Proxemics Play: Understanding Proxemics for Designing Digital Play Experiences

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ABSTRACT

Digital games are increasingly profiting from sensing technologies. However, their focus is mostly on sensing limb movements. We propose that sensing capabilities could also be used to engage players with proxemics: the interpersonal distance between players. We further add that wireless networks offer complementary distance zones for designers, offering novel design resources for digital play. We use our own as well as other games to articulate a set of strategies on how designers can utilize both proxemics and the new wireless proxemics to facilitate novel play experiences. Ultimately, with our work, we aim to expand the range of digital play.

Author Keywords

Games; proxemics; play; exertion games; whole-body interaction

ACM Classification Keywords: H.5.2. [Information Interfaces and Presentation]: User Interfaces - Miscellaneous.

General terms: Design, Human Factors

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INTRODUCTION

Proxemics describes an area of study that identifies the culturally dependent ways in which people use interpersonal distance to understand and mediate their interactions with other people [14]. Originally emerging from anthropology in the 1960s, proxemics thinking has recently gained attention in interaction design, in particular to support a ubicomp vision concerned with how people interact with each other using interactive devices [13]. For example, proxemics has been used to articulate how interactive devices can be more deeply connected to what we are doing, how we are doing it, and in which surroundings [13]. Extending this trend, we argue that proxemics thinking could also be a useful resource when designing digital games and novel play experiences. We support our claim by describing a set of games from our own as well as other work that utilize proxemics to offer novel play experiences. Using these examples, we derive a set of practical design strategies in the form of intermediate design knowledge [17] to aid designers of future systems who consider proxemics in order to facilitate engaging play experiences.

The most prominent, and probably most utilized aspect of proxemics in HCI is the concept of the four proxemics zones [13]. Consequently, we also focus on these zones in this paper and leave other aspects of proxemics for future work. The four proxemics zones describe how people interpret their interpersonal distance. Although the physical distances can vary between cultures and contexts, the interpersonal distance can be categorized as follows: the intimate zone (where interpersonal distance is roughly less than 0.5m), the personal zone (with interpersonal distance between 0.5m-1.2m), the social zone (1.2-3.6m) and the public zone (3.6-7.6m). The expectations of interpersonal

engagement and intimacy increase as distances between people become shorter. People adjust these distances according to their social activities, but sometimes this distance is also used to raise defense mechanisms when others intrude into these zones [14].

Recent work in ubicomp has operationalized the concept of proxemics by focusing on how sensors can support interactions between people as well as between people and devices [13]. We are motivated by the fact that digital games increasingly utilize sensing capabilities similar to the ones used in the ubicomp field. However, use of sensing in games has mainly focused on sensing a player's limb movements. We put forward an expanded view and propose that sensing in games could also benefit from an understanding of proxemics. In particular, we suggest that game designers could profit from engaging with proxemics to facilitate novel play experiences.

We are also inspired by the fact that in traditional games, like playground games and team sports, interpersonal distances between players, and between players and play objects, play an important role in facilitating engagement. For example, in the game of *Tag* the interpersonal distance is at the core of the gameplay experience: participants try to keep a physical distance from each other since a player loses when a catcher touches him or her. In soccer, players have to consider the entire range of interpersonal distances: the intimate zone when fighting for the ball, the personal zone when negotiating space to defend another person, the social zone when arranging tactical positioning with teammates, and the public zone when considering the audience.

These kinds of traditional games suggest to us that proxemics can be a valuable design resource for supporting engaging play experiences. We also propose that, with the advancement of sensing abilities in digital games, proxemics can be a design resource for creating novel digital play experiences. Furthermore, we argue that in addition to traditional proxemics zones, designers can also explore wireless networks, which offer complementary zones for designers to utilize as design resources for interpersonal digital play. To support this claim, we investigate existing games of our own as well as other people's games based on proxemics play. With these games, we articulate a set of design strategies on how designers can utilize both traditional proxemics zones and wireless zones in order to facilitate novel play experiences. Therefore this work contributes to the knowledge on how to utilize proxemics to support designers facilitating engaging games and digital play experiences. Ultimately, with our work, we aim to expand the range of digital play.

RELATED WORK

The idea of proxemics play draws inspiration from existing research on embodiment [10], whole-body interactions [11], exertion games [25], location-based games [1] and ubiquitous computing [13] that is concerned with interpersonal interactions amongst people as well as people and devices in space, and then applied to the context of play.

