individual sessions (a session being defined as a player attempting to match at least one pose) and graphing these by week (Figure) we can see waves of higher engagement which align with the beginning of each University semester. This makes sense, as new students enter the campus who are yet to be accustomed to the displays (display blindness), the amount of engaged players' spike. One particularly large spike on Display 1 (the display installed in the student center/student study space) during the week beginning Monday 27th of July 2015 can be explained by a large line of new students applying for and collecting their new student access cards. This line snaked past the display and a large number of students entertained

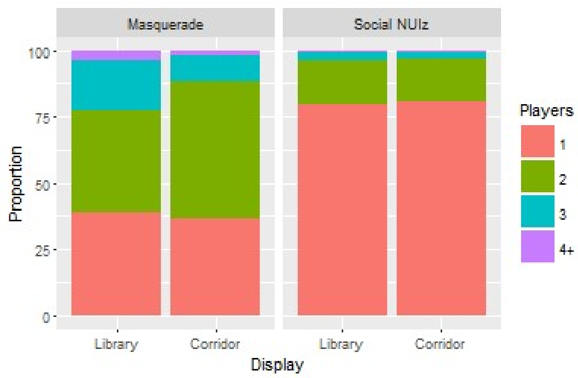

Figure 5. Percentage of 1, 2, 3 and 4+ player games of Masquerade and SocialNUIz over Display 1 and 2

themselves while they waited by playing *Masquerade.* This spike occurred mostly on the Monday with the numbers quickly falling to more regular engagement levels.

SOCIALNUIZ

The second game developed for the Campus Displays project was *SocialNUIz*, a quiz game which utilized PathSync (Carter, Velloso et al. 2016), a discreet multi-user interaction technique. In *SocialNUIz* Players are shown a multiple choice question and using their hand trace the movement of the target rotating around the answer they wish to select. This game was deployed to act as a contrast to the full-body, exertion style interaction of *Masquerade*, but also to evaluate the social use and discoverability of this novel interaction technique in the wild. The deployment of *SocialNUIz* highlights the different motivations for use in the distinct publics, and the way that social play supports prolonged, rather than fleeting, use. We present the results of two deployments, where minor changes were made to the design of the game in response to discoverability issues.

Game Design

SocialNUIz is a multiple-choice quiz game, with general knowledge trivia and trivia about the University. As we wanted to motivate people to stop and interact with the displays, the questions were specifically designed to intrigue those walking by. In the context of a quiz game, we identified two types of questions that are best suited for doing so; easier questions that allow the user to confirm (i.e. demonstrate) their knowledge, and harder (obscure) questions which the user is interested in finding out the correct answer.

The 'attract mode' (Houser and DeLoach 1998) presents a question with two possible answers (see Figure). If no user is detected by the Kinect, the text on the screen reads 'Come closer'. When a user is detected, their silhouette is depicted on the screen to emphasize that they are being tracked by the system, and the text changes to 'Select your answer by matching the dot with your hand!'. An animation shown on the right side of the screen demonstrates the technique of following the orbit of the answer with the hand. When all users detected by the system have selected an answer (or after a 30 second time-out), the correct answer is shown and the user's silhouettes are displayed with a crown on the head of those which selected correctly along with their score. Subsequent rounds (post-attract screen) depict users as colored bars rather than silhouettes (retaining the same color during their play). This was due to the fact that in our initial testing we found that detailed silhouettes of players on screen

Figure 6. SocialNUIz attract mode.

would allow others to see how they were moving their hand and therefore which answer they were selecting.

Interaction Technique

SocialNUIz employs PathSync, a gestural interaction technique based on the principle of rhythmic path mimicry (Esteves, Velloso et al. 2015, Vidal, Bulling et al. 2015, Carter, Velloso et al. 2016). When a user replicates the movement of a screen-represented pattern with their hand, they can distally select an on-screen object quickly and at a high level of accuracy. By using a Pearson's correlation, PathSync can distinguish between up to 36 different simultaneous targets based on phase, speed and direction. Carter et al. (2016) found that PathSync was a comparable technique to press-to-select in a task-selection challenge, and argue that it is better suited to multiple users due to being distal; not requiring users memorize gestures; requires a smaller range of motion to interact; and because a user's input is not revealed to other users.

PathSync's non-revealing of user input (unlike cursor-based techniques) makes it highly suitable for a quiz game like *SocialNUIz*, while its distal nature allows multiple users to stand in front of and perpendicular to the screen and still interact, limited only by the number of users the Kinect can simultaneously track (six). Particularly in comparison to *Masquerade*, PathSync allows *SocialNUIz* to employ as little gestural excess as possible, and many users were able to stand still and select answers without attracting the attention of those around them.

