Combining Moving Bodies With Digital Elements: Design Space Between Players and Screens

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ABSTRACT
In playground games, an important part of engagement occurs in the physical space where people focus on each other's movements. In contrast, digital games often focus on engagement via a screen. By combining digital elements with playground ideas we identify new design opportunities where players are given freedom to play face-to-face. During a Game Jam workshop, we explored this design space by looking at innovative ways that digital technology can respond to movement. We find by removing the disparity between player movement and its digital representation, players can concentrate on each other and enjoy closer interaction. Through the exploration of digital elements and playground ideas, we suggest designers of movement-based games should consider the design space between the player and the screen using interactive technology to create engaging social digital play experiences.

Categories and Subject Descriptors
H.1.2 [Models and Principals]: User/Machine Systems – Human factors; H.5.2 [Information Interfaces and Presentations]: User Interfaces – Evaluation/methodology; User-centred design

General Terms
Design, Human Factors

Keywords
Movement-based game, digital game, game design, immersion, social interaction, engagement, kinesthetic interaction, performance, exertion game, proxemics, social play

1. INTRODUCTION
Our work is situated in the context of playground games and the effect screens have on social play in movement-based games. Playground games often involve children playing together in schools and playgrounds without digital elements. We believe that player engagement in playground games such as tag and hide and seek often comes from the social interactions players share with each other as a result of being involved with and challenged by the movements of others in a physical space. The new games movement [1] emphasizes the importance of collaboration, togetherness and lighthearted playfulness as essential components of engagement in playground games. We are inspired by Bernard DeKoven [2], who suggests we can renew interest in play by reconsidering old playground games and exploring how we play together. We therefore consider the importance of social interaction between players and the role of spectators in order to create better gaming experiences.

Alternative gaming interfaces, such as the Nintendo Wii, Sony Move and Microsoft Kinect, and accessories such as balance boards, dance mats and musical instruments offer unique opportunities to foster and enhance acts of sociality and performance in movement-based interactions. Interactive technologies can recognize and respond to gesture-based and whole-body movement, which can engage a player's kinesthetic sense of movement [3]. However, while popular movement-based games such as Wii Sports [4] promote engaging social digital play, players focus on a graphical representation of virtual avatars instead of the actual people playing. This means a gamer often concentrates on the screen and a virtual space removed from the reality of the physical space. By unpicking the effect of this disparity we can develop a deeper understanding of how digital elements effect social interaction between players.

In this paper we present the game i-dentity, a design-led research exploration testing how to combine interactive technology with movement, which we find benefits its social experience. The minimal visual aesthetic we used encouraged us to avoid overused game clichés such as high-scores, achievements and formulaic game structures allowing our game to be played with more freedom. By removing the need to look at the screen we also remove the computer and its corresponding game logic as the referee. We find potential in using interactive technology to hide the identity of a player's role from others to significantly enhance a social experience, particularly when its digital representation is obscured by players' movement, stimulating conversation and collaboration amongst players and audiences. Importantly, the removal of on-screen avatars means that players looking at full body movement must turn their attention to one another making them engage in face-to-face interaction. We suggest game designers of movement-based digital games should consider how the representation of movement, for example, on-screen avatars, can influence the experience of the social interaction between players and audiences. Furthermore, we challenge designers of these games to consider how removing the screen altogether shifts the players' focus to one another.

IE'2013, September 30 - October 01 2013, Melbourne, VIC, Australia

978-1-4503-2254-6/13/09⋯$15.00.
http://dx.doi.org/10.1145/2513002.2513014

The key contributions of this paper are twofold; firstly, we identify a set of four digital dimensions from our design process that help describe the design space of social digital play in movement-based game experiences. These are:

i) Spatial: The relationship between performance and digital representation of movement in physical space.
ii) Hidden: The level of understanding of a player's role among others.
iii) Fidelity: The range of fidelity in the digital representation.
iv) Control: How a player's control over digital representation fosters co-operation or collaboration with others.

Additionally, we present a set of design strategies for these dimensions that will help us create new engaging experiences.

2. RELATED WORK

Our work is informed by work on movement-based social digital games that explore the design space of social play between the player and screen. Interpreting physical movement in computer games is becoming more popular. Wii Sports allows a player's movements to control a virtual avatar, whereas in Guitar Hero [5] players embody a musical performer and in Dance-Dance Revolution [6] players aim to synchronize their movements with music. However, in these games a player's attention is directed away from movements such as downwards at a guitar or even a dance mat; the focus is more on individual movement performance and less towards other people in the physical space. In contrast, we aim to use digital elements to make people more aware of other peoples' movements.