The importance of interpersonal relationships is highlighted in philosophies such as phenomenology, with contemporary proponents such as Van Manen [23] asserting that these interpersonal relationships are key to the understanding of contemporary life. In particular, Van Manen proposes the notion of "relationality" to describe the sense and sensuality in encounters with others [23]. With games pervading more and more contemporary life (for example see pervasive games [24]), we believe that interpersonal relationships can be a key aspect that deserves dedicated attention when it comes to designing digital play. In response, we put forward a perspective of such thinking targeted at interaction design.

Dourish took these philosophical perspectives into account when constructing an understanding of embodiment for HCI [10]. He argued that an embodiment focus involving a consideration of the social interactions among bodies could contribute positively to the future of interaction design. However, his work does not delve into practical details on how such a vision could be realized in practice, in particular for supporting play experiences.

In contrast, Benford et al. [4] argued from a designer's perspective that the consideration of bodies and their movements should become more prevalent in interaction design with the advent of modern sensor systems. According to the authors, designers should use sensed interactions among people as a design resource. Our work attempts to utilize this thinking about sensing and interpersonal relationships when designing play experiences.

Vogel et al. examined interactions between people and devices more closely to understand the potential of introducing sensors into these interactions [34]. The authors started exploring how physical distances can be used to mediate interpersonal relationships relative to a large display [34]. The authors designed an interactive display with a distance sensor that highlights how walking closer or further away from each other affects our interactions with other people as well as with interactive devices. The authors describe how the distances between users and devices can be sensed and how designers can use any changes to trigger different interaction modes. According to the authors, such sensing abilities have potential to enrich digital interactions. Here we extend this work by proposing benefits when considering the design of digital play.

Recent sensor-based game consoles such as Nintendo Wii, Microsoft Kinect and Sony Move build their gameplay experience around the movements of players, focusing primarily on tracking players' limb movements. We believe the associated sensing devices have potential and can also be harnessed to support designers' proxemics thinking, as

suggested by emerging frameworks around sensed bodily play [26, 33].

These body-centric frameworks often draw on prior research within traditional play and sports [26], which highlights how spatial relationships between people can facilitate different forms of play [29]. As we see sports as a form of play, we also believe we can learn from sports: sports can involve a whole range of interpersonal bodily relationships, from far-away spectatorship to close body-contact. This inspired us to consider the whole range of proxemics interactions in our work around digital play.

De Kort et al. [9] extended this work by arguing that interaction design could benefit from this thinking on interpersonal bodily relationships and suggest that designers should consider this when aiming to facilitate digital play. Frameworks that followed have taken this into account. For example, the exertion games framework [26] suggested four lenses on the body when designing bodily play, with the "relating body" being the most relevant here as it highlights the importance of people relating to each other during bodily play. This lens strengthens our belief that the consideration of the relationships between people has potential for the design of digital play; however, what is missing is guidance on how to design such "relating body" play.

In sum, prior work pointed out the potential of proxemics for interaction design, in particular in light of increased sensing augmentation. Many traditional bodily games draw extensively on proxemics, and considering the increase of these sensing augmentations, it has been argued that digital games could also benefit from proxemics. However, concrete strategies on how to engage with proxemics for digital play that designers can use in their practice are still missing from earlier works. With this paper, we aim to bridge this gap by providing an initial understanding of how designers can engage with proxemics in order to design engaging digital play experiences.

PROXEMICS IN GAMES

We now investigate several existing games and playful systems that exemplify our thinking. Some of these examples include work done by us while others are taken from the work of others. Based on our experiences of designing, playing, exhibiting and reflecting on these games, we articulate a set of strategies on how designers can utilize proxemics thinking illustrated with our examples. The strategies have emerged through an iterative process in which thinking about proxemics has also influenced our design practice in return. This process has been previously used successfully to develop a framework about sensing movement [4]. By engaging with such a process, we believe we are able to paint a picture of proxemics and digital play that is abstract in nature yet close to design practice.