Redeployment

The first deployment of *SocialNUIz* was conducted as part of a study evaluating PathSync (Carter, Velloso et al. 2016), which found the interaction technique sufficiently discoverable for public display use and comparable to the default 'press-to-select' Kinect interaction technique on the Xbox One. However, a number of minor issues with the design of *SocialNUIz* were made apparent during this initial deployment that were corrected in the redeployment.

The principal and significant issue for the discoverability and use of the public display was users assuming that the game was a touch screen, and then not exploring other ways to interact when that modality did not work. This is unsurprising considering the public novelty of gestural interfaces. We expect this issue was exacerbated by the resemblance of our interface to the Windows Metro UI, in which large square tiles are optimized for touch. We attempted to solve this issue by the removal of the colored backgrounds on the buttons with the aim that they would be seen as a path rather than a button. Despite the change, we continued to observe users touching the screen.

The second change we made involved replacing the solid line around the shape and solid circular target with a dotted line and hand icon. It was hoped that this minor change to the appearance of the UI, using the open palm cursor familiar to XBOX users, would facilitate users discovering the gestural interaction afforded by the new game.

SOCIAL NUIZ TRIAL RESULTS

Over the course of the two deployments (totally 63 days) 6 hours of observations were recorded along with interviews with 5 participants, all students. All interviews were conducted after discrete observation of participants playing SocialNUIz. The interviews were semi-structured and asked users about their feelings toward the game (Did you enjoy this game? Would you play again?), and the location in which it was deployed (Did you feel comfortable interacting?). Overall we found participants enjoyed the games but felt the questions were 'too difficult'. This is explored further below.

Success of the interaction technique

Overall from the two deployments of SocialNUIz*,* 2283 sessions of player interaction (one or more questions answered using the technique) were logged. Of these, 249 sessions were on Display 1 and the 2034 were completed on Display 2. In this results section we do not concentrate on the efficacy of the technique, but instead consider the social play ramifications reflected in the data collected.

Single player engagement

Single player games accounted for 83/74% (Display 1/2) of player sessions (242/2034 sessions respectively) on each screen. This shows that where players understood the technique they were comfortable playing the game in a public space. The high amount of single player games within both spaces is surprising, especially when we consider this in relationship to the data collected from *Masquerade's* deployment of higher engagement (in both games played and use of their bodies) amongst groups.

This may be explained due to the different type of social embarrassment that *SocialNUIz* engenders. Answering questions in a public space opens up players to judgement from spectators if they answer incorrectly. When players were asked in interviews for suggestions of changes they would make or what would promote enjoyment the suggestion of 'easier questions' was given in many cases which suggests this is of concern to *SocialNUIz* players.

Multiplayer engagement

Across both displays a similar percentage of the games had two, three or four player games with 16/15% (Display 1/2) of the games having two players. Based on these statistics *SocialNUIz* did not seem to lend itself well to multiplayer engagement, possibly for the social embarrassment of getting answers 'wrong' discussed above.

REFLECTIONS ON BOTH GAMES

Whereas the two games we described share certain similarities, they were designed to offer players substantially different experiences. In this section, we take a step back to analyze how the differences and similarities in their design may uncover insights into how the games were used.

Similarities

Single/Multi Player Support

Both games were designed to support both single- and multi-player interactions. In principle, there is always a multi-player aspect involved, even in single-player interaction: in *Masquerade*, players challenge and attempt to mimic postures performed by other players; in *SocialNUIz*, the high score indication offers a record to be beaten. However, in this mode of gameplay, players can be both temporally and spatially separated. In both games, a single-player game can seamlessly turn into a multi-player game, as spectators become players and vice-versa. As shown in Figure , the nature of the different games led to a different distribution of the number of players for each game.

Novel Interaction Techniques

Both games explore a novel input device and interaction technique. Whereas XBOX players might be familiar with the Kinect sensor, a large segment of the population has never used a depth camera before. While the interaction technique in *Masquerade* might allude to similar mimic games, *SocialNUIz* included a completely novel selection technique—*PathSync*. The use of a new interaction technique in the games means before playing, potential players must acquaint themselves with the technique. Looking from Goffman's perspective (Goffman 1971), this increases the risk of embarrassment, making it an important aspect of the game design, particularly for the 'attract mode' screen.

Body-Based

Though the use of the body in each game is different, both games are body-based. This carries consequences for the gameplay, particularly considering that the games were deployed at a University campus, a setting with its own set of social norms and expectations. Below we discuss how the subtle differences in the use of the body in the different game mechanics affect and are affected by these social aspects.

Differences

Gestural/Postural

Bodily play can make use of the body in different ways, these include exerting movements, ranging from subtle postures to bold physical activity. Whereas Masquerade's core mechanic relies on users making and mirroring different postures, SocialNUIz instead requires only hand gestures. By using postures Masquerade demands more spatial awareness.