In Bubble Popper [7] players strategically position themselves around a projected surface during play. These players compete against each other, applying pressure to a projected surface to pop as many bubbles as they can. This creates an engaging shift in focus between physically interacting with the screen and observing other players' positions around the screen. From this, we learn how the utilization of physical space around the focus of a screen increases awareness of others through graphical content. However, it does not help unpick how combining bodies with digital technologies can affect a player's experience of movements and social interactions with others in the physical space.

In Johan Sebastiaan Joust (JS Joust) [8] players move around a physical space trying to knock other players' PS3 Move controllers while keeping their own controller steady. Having technology attached to players reduces the disparity between movement and the digital game. The face-to-face dynamic enhances a player's engagement with the movements of other players in the physical space to create a socially engaging spectacle of light, sound and motion. Players must affect each other's controllers by direct movement, which accentuates a player's role in the game. In contrast, we see potential in using digital elements to give a player an ability to control someone else's controller in performing movement while masking an individual's role, something not often considered by designers of movement-based games.

The Mediated Bodysuit [9] explores embodied performance as an immersive experience. The authors argue the physical aspect of embodied interaction enables more immersive and captivating user experiences, whereas the social embodiment aspect generally entails empowering the user to perform. Identified as performative immersion, a state of duality occurs where participant and performer are concerned with playfully exploring the combination of touch, audio and light, and performing for an audience. This shows how digital elements can enhance social movements resulting in players experiencing immersion during a physical performance. However, only having two players mean audiences has limited involvement or input.

Musical Embrace [10] explores social awkwardness as an engaging game element, where two players hug each other in order to control movement in a virtual environment. The uncomfortable interaction promotes the development of player-to-player and player-to-audience relationships, as spectators engage with the experience while affecting the relationships between players.

Cart Load of Fun [11] takes place on public transport, where engaging gameplay encourages commuters to be more sociable. Players share this gaming experience by getting spectators to participate and we learn that spectator experience is not only about getting people engaged but also creating an inviting social environment that has players willing to share play with each other.

Lumahelm [12] is a safety helmet designed for cyclists and is embedded with colored LED lights. The cyclist interacts with the lights using head movements as means to signal to others their intention, such as stopping or turning. Despite the lack of gameplay elements, we see the potential of minimalism over realism in visuals to enhance the spectator experience.

These existing works explore the relationship between the player, the game and the audience, where digital elements served to enhance social play experienced from movement. However, we do not yet know how digital elements affect social relationships formed in the virtual space work in physical space. This motivates us to answer the research question: How do we use interactive technology to support play around movement and social interaction? We see potential in exploring an emerging design space between players and digital elements to develop a deeper understanding on how technology affects social play among players of movement-based games.

Despite knowing that movement can enable social digital play [13,14], designers rarely consider the ways in which digital elements, in particular the removal of a screen, can change the social relationship and perception of others. We respond to this challenge by building a game that explores how new digital elements change the experience of playground games. Our game allows us to observe behavior and experiment within this new design space.

2.1 Design space of social play between players and screens in movement-based games

Based on our play experiences, we believe social play in movement-based games may be affected by the way digital content represents the player's body. In Bubble Popper, the physical interaction with the projected surface is emphasized over the actual position of other players. In contrast, JS Joust uses the PlayStation Move controller's light to highlight the player's position in the physical space. In Figure 2 we compare the social experience of these games to Wii Sports, ordered by their representation of the player's position through either virtual space or physical space. Comparatively, in Figure 1 we illustrate the balance of engagement between players and spectators in our observation of people playing social movement-based games. We hypothesize interactive technology and its representation may influence the level of engagement others have with a player's movement performance. To substantiate this, we use a design-led

approach to create a game for the purpose of exploring the design space of social play between players and screens in movement-based games.

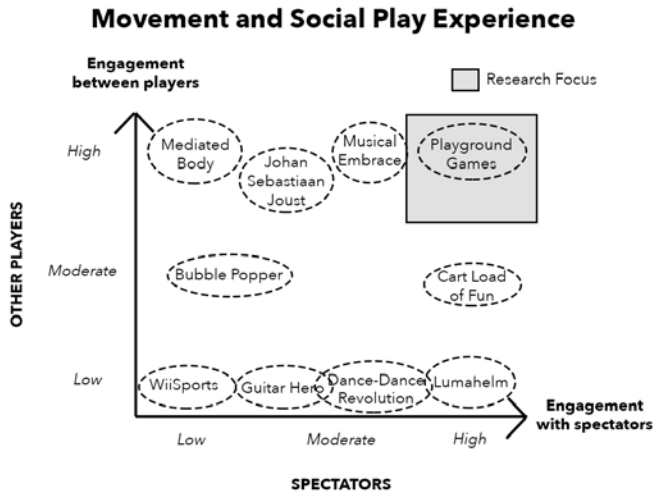

Figure 1: Interactive technology in games could have influence on how others engage with a player's movement.