Musical Embrace

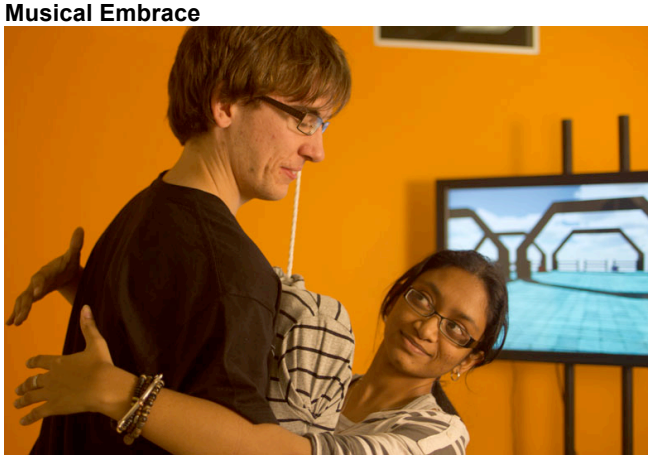

Figure 1. Musical Embrace is a game where strangers hug a shared pillow to advance in a virtual world.

The first game that we investigate is Musical Embrace [18-20], a two-player game that benefits from being played in front of an audience. It engages primarily with the intimate zone by motivating players (that are preferably strangers) to hug a shared pillow-like controller together in order to advance in the game (Fig. 1).

The game has been exhibited at festivals and conferences to support the social focus of the play experience [20]. The setup consists of a pillow-size controller hanging from the ceiling and a large screen (situated to the side of the players), which accommodates the virtual component of the game. To create the pillow controller, we used the sensors from a Nintendo Wii Balance Board encased in foam padding and wrapped with a custom-made pillow cover. Players are invited to apply pressure to the pillow, but as it is hanging off a rope, they are required to do so from opposite ends, at the same time. The players are only allowed to use their torsos to touch the pillow. No direct hand contact is permitted, but they can use their arms to embrace the other player to intensify the pressure.

The pressure applied to the pillow is important as the players navigate a virtual world on the screen that contains sound sources players need to reach. By applying pressure to the four corners of the pillow – through various (more or less awkward) bodily actions such as pressing at each other, bending one's own and twisting each other's bodies – the players navigate from destination to destination, hearing different sounds when they get closer. By applying different pressure intensities, players determine the speed at which they travel. The objective is to navigate to as many sound sources as quickly as possible. The game lasts for a minute and at the end the players are presented with the number of destinations reached.

This game creates socially awkward interactions between players, which we observed especially at conference venues where work colleagues engaged in uncomfortable hugs with each other. Our analysis [19] revealed a trajectory through the digital play experience, beginning with the entering into

the public zone where the unique pillow-controller piques interest, the finding of co-players in the social zone, the beginning of play in the personal zone, culminating in focused play in the intimate zone, with players breaking the social norm of hugging a stranger.

Proxemic Pong

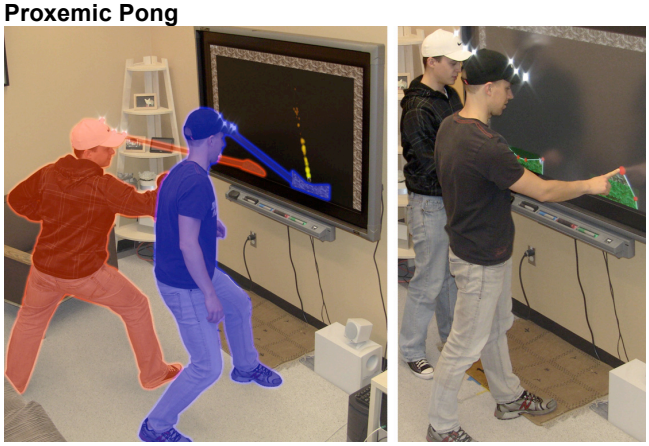

Figure 2. Proxemic Pong is a game where two players move about to hit a moving virtual ball with a virtual paddle.

The second game is Proxemic Pong [13], loosely based on the original pong game. Here, a person hits a moving virtual ball with a virtual paddle, the ball bounces off from the walls, and then the other person tries to hit the returning ball until someone misses. Proxemic Pong was created to demonstrate the potential of proxemics, running on a vertical surface (Fig. 2). We also created Auditory Pong [15] that demonstrates that proxemics play does not require a display (it is played entirely with sound); however, here we focus on the original Proxemic Pong.