Masquerade encourages complex postures and therefore asks users to take over a large amount of space within a public context. Moreover, they must hold this posture for a certain amount of time and are rewarded for remaining still. SocialNUIz on the other hand demands temporal awareness due to the dynamics of the interaction technique—if the user is not in sync with the desired answer a different answer could be selected. The contrast between spatial and temporal acuity demonstrates the power of the body in enabling novel game mechanics.

Discreet/Conspicuous

A consequence of the large amount of space taken by the postures players mirror in Masquerade is that the user interaction becomes substantially more conspicuous than in SocialNUIz. Conversely the interaction technique used in

SocialNUIz was chosen because players cannot infer what others are selecting. SocialNUIz would be presumed then to afford less social embarrassment due to the discreet nature of the interaction, but as shown in the following point, it rather engenders a *different* type of social embarrassment.

Mental/Physical

While *Masquerade* used an interface that required full body movement to score a higher amount of points, in *SocialNUIz* the point scoring mechanism relied on the player's general knowledge. Considering the distribution of the number of players in each session of both games (Figure) we find 36/38% (Displays 1/2) of Masquerade's games were single player compared to 83/74% of SocialNUIz's. While this significant difference in the percentage of one versus two player sessions for each game can be explained by single players feeling more exposed when moving their bodies in public space—and this was found in interviews to have an influence on if solo players would play again—we cannot discount the social embarrassment that could come from displaying an ignorance of general knowledge being answered in SocialNUIz. The attract screen displayed questions we considered 'easy' to highlight the fact that the screen was interactive, however, this may have put off potential players if they did not know the correct answer.

LESSONS LEARNED

Position sensors to encourage interaction: In both Masquerade and SocialNUIz the Kinect sensor could detect not only users but also nearby spectators. As both games visually reflected the bodies of users on the screen, spectators, who the software would detect as other users, would also be quantified visually on screen. This allowed spectators to move in and out of the play zone easily but also encouraged them to interact as they were already complicit in the visuals of the game play. Brignull & Rogers (2003) have previously highlighted that allowing people to "dip in and out" of interaction is important in making them comfortable interacting and we have found that a way of augmenting this process is by blurring the line between interacting and spectating.

Attract screens should set expectations for the type of interactions that will occur: Masquerade's attract screen encouraged user's to 'wave to begin' immediately setting an expectation that user's did not have to be standing within arm's reach of the screen. SocialNUIz immediately expected users to master an unfamiliar technique to select a quiz answer while presenting 'button-like' symbols. The orbits rotating around each possible answer, as well, could be easily misread as ornamentation rather than part of an interaction technique. This led to users attempting to select an answer by approaching the screen and pressing as if it were a touchscreen. From observations it was seen that when this did not work users displayed self-conscious body language (looking around to see if anyone had noticed their failure) before quickly walking away.

The interaction technique affects strangers joining games: Despite both games allowing drop in/out gameplay by spectators there were very few circumstances observed where spectators who were not already acquainted with active players joined in a game in progress. More socialization and dropping in did occur during the *SocialNUIz* game which required less physicality in its interaction technique.

Deploying the same hardware/software in two different contexts simultaneously: The ability to compare and contrast the data collected from two simultaneous installs of the same hardware and software should not be ignored, especially if they can be deployed in two different contexts. With Display 1 being located within a quiet study area we found a comparatively larger amount of three or four player games in *SocialNUIz* than in *Masquerade* with the opposite holding true for the more transitory location of Display 2. This, we believe, can be explained due to Masquerade's social aspect and broad body movements which could be distracting to other students and more conspicuous to a largely static audience using the space, thus causing a larger amount of social embarrassment which limits play. Without the simultaneous installations the effect the context has on the gameplay may not have been apparent.

CONCLUSION

We set out to study how natural user interfaces (NUI) allow or produce different kinds of social play in the context of a public display, where notions of gestural excess (Simon 2009) and public embarrassment (Brignull and Rogers 2003) collide with the 'honey-pot effect' of public play (Wouters, Downs et al. 2016). Through doing this we have contributed to theory and design practice around public display play, particularly regarding how different interaction techniques limit or encourage social engagement between players of a game, how and if spectators feel comfortable transitioning to players as well as how this then effects the social embarrassment of current players.

We presented two case studies of public display games with different NUI techniques successively deployed on two sensor-enabled screens on the University campus. We found that the techniques examined had direct impacts on the social play engendered. *Masquerade's* interaction encouraged silliness and gestural excess, which increased in, and thus encouraged, social play situations. In comparison, *SocialNUIz*, which required limited hand movements to interact was mostly played by single players, highlighting the impact of the different techniques on social use.

In our subsequent reflection, we have discussed the broader insights generated from the two studies and offered concrete recommendations on how public display games can be built to encourage social play, limit social embarrassment and anxiety, and move spectators to active players. In doing so this paper has contributed to the breadth of related work that has examined interactive public screens, particularly contributing a focus on the play and social dimensions of the design space.

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