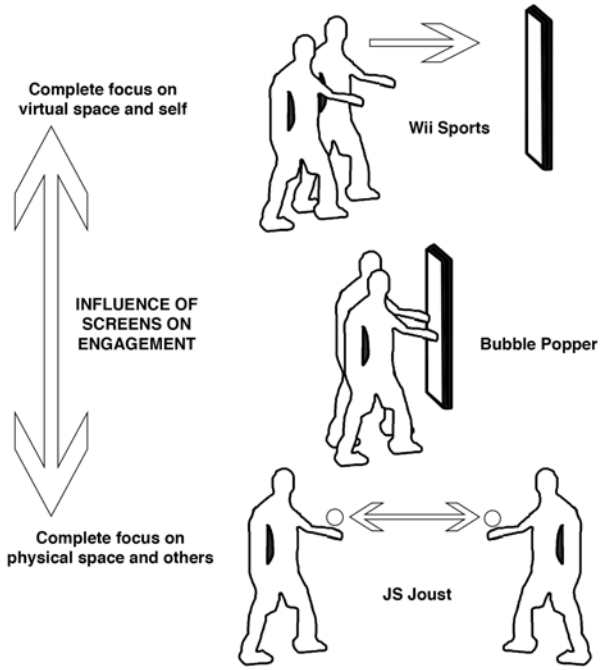

Figure 2: How players interact with screens affect engagement with one another's movement.

To answer how interactive technology and its representation affects social play; we propose that spatial, hidden, fidelity and control aspects of digital play shape the shared user experience in movement-based games. The spatial characteristics relate to the physical movement of players in the space, hidden characteristics concern the relationships fostered with one another from role ambiguity, fidelity characteristics are the range of movement representation in digital content and control characteristics are how players share control over a digital movement representation. To guide designers in the design space of social play between players and screens, our digital prototype explores these four digital dimensions of social physical play, before suggesting a set of design strategies for new games in this design space.

3. I-DENTITY

3.1 Gameplay

I-dentity is a collaborative movement-based game combining digital elements with a playground game, where each player holds a PS3 Move controller. It is inspired by the playground game "What time is it Mr. Wolf?" and takes the key component of the original game where players act as a metaphorical "wolf in a sheep's clothing". The wolf is "the odd one out" and by playing the game players can discover which player is the wolf. However, we decided to change this game's metaphor to make more sense in the context of our new game, as a wolf is part of a group who wanted to protect the "odd one out". Therefore, instead of a "wolf in sheep's clothing", our new game revolves around spies protecting their leader during an interrogation. To create this digital game we gave each player a controller and took the best elements of the original game rather than "digitize" its gameplay. We opt for a minimal visual interface in the form of colored lights and implement the game using the PS3 Move controller to ensure the focus is on gameplay and the game's physicality.

In i-dentity, players are given PS3 Move controllers, which illuminate whenever "the leader" moves. Players assume one of three roles: an interrogator, leader or spy. One PS3 Move controller is randomly selected by the game to represent the leader. The leader is the only player who knows their own role, as their controller vibrates when they move. While the leader moves through acting out a command, everyone's light goes on. When the leader is stationary the lights go out. A competent leader should try and move with everyone else in the group and not move noticeably differently.

An interrogator, separate from the group conducts or asks the spies to perform movements. The leader and other spies collaborate together as a team to mimic the movements or directions given by the interrogator while the interrogator tries to unveil the leader amongst the spies. The game continues until the interrogator believes they know the identity of the spies' leader. At this stage, the interrogator points towards the leader. The chosen leader waves their controller; if all the spies' controllers illuminate, the interrogator wins and the leader and interrogator switch roles, otherwise the leader and their spies win.

Figure 3: In our game i-dentity, a leader and his spies observe before attempting to mimic an interrogator's performance or commands.

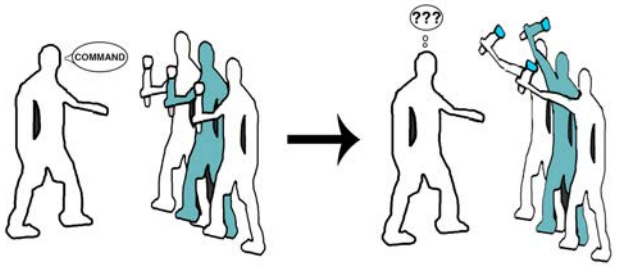

Figure 4. The interrogator command's "Raise your arm!" The leader and their spies coordinate movement so it is difficult for the interrogator to identify whose movement lights up all controllers.