The game reacts to distance, orientation, movement, and identity, where identity distinguishes between different players. Proxemic Pong recognizes when a person enters and stands in front of the screen. It creates a paddle for that person and starts the game. The player controls the paddle with their body by facing forward and moving from side to side. When a second person stands in front of the display, a second paddle automatically appears and the game continues via turn-taking. To penalize the player who interferes with the active player by standing in their way, Proxemic Pong enlarges the active player's paddle to make it easier to hit the ball.

Proxemic Pong introduces an exertion element into computer game play. Initially, the player's movement matches the paddle's movement. As the game play continues, the system increases the ratio of the physical distance that needs to be covered to move the paddle, while also increases the speed of the ball. This means that people have to move farther and faster to hit the ball. Proxemic Pong also exploits front-to-back motion. If a player moves very close to the display, the game automatically pauses; control points appear on the paddle, allowing that person to adjust the paddle shape by direct touch (see Fig. 2, inset). If a player moves backwards and sits down on the couch (i.e., the player becomes an observer), his or her paddle disappears and the game continues in single-player mode. If both move away, the game pauses.

Before we explain the next games, we now shift our attention to wireless zones, as the following games make extensive use of these zones.

EXTENDING THE TRADITIONAL PROXEMICS ZONES WITH WIRELESS ZONES

We have described the traditional proxemics zones that are based on interpersonal distance between people and people and devices. We note that these zones have four key characteristics. First, they are characterized by a range often marked in meters, such as "between 0.5 and 1.2 meters is the personal zone". Second, they have the approximate shape of a disc or sphere, with the person or the device at the center of the zone. For example, the intimate zone can be described as a sphere extending from a person's body by roughly 0.5 meters. Third, the zones are invisible for the human eye (in contrast to a line on the floor for example). Fourth, there is no hard boundary between zones, but rather, the borderlines are "blurry". For example, the borderline between the intimate and the personal zone is often defined as starting at 0.5 meters. However, it can vary based on cultural and personal differences, so it can start at something like 0.4 or 0.6 meters.

We now argue that designers have an additional opportunity to exploit proxemics thinking besides the traditional proxemics zones in the form of wireless zones. Wireless zone examples are the zones spanned by Wifi, a cellular network for mobile phones, Bluetooth and NFC (near field communication). These wireless zones have similar characteristics to the traditional proxemics zones: they are also characterized by a range (e.g. Wifi zones are roughly 20 meters) and have the shape of an approximate sphere, with a device (and its antenna) in the center. Wireless zones are also invisible to the human eye. Borderlines such as being in and out of range of a Wifi network, or between one and two bars on a mobile phone, are also blurry (affected by outside contexts such as weather) in terms of participants' experiences (Fig. 3).

We argue that traditional proxemics as well as wireless zones share many characteristics. Based on these shared characteristics we propose that designers should not only consider traditional proxemics zones, but also wireless zones, which we call wireless proxemics zones. We now present two play experiences that engage both traditional and wireless proxemics in order to illustrate our thinking.

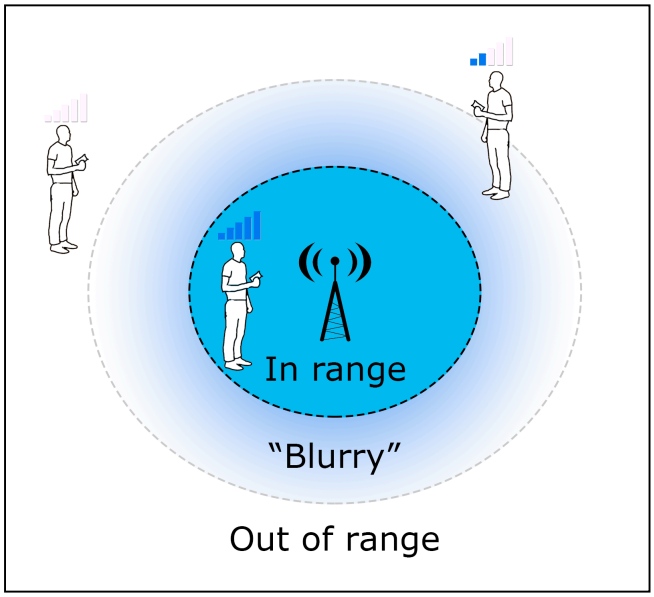

Figure 3. Wireless proxemics zones

WarDriving

Figure 4. In WarDriving, participants seek out wireless networks.

WarDriving is not one of our own games but rather a playful cultural practice that emerged with the increased popularity of Wifi networks [5]. WarDriving involves the act of searching for Wifi wireless networks, usually by driving around in urban environments, with laptops or mobile devices that continuously search for Wifi signals [5] (Fig. 4). What happens once a network is found depends on the participants. Various possibilities exist: some people simply identify these networks, others map their geographical locations to contribute to open-source maps of network access, or use these networks to gain free Internet access, while some try to hack into these networks.

Although not strictly a game (however a commercial game for the Nintendo DS exists that revolves around WarDriving), WarDriving is a playful engagement with proxemics as participants engage in playful interactions involving physical distance. First, participants move around the city, closing in on their distances to other people (and their homes featuring the Wifi router). They do enter the public zone when parking outside people's houses in order to reach the Wifi zone, yet being in the car ensures a certain safe distance to not get discovered, as the legality of WarDriving is still debated [31].

Jelly-Stomp

Figure 5. Jelly-Stomp exploits Bluetooth connection issues underwater.

Jelly-Stomp [21] is a four-player game played in teams of two. The game is played in shallow water (Fig. 5) with a set of Sony Move controllers and no screen. Each player gets a *jellyfish* (the Move controllers are wrapped in condoms to make them waterproof), which is tied to a long rope. Teams must keep their own jellyfish alive while stomping on the other team's jellyfish in an effort to 'kill' them. Stomping a jellyfish submerges the Move controllers underwater, which breaks the Bluetooth connection. The game monitors this disconnection and "kills" the jellyfish after several dips out of Bluetooth range (i.e., a fixed number of successful stomps). The controller's light changes color to indicate the amount of life left. Players have differently colored jellyfish, and they try to avoid stomping on their own or their teammate's jellyfish.

In Jelly-Stomp, players' interactions create a tension of positioning and movement between the social and intimate zone. Players strategically position themselves in the social zone (i.e., just out of reach of other players) so their own jellyfish does not get stomped. However, they quickly move into another player's personal and intimate zone to stomp

on their jellyfish (i.e., to break that jellyfish's Bluetooth connection), and then retreat (so they are not stomped in turn). All this is complicated by the splashing of water on each other.

DESIGN STRATEGIES TO ENGAGE PROXEMICS FOR PLAY

In order to provide designers with a better understanding of how they can utilize proxemics, we now describe a set of strategies identified from the games described above. These strategies are aimed to highlight the potential of using proxemics as design resource. As some of the example games described above engage more with the traditional proxemics zones, some more with the wireless proxemics zones, our strategies also initially focus on one or the other. However, we make explicit throughout the text how engaging with one offers opportunities to also consider the other. By looking at the complementary design opportunities, we aim to point out the potential to engage with both traditional and wireless proxemics zones in order to facilitate novel play experiences, extending prior work that, for example, focused only on the wireless zones [8].

This set of strategies is of course not an exhaustive list, but rather a starting point where we aim to emphasize salient features through our work of designing, playing, evaluating and reflecting on these games. Further work is needed to articulate a more comprehensive list. However, we believe that our work lays a foundation through a structured approach towards utilizing proxemics to facilitate engaging digital play experiences.

Challenge proxemics' cultural norms

This strategy is concerned with the extent to which the system supports challenging cultural norms associated with proxemics by means of digital game elements. Challenging cultural norms can be an engaging experience for participants, as previously pointed out by work on computer support to facilitate uncomfortable interactions [3].

Musical Embrace significantly exemplifies this strategy, as the game challenges the cultural norm of not getting into other people's intimate zone, especially not "hugging strangers". Doing so, however, did not cause significant distress for our participants, as the entering of someone's intimate space was within the context of "play", similar to how Milton Bradley's Twister engages players. The magic circle of play [30] allows players to be in a "safe" zone, in which it is safe to hug strangers (in contrast to non-play settings, where one could expect a hostile response). Our observations and interviews with players suggest that participants found that this opportunity to enter a stranger's intimate zone - while challenging cultural conventions - was sometimes liberating. This confirms previous games research that showed that allowing players to perform actions outside what "normal" life allows can be engaging [16].