3.2 Implementation

All players have PS3 Move controllers connected via Bluetooth to a computer. The accelerometer and gyroscope motion sensor are used to detect when controllers are moved. These sensor values are used to control the illumination of the built in light and vibration, according to the assigned role of the controllers. The leader's movement illuminates all three of the spies' controllers while the spies' movement is ignored. The leader copies the spies' movement in order to conceal their role from the interrogator. Vibration feedback is discretely sent to the leader's controller as they move to let them know their role in the game.

3.3 Development

We designed many prototypes to investigate the effects of combining digital elements with playground-inspired ideas having begun this research as part of an academic GameJam. The GameJam structure gave the authors a challenging environment for design encouraging innovation, experimentation and iteration over 48 hours. Game designers who are also researchers have advocated the benefits of using a collaborative and experimental design-led 'research after design' approach. [8]

We started development using two separate digital elements to visually represent the leader's movement, a PS3 Move controller and a laptop screen placed in between the leader and their spies. The laptop screen visually represented changes in the movement of the leader using a rendered graph. The interrogator's attention shifted between the graph and movement of the spies. The shift in focus between movement and virtual graphics on the laptop screen created disparity as the interrogator would look up from the graph, only to find movements in physical space had completely changed from what they had previously been shown on the graph in virtual space. To address disparity issues we used the lights on the PS3 Move controllers to indicate movement. These controller lights would even work in darkened rooms and the ability to individually control the illumination of each player's light directed attention towards the important movements. Rather than use high fidelity graphics or motion capture to virtually represent subtle changes in movements, we believe a low fidelity "1-bit" range of graphics facilitates engaging social digital play from movement shared between players, as errors in collaborative movements became more pronounced from binary representation.

We experimented by playing our new game with others in different ways since an important feature of engaging social play in playground games is the freedom to "create the fun". We believe in having the decisions on how the game should be played made in collaboration. As such, the goal for us is to design a flexible digital system with no "best case" scenario but one which facilitated player choice by offering multiple scenarios. During play we found members of the group would negotiate their own rules before deciding on their game. Game rules fitted one of many scenarios:

1) Players assume the roles of leader and spies with spectators electing an interrogator. As in many children's games, a single player is chosen to stand in front of the rest of the players. They would ask the group to perform actions before trying to guess the identity of the whole.
2) The leader would hide amongst the group of players and the spies (and leader) would take turns addressing the whole group to oust the hiding leader.
3) Instead of asking the spies to perform actions, the interrogator could physically "act out" movements, which the spies would mimic.
4) The game was played as in 3). However, the leader is unaware they are the leader.
5) Six players each choose controllers. These illuminate blue or red when moved which decides two teams of three players. One leader is hidden on each team, with one person from either team being chosen at random by the digital system to play the interrogator. The spies on the other team follow the movements of the interrogator simultaneously until the end of a turn, where the interrogator's role changes to another person.
6) The game was played as in 5). However, the interrogator "conducting" and spies "following" stages are separated, with the spies on the opposing team waiting until the end of an interrogator's turn before mimicking the movements.

We used many playtests to find a minimal set of rules, before deciding only one was always necessary for a working game: the leader could only be found out by someone addressing the whole group at once, for example, the group could be asked to jump up and down, they could be asked to "pretend they had just been shot", or even to play air guitar. Variations with the game play included sharing the role of the interrogator around during the game and enabling the interrogator to physically 'act out' the performance. Having many interrogators caused the spies to circle around as rather than facing off against the interrogator. This often caused spectators to gather around the space and become more involved in the gameplay. Giving the interrogator an option to perform the movements rather than asking the spies to perform create a more engaging spectacle as the interrogator tried to "upstage" the spies.

Our final prototype removed the disparity between virtual and physical space by using digital elements attached to players and using minimal visuals as means to enhance social play.

3.4 Inspirations

To begin the design we collated names of childhood games from playground games. Games included Tag, Hide & Seek, an egg & spoon race, a game of marbles, "What time is it Mr. Wolf?" Sleeping Lions, Musical Chairs, Mafia and Follow My Leader. All these games feature social and physical engagement between players. We then chose words to weight the game's emphases. These were distance, speed, height, scale, dummy controllers, minimalism, extremeness, provocation and cheating. The game "What time is it Mr. Wolf?" was chosen as the most inspiring game: it was played at a slow pace in comparison to JS Joust, yet retained rich social gameplay. The group started by playing the original child's game without technology. Players crept up on 'The Wolf'. If the wolf turned around and spotted a player moving they were removed from play. This led to an interesting insight

Figure 5: Reenacting playground and party games informed our design process.

that the original game required players to negotiate rules. What if 'The Wolf' turned around too frequently or identified someone as moving falsely when they were stationary?