In WarDriving, players have to drive by slowly or park outside people's homes in order to access the Wifi network for longer periods, which creates the challenge of getting as close as possible for a good signal, but not too close to raise suspicion. The wireless zone facilitates wardrivers (who are strangers) moving conceptually closer into people's interpersonal zones, motivated by the opportunity to have a better hacking experience by means of receiving a better wireless signal. That is, participants are breaking the cultural norm of not lurking outside someone else's home, which adds a sense of thrill to the experience. This goes hand in hand with previous theory that suggests that supporting the emergence of thrill can be a key ingredient for interactive entertainment applications [32]. We extend this work by proposing that challenging the cultural norms that are associated with proxemics can be one key strategy for designers to facilitate a sense of thrill that participants can find engaging.

In Jelly-Stomp, the game rewards players for stomping the controller with their feet, while also submerging it in water. This action also challenges cultural norms. Players move in and out of other's personal and intimate zones competitively. Their "attack" of a person's jellyfish device also challenges personal ownership, especially because electronic devices are usually not meant to be kicked and put in contact with water. Players also stand in the way of other players to block their Bluetooth signal (as Bluetooth does not travel well through bodies). Furthermore, players are motivated to stomp the controllers in water like children playing in a pool or the sea, allowing participants to engage in bodily actions they might remember from their childhood, but are now outside everyday life, contrasting "normal" adult behavior.

Facilitate players' awareness of zones

This strategy is concerned with the extent to which the system facilitates players' awareness of the proxemics zones. From our experiences, supporting players' awareness of the zones can be a design resource for engaging play experiences. In particular, we believe that designers should support participants' awareness in a playful way. We acknowledge that proposing to support "playful" awareness is not a straightforward endeavor. However, one way to support such playfulness is through supporting players' autonomy [28]. For example, participants should not just be informed that there are zones, but rather the system should make players aware that they can explore these zones freely themselves.

Musical Embrace supports players in becoming aware that they are in the intimate zone because of the tactile experience of touching the controller. Moreover, the system also supports awareness of the intimate zone through the virtual world: players reducing their interpersonal distance to about 10cm will notice that their viewpoint in the virtual world starts to move, as picked up by slight touches to the cover that triggers sensor data. The awareness that the

interpersonal distance between players triggers movements in the virtual world appears to facilitate participants' playful engagement with proxemics: in the players' quest to move in the virtual world while offering a spectacle to the audience, we observed them expressing themselves by bending their torsos in unexpected ways, moving their partner back and forth, spinning them around and even lifting their partner up. This highlights how the system supported the players in freely exploring the many ways to achieve the game's goal.

In Proxemic Pong, the display makes the passer-by aware of the opportunity to play a game not only by displaying a paddle that waits for users to play with, but by seeing the paddle move in response to his or her body motions.

Wardrivers are being made aware of opportunities to "play" with wireless networks once they get close enough with a visual alert (such as an animated icon on screen), often supplemented by a "playful" audio alert. The different bar sizes indicating wireless strengths serve as awareness tools for participants on what kind of experience they can expect when starting to engage with the new-found network.

In Jelly-Stomp, players are made aware of the zones through the rules of the game: leaving the wireless zone results in a jellyfish death. But players also engage with the physical zones: through the rope, the jellyfish stay with their players, and players are not allowed to leave the water as per the rules of the game.

Facilitate bodily movement by supporting the exploration of proxemics zones

This strategy is concerned with the extent to which the system facilitates bodily movement by supporting the exploration of proxemics zones. Designers can facilitate participants' bodily movement by making movement within and across these zones interesting, for example by using visual and auditory effects. In turn, the resulting bodily movement can facilitate more emotional experiences, as prior work on bodily movement in games and associated heightened emotional involvement suggests [6, 7]. Designers can use proxemics to create more emotional play experiences, as they can use the proxemics zones to motivate players to move, which facilitates the emergence of emotional experiences.

For example, in Musical Embrace, the game motivates players to move from the public zone to the intimate zone by enticing passers-by to engage with the comfortable-looking pillow controller. However, this can quickly change into an awkward experience, taking players onto an emotional journey [19]. Moving from the public zone towards the pillow controller to enter the intimate zone is only part of the emotional experience. Within the intimate zone, players need to move their entire bodies collaboratively if they are to operate the controller effectively (i.e., by swaying back and forth / left and right, as using the torso only is quite challenging). By doing so, they explore the virtual world to navigate to the sound sources. This can be seen as an exploration of the intimate zone, facilitated by the exploratory nature of the virtual world.

Proxemic Pong gets harder and harder over time by increasing the ratio of the physical distance that needs to be covered to move the paddle while increasing the speed of the ball. This means that people have to move farther and faster to hit the ball. In other words, the game design facilitates bodily movement by supporting the exploration of the proxemics zones over time. Consequently, the increase in movement is believed to increase participants' emotional involvement with the game.

In WarDriving, participants need to move in order to play the game. Although most WarDriving players sit in cars, alternative versions like WarCycling, WarWalking and even WarBoating [5] require participants to invest physical effort as part of their experience. This investment of physical effort forms part of the challenge for participants: engaging in WarWalking in urban environments is relatively easy due to the dense Wifi population (hence most players seem to start in urban environments). However, the game becomes more challenging in rural areas.

Furthermore, WarDriving highlights the role physical elements of the urban environment can have on the experience. Being in a car limits the opportunities for bodily movement. However, the car also affects the quality of the wireless signal, hence the urban environment affects the experience for the participants in terms of both the traditional and wireless proxemics zones.

In Jelly-Stomp, players explore the Bluetooth zone through stomping with their feet. This exploration of the wireless zone is exacerbated by the water, as it requires more exertion to stomp in water than in air. So the wireless zone facilitates movement through the medium (water) that affects the distribution of the wireless signal. The results are bodily actions that can facilitate emotional experiences, possibly reminding people of their childhood experiences of playing in and with water.

Support discovering proxemics zones' blurry borderlines

Proxemics zones' borderlines are blurry. For example, the boundary between personal and intimate zone has been defined at 0.5 meters [14], however, there is no precise borderline, and where the personal zone begins and the intimate starts is often rather ambiguous, as it depends on culture and context [14]. Within proxemic interactions, researchers are already designing systems that react to interpersonal distance in a continuous rather than discrete manner, where the zones are reconsidered as points on a spectrum rather than boundaries [13]. Similarly, the wireless borderlines are also blurry. Wireless network's reach and strength depends on many factors, many of them

environmental such as weather, allowing us to characterize the borderlines between, for example no signal, a weak and a strong signal, also as "blurry". Supporting players to discover these blurry borderlines can facilitate engaging play experiences, as previous games research suggests [8]. This is in line with prior research in interaction design that highlights the potential of ambiguity when aiming to design engaging digital interactions [12].

An interesting aspect for designers, we believe, is that although humans can often subconsciously feel when they have left one interpersonal zone and entered another, interactive technology can support and help people in discovering these borderlines between zones explicitly. With the new wireless zones, digital technology is needed to allow participants to discover the borderlines of the zones. For example, without a laptop or mobile device, the act of WarDriving would not have existed, as people cannot "feel" wireless zones. However, interactive technology lends itself to characterize "hard" boundaries (is there a wireless network?) in contrast to support discovering blurry boundaries (does the signal "kinda" work?). For example, in [27] the authors decided for making different distances explicit in form of simple distance classes to support awareness of team players, which are communicated by an additional tactile display. We therefore suggest to designers who engage with the blurry borderlines of wireless signals to learn from the experiences with blurry borderlines from the interpersonal zones. In summary, we encourage designers to see the blurry borderlines of proxemics as resources for game design to support players in discovering these borderlines and engage with the blurriness, which can support the playful character of the experience [8].

With Musical Embrace, we observed diversity in the comfort level of players: some are more comfortable being close to another player than others. This resulted in experiences where players were aiming to discover how "much" their partner would allow them to hug [20]. As such, players were exploring the blurry borderline together. They found it an interesting challenge to discover the optimal compromise between squeezing hard (to maximize scores) while not being too intimate (where the other player would quit). Supporting the discovery of this blurry borderline between "too intimate" and just "intimate enough" was one of the key success ingredients of the game.

In Proxemic Pong, players have an opportunity to play with the borderline of being a player or a spectator: if a player sits down, the game treats him/her as a spectator, if the player is close-by, then she/he is a player. However, what happens if the player is in the blurry zone between sitting down and standing up? Players can play with this blurry zone by quickly moving back and forth, causing erratic behavior on the screen.