In order to explore the social design space around physical digital play, the authors selected the PS3 Move controller as input device. The PS3 Move is ideal to position digital representation close to movement as the gyroscope and accelerometers provide movement data and its bright light can be used as a visual indicator. By giving a PS3 Move to each designer we found face-to-face design around the controller unexpectedly democratized the design process and the team was technologically inspired [13]. Designers could also pick up a PS3 Move controller and walk away from the group for quiet reflection. In contrast a screen, mouse and keyboard would elevate the programmer or artist to lead, leaving the team in the background.

3.5 Participant experience of i-dentity

The structured Game Jam design process of i-dentity involved a total of 8 playtesting sessions. We observed 20 people engaging throughout the iterative development cycle of the system, with all 4 developers present at each playtest to observe people's play experiences. Those who participated were part of the game or HCI design field or shared related interests. One playtest lasted around 20 minutes duration with a total of 5 games being played, and participant's switched roles at the end of each game. We made individual observations, where each of us focused on one of the four roles (interrogator, leader, spies or witnesses). We made separate notes from a playtest, before proceeding to collectively discuss our findings as a group to work out the areas of the design we thought could be improved upon before presenting the next iteration to the participants. This process provided the basis for our observations of how players played differently, according to their role in the game.

We noticed social interactions during our game generated emotional responses between players according to a player's role. Playing different roles meant attention shifted during gameplay. As the leader's role was the hardest they were under pressure to move in sync with the spies. In contrast, the spies and audience could relax, often laughing when the interrogator performed silly or hilarious movements, such as hopping on one leg or performing dance moves. The interrogator would often try to distract the spies by pulling facial expressions or talking with the audience to get them involved. The interrogator also performed elaborate movements that involved fast, precise, intense or sudden changes in movement speed and awkward positions, which made for an engaging spectacle. We devised the following chart to describe the reactions of players with respect to their role in the game:

Player role	Reaction to others
Interrogator	When observing, the interrogator would closely focus on the spies' movement and facial reactions while also experimenting with different tactics to try and distract the group, using body language, intimidation by moving close to players or getting the audience involved.
Leader	The leader tried to deceive the interrogator and witnesses in making them believe they were not the leader by looking at and pretending to follow another of the spies. However, this often worked against them, causing suspicion if made too obvious.
Spies	In contrast to the leader, the other spies tactically tried to fool the interrogator and audience into believing they were the leader (such as body language). They did not know who in the group was the leader themselves thus shared uncertainty when trying to act out the interrogator's commands.
Witnesses (Audience)	The intensity of spectacle in the interrelationship between the interrogator's expressive performance and rhythm of the spies' efforts to coordinate movement enthralled audiences. Rather than standing back and observing the actions being staged, spectators would often share conversations with one another and become actively involved in gameplay, offering advice to the interrogator who they thought were the leader, giving suggestions on challenging movements that would help to reveal the leader and attempt to distract the spies' focus on coordinating movement.

4. DIGITAL DIMENSIONS OF SOCIAL PLAY IN MOVEMENT-BASED GAMES

We now describe four digital dimensions that have culminated from our collective play and design experiences below. These dimensions relate to the spatial, hidden, fidelity and control aspects of interactive technology, which we propose can be used to facilitate social play in movement-based games. We consider these digital dimensions give insights on how the digital aspect can enable social play. By informing designers on dimensions of a social experience in technology-mediated play, we aim to foster the creation of new games in the design space between players and screens for engagement around movement and social interaction.

4.1 Dimension 1: Location of representation In relation to the body (Spatial)

We consider the notion of proxemics [16] to describe how interactive technology and its representation can affect the social relationship of a physical space. We noticed visual feedback systems direct players' focus of attention toward locations in space, which had an affect on social play. Designers should consider where digital elements are in relation to a player's body, as this affects how social play is experienced from movement. Many movement-based games, such as Wii Sports, have digital elements further apart from other player's bodies. This can cause stronger individual relationships with a virtual space to develop; however, engagement with others in physical space occurs less directly. This causes spectators become less engaged by a player's performance and more by the screen. Addressing disparity issues between movement and representation changes the focus of engagement. Designers representing digital movement on screens can consider performative actions in relation to the space occupied by players, as interactive technology can be used to emphasize movements, as seen in JS Joust. Alternatively, engagement with digital representation facilitates collaborative player interaction when players gather around the location of and touch a single screen, as seen in Bubble Popper and Fingle [17]. Using the understanding of four distinct proxemics interaction spaces based on distance of technology from people in physical space [18], we recommend for designers to consider the design options in this digital dimension for how peoples' focus of engagement affects awareness of oneself in relation to others in digital play around movement and social interaction.

DESIGN OPTIONS OF THIS DIGITAL (INTERACTION SPACE) DIMENSION FOR SOCIAL PLAY:

Away from bodies (Public interaction space)

High physical disparity between movement performance and its representation, players have complete focus on self-performance of movement on screen positioned away from movement, no focus on other's movement (e.g. Wii Sports).