In WarDriving, participants engage in the challenge of discovering the Wifi zone's borderlines of "getting a signal" and "not getting a signal". This can often involve stopping the car once a Wifi signal popped up briefly, and then driving back and forth to get the signal back. These suspicious driving maneuvers are part of the playful "being a spy" experience, as players need to engage in this unusual driving maneuver in order to get the best signal, yet they do not want to come across as suspicious to the people around them who might call the police. As such, the support for discovering the blurry borderline of the wireless zones results in physical movement that can cross interpersonal distances, which adds to the excitement of the experience. Supporting players in discovering blurry borderlines spatially has been previously described as engaging game play resource in the context of pervasive games [24]. We extend this work by pointing out the potential of blurry borderlines of wireless signals as another design resource that could complement the blurry borderlines of interpersonal distance.

In Jelly-Stomp, players want to stomp out the jellyfish, but they do not know how deep they need to stomp them, as they do not know how far Bluetooth reaches underwater (it depends on the salt level of the water, amongst other factors). The players engage in the challenge of figuring out where the blurry borderline of Bluetooth reach is underwater. As such, players engage in a challenge of identifying an optimal strategy, which has been previously described as one of the key reasons why games can be so compelling for people [22].

CONCLUSIONS

We believe the emerging trend of enhanced sensing abilities in combination with proxemics thinking can not only be useful to support the ubicomp vision as prior work suggests [13], but in particular be useful to facilitate engaging play experiences. In this paper, we have argued for the potential of proxemics to support the design of digital games and play. We articulated a set of strategies based on our experiences of designing proxemics games and play experiences that designers can use as starting points when considering engaging with proxemics in their games and digital play design practice.

One limitation of our work is that our strategies emerged from our practice of designing proxemics play systems and analyzing existing works, where both the design practice informed our theoretical thinking behind it, and our theoretical thinking informed further designs. What is still missing is an evaluation that verifies that our strategies can be useful for other designers. For example, this could be achieved by holding workshops with designers who design future play experiences with and without our strategies. We leave this for future work. Nevertheless, we believe our work can serve as initial starting point towards an engagement with proxemics and play, offering the first structured approach towards understanding how digital game design could profit from proxemics.

Our work has also focused primarily on one facet of proxemics: how people interpret social distancing as a

function of physical distancing. Yet proxemics is more nuanced than that. For example, Greenberg et al. [13] list four further dimensions that can be exploited by proxemic interaction and thus by extension by proxemic play. *Orientation* between entities can act as an estimate of sensing attention, which in turn suggests a decrease in social distance. *Identity* uniquely describes the entity, which means proxemic relations can depend on the particular people and devices involved. *Movement* captures the distance and orientation measures over time, where different actions can be taken, for example: is one entity moving towards another vs. moving away? Finally, *location* describes the physical context in which the entities reside, where all the other inputs and resulting actions may be context dependent. Another role of proxemics has also to be discussed which is remote game participants. Revisiting work for example on sport over a distance [25], Can you See me Now [2] and on the many location-based games that were developed over the last decade show the potential of considering virtual proxemics into games in which remote players and their real and virtual distances from other players can become an integral part of the game's design.

By illustrating our thinking with examples, we also hope to engage game designers who previously have not heard about proxemics to consider it in their practice. Furthermore, we aim to expand the range of proxemics that designers consider with the introduction of the wireless zones. Lastly, we hope our work can also encourage ubicomp designers to consider how their expertise around proxemics could be useful for the creation of more playful experiences. The result will be more systems that facilitate play in novel ways, ultimately extending the field of proxemics as well as play by highlighting the opportunities when these two come together. Ultimately, with our work, we aim to expand the range of digital play.

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REFERENCES

1. Benford, S., Anastasi, R., Flintham, M., Drozd, A., Crabtree, A., Greenhalgh, C., Tandavanitj, N., Adams, M. and Row-Farr, J. Coping with uncertainty in a location-based game. *IEEE pervasive computing*, *2* (3). (2003), 34-41.
2. Benford, S., Crabtree, A., Flintham, M., Drozd, A., Anastasi, R., Paxton, M., Tandavanitj, N., Adams, M. and Row-Farr, J. Can you see me now? *ACM Transactions on Computer-Human Interaction (TOCHI)*, *13* (1). (2