Near bodies (Social interaction space)

Focus on a screen away from moving bodies creates disparity between players in physical space, players' focus on interacting directly with a screen, some focus on other players in close physical proximity, no focus on the audience (e.g. Bubble Popper).

With movement (Personal interaction space)

Low physical disparity between players, a player's focus shifts between themselves, other players and the audience. Spectators are more engaged by movement than the screen (e.g. i-dentity).

Direct body-body contact (Intimate interaction space)

No physical disparity between players as focus remains on one another, limited focus on or involvement from an audience (e.g. Mediated Bodysuit).

4.2 Dimension 2: Ambiguity of a player's role among others (Hidden)

We noticed existing movement-based games typically expose the player's role. However, in i-dentity an interrogator and spectators did not know the identity of the leader among the spies. Established game design (and also HCI) principles teach us that feedback to players' actions should be clear and non-confusing [19], so the identity associated with different represented

Figure 6: Moving the interactive visual to the body emphasized focus on movement.

movements should be readily immediate to the players. In contrast, we propose that game designers can obscure this representation identity as a new way to conceal a player's role for engaging social digital play. A desire to uncover a hidden identity can stimulate conversation and collaboration among players and spectators. We recommend designers of collaborative physical games consider how digital information is withheld and revealed to enhance social play, as elements of mystery and intrigue can encourage spectators to fully engage with a performance [20]. We introduce the potential of using digital elements to conceal roles for engaging social gameplay when players are given control over how a player's role is concealed by performing movement together at the same time. We anticipate new games can emerge in this design space by experimenting with ways how a player's concealed role is digitally represented to others, as players' real-time concealing of a player's role through movement enables the creation of new engaging social digital play experiences.

DESIGN OPTIONS OF THIS DIGITAL (HIDDEN SPACE) DIMENSION FOR SOCIAL PLAY:

Rules of play or game logic determine how game states are concealed and revealed to players

The game defines how people play, where a game state is concealed to some players but not others; social interactions are directed at turn-based changes in the game state (e.g. a player's location of pieces in the board game Battleship or a player placing a card on the table in Poker).

Player movement controls how roles are concealed and revealed to others

Player movement performance controls concealing of roles, social interactions are directed at the players' movement causing real-time obscuring of a movement representation identity (e.g. i-dentity).

4.3 Dimension 3: Range of representation in response to movement (Fidelity)

Advanced sensing technology such as motion capture is capable of detecting subtle changes in movements. This graphical fidelity produces highly accurate visual representations of movement and games strive for graphical realism. However, motion capture suits can be expensive and intrusive. Many movement-based digital games such as Wii Sports utilize virtual avatars, representing movement with relatively high fidelity. Realistic graphics can be complex to understand thus distract players from the performance

of others' movement. Technology can also be used to facilitate networked communication for social bonding via audiovisual conferencing. [21] We see potential for new games to emerge in this design space by using simplicity and being minimalist with representations of movement and form, so focus can remain on other people occupying the space. Designers should not just consider the range of representation in terms of visual fidelity but also viewing angle, brightness and size of the display. For example, playing i-dentity with mobile phone displays would make it harder for an audience to engage, as the representation would not be viewable outside a close proximity. Designers could experiment with non-visual means of movement representation to uncover how removing screens can facilitate social physical play among people in the same room, such as audio or haptic feedback.

DESIGN OPTIONS OF THIS DIGITAL (REPRESENTATION SPACE) DIMENSION FOR SOCIAL PLAY:

Networked digital representation of another person over a distance

Interactive technology facilitates social interaction between two or more people via video/audio conferencing; focus on another person in a different location, not on others sharing the same space (e.g. Table Tennis For Three [22]).

Virtual avatars as digital movement representation identity

Player-avatar interaction with graphical representation mimicking a person's movement in virtual space, focus on the self being represented by the avatar, not on others in the reality of the physical space (e.g. Wii Sports).

Low fidelity 'abstract' digital movement representation

The low fidelity of players' digital movement representation emphasizes focus with one another's movement in the same physical space, as opposed to diverting engagement towards graphical representation of a separate virtual space (e.g. i-dentity).

4.4 Dimension 4: Connectedness to others over control of representation (Control)

Prior work has shown many multiplayer movement-based games give players shared control over a single digital movement representation [10,11]. Physical co-operation or collaboration with others in technology interactions can engender a greater feeling of social connectedness with digital gameplay [13,14] Our play and design experiences with movement-based games suggest co-operation or collaboration over control of a digital representation can facilitate social play among players and spectators. We also found from our design process that performing movement can engage players and spectators even when this movement is not registered by technology [23]. Designers could consider coordinated movement as a feature of a performance and how controlling the representation of this collaboration can create a bond between players and engage an audience, even when only one player has control over a representation, or another's source of representation.

DESIGN OPTIONS OF THIS DIGITAL (CONTROL SPACE) DIMENSION FOR SOCIAL PLAY:

Collaborative control of a single digital movement representation

Players share control of a digital movement representation, with an individual controlling either different parts of the overall representation (e.g. Cart Load of Fun) or the same parts of the overall representation (e.g. Musical Embrace).

A player controls multiple digital movement representation sources, other players have no control over this representation

One player's movement controls multiple digital representation sources and others' movement is not represented, however their movement can obscure the controlling player's representation identity from an audience. (e.g. i-dentity).

5. STRATEGIES FOR ENGAGING SOCIAL PHYSICAL PLAY WHEN COMBINING PLAYERS AND SCREENS

Designing for social play between players' movement and engagement with screens is not easy, and it took us many iterations, playtesting sessions and discussions to understand how digital elements can engage people with one another's movement performance through digital movement representation as opposed to being focused on a screen but not on other people. By reflecting on our design process and what we have learnt from the rapid, collaborative and experimental development experience, together with our observations from playtesting the game with people who witnessed the game progress throughout its development, we have derived a set of design strategies for designers interested in using screens to facilitate engaging social physical play experiences.

We now discuss strategies for how designers of physical and social games can use interactive technology to facilitate social physical play. These strategies are derived from the digital dimensions presented above, to provide guidance on how combining interactive technology with movement enhance a social experience. We chose these strategies, as we believe they reveal how the digital aspect of physical play can facilitate an engaging social experience.

5.1 Strategy 1: Have players define how movement is performed

The visible and unexpected nature of actions in i-dentity encourages a social experience. Movement-based games generally use game logic to enforce rules determining how movement is to be performed. However, competing against a computer can lead to players performing movement with restraint or caution from having a more 'hard fun' experience, as players will often only perform the necessary movement required in order to win [14]. To allow for a wider range of movement, we give a player full control over how movement is to be performed, as opposed to having technology act as a referee to control movement. This made for a more enjoyable experience for the person defining the performance, as they could spontaneously move without being restricted by technology constraints or rules. The interrogator had to get someone to move out of line thus tried upstaging the players by stimulating physical challenge. When they observed other's movements, attention shifted outward toward the spies and consulting with the audience. Although the interrogator had the final say on what movements were to be performed, the spectators also had the opportunity to give suggestions on movement they thought could challenge the spies. This resulted in elaborate or expressive movement being performed, often featuring fast, precise, intense and sudden changes in movement speed and awkward positions. These movements were hard to perform successfully. As spies could not predict how someone on their team would react when given a command, this created uncertainty. Spectators expressed how they were engaged by the friendly yet competitive rivalry between the interrogator and spies' performance thus become involved by teaming up with the interrogator to try and oust the leader. Games in this design space

Figure 7: Spies coordinate movement with the leader in the center in order to conceal his role.

should consider how having a player define the physicality of movements with consultation from others could make for a more compelling social performance.

5.2 Strategy 2: Have players coordinate their movement by using interpersonal synchrony

Interpersonal synchrony as part of physical play could establish a stronger social connectedness with others' moving bodies [24] and this is evident in many real-life spectator sports, such as synchronized swimming and rowing. In i-dentity, players' can only conceal a leader by moving together, as it caused the digital movement representation identity to be obscured. The bright illumination and limited visual range of representation meant if one of the spies moved differently from their leader, this would be easily seen by others. As we required players to coordinate movement to win, this meant the spies had to work together. Having players mimic movement after observing the interrogator rather than at the same time caused players to strategize on how to approach a performance before doing so. Controlling the timing and speed attributes of movement as a group proved challenging. Each player in the group had to be self-aware of how their movement affected the movement of others, as even a small movement disparity between players could be enough to cause the leader to be spotted. Designers could have digital gameplay center on a synchronized performance of coordinated movement between players to foster development of a social relationship from the sharing of movement.

5.3 Strategy 3: Give a player control over another's representation source to facilitate social bonding

Being a spy required awareness on self-performance while having perception of others. To emphasize the importance of this collaboration, we made a leader's role unknown to everyone except the leader. One player's movement had control over the other team members' controller representation sources. The other spies knew they weren't the leader, however did not know who had control over their representation source. This established a connection with one another's movement, as players' coordinated movement served to protect one of their own. Attention shifted as players became more aware of others on their team. The control a player had over another's controller meant the digital sources of representation facilitated a bond that connected players with one another's movement, despite only one player's movement being registered by the technology.

5.4 Strategy 4: Have representation with movement to orchestrate peoples' attention towards players' performance

Screens give designers the ability to direct peoples' attention towards movement. With i-dentity, we had an interactive light attached with each player's movement. The PS3 Move controllers motivated players to perform whenever their controller illuminated, as they had full attention of other players and audience. How movement performance influenced engagement with others in a physical space depended on how closely integrated digital elements were to movement. Attaching low fidelity representation with movement orchestrated focus to the performance, whereas high fidelity graphical representation (such as graphs shown on a laptop screen away from movement) negatively impacted this focus by distracting people from movement. Using low-fidelity interactive visuals on moving bodies to emphasize movement performance facilitated engaging social physical play between players and audience around how each person's movement corresponded to their digital movement representation source. This meant focus remained on both the physical and digital. Designers can combine interactive technology representation with movement to create a spectacle that facilitates more active engagement from others with a performance.

5.5 Strategy 5: Create engaging gameplay from role ambiguity by having players' movement obscure its representation

The ambiguity of player roles was experienced among the spies, interrogator and spectators, as nobody knew the leader of the group. We give players the ability to use interactive technology to keep a leader's role hidden to others through movement. However, the technology didn't referee how a player's role was concealed, as players could only conceal a role by coordinating movement together. This facilitated social play, as it stimulated conversation and collaboration between team members performing and audience observing their movement. The digital movement representation identity is obscured as a result of this coordination, making it hard to discern whose movement controls the representations. As roles were ambiguous, body language was used as a tactic to manipulate others. Skilled players' body language made others wrongly guess the leader's role by pretending to be following someone else or looking suspicious. Over time, people also learnt how concentration, fast hand-eye coordination and peripheral awareness of others were important skills to help distinguish physical to visual disparity between a player's movement and the digital representation. This meant people could develop a physiological understanding of body movement from physical digital play. We introduce the potential use of interactive technology representation to have players' movement control how a role is concealed as a new way to foster an engaging face-to-face dynamic between players and with an audience.

5.6 Strategy 6: Stimulate spectator involvement with gameplay

A key aspect of playground games is having observers become involved in play. With i-dentity, a winning team got to keep their positions until losing, where they would switch positions with people from the audience. An audience became actively involved as we shared the play experience among players and non-players. Spectators often worked against a winning team, making successive games more challenging for skilled players. People often wanted to take center stage thus gathered around the space to become involved in gameplay. Spectators used various tactics to help reveal the leader. Some people were assigned by the interrogator to spontaneously jump around the space to distract players so they would lose concentration, whereas others were tasked to closely observe an individual player and give input on their performance. Some spectators would even try get in the way of one of the spies, so they were unable to focus on the interrogator's performance. These role-related factors built social bonds among the members of a winning team, who formed a rivalry against the others. Designers should consider getting spectators more engaged with gameplay around concealing and revealing roles through movement as a way to increase dialogue between players and spectators, whose shared involvement made for more engaging social interactions.

6. LIMITATIONS & FUTURE WORK

The design was made as a part of a GameJam and limited to development and evaluation that could be achieved inside 48 hours. The GameJam had many constraints including the number of players available for play testing. In future work the design space around more players could re-visit the game as a performance.

There are also other games that can be played using a networked PS3 Move controller, for example, the game "Sleeping Lions" was briefly considered at the start of our design process. We also anticipate our introduction to the use of obscured movement representation as a game element for new engaging social digital play experiences will be fully explored to further inform the digital aspect of the social design space presented in this paper.

We recommend for people to organize future Game Jams where designers benefit from having enforced hardware limitations such as banning the use of screens or designing games for a particular type of controller. We also see an opportunity for designers to reenact playground games at the start of the design process to help inspire new types of digital experiences and form social bonds among a team of designers.

7. CONCLUSION

We have presented i-dentity, a new game that is inspired from an idea of merging a traditional playground game with digital technology. We find our new game engaged players with its novel, social and spontaneous game play while adding a minimal aesthetic through the use of the PS3 Move controller's light. From our game observations, we presented a social-digital design space to identify ways how interactive technology can affect players' social experience in movement-based games and discussed the benefits of combining the virtual and physical space for engaging social physical play across both performing and spectating. To guide designers on the opportunities of the social-digital design space between players and screens, we presented four digital dimensions for the spatial, hidden, fidelity and control attributes of interactive technology and digital movement representation to affect a social experience and strategies from our design-led research exploration on how combining interactive technology and its representation with movement can enable engaging social physical play. We believe our digital dimensions and corresponding strategies can be applied to physical and social games in general, rather than just playground games, as they can assist designers in developing a deeper understanding of how engaging digital play around interactive technology and players' movement representation can have an affect on the social relationship between people and movement.

8. ACKNOWLEDGEMENTS

We would like to thank Exertion Games Lab, RMIT, Australia / HCII, CMU, for organizing the GameJam at CHI2013 which presented the authors the opportunity to start this research.

This work was part supported by the Arts and Humanities Research Council through the Creative Exchange.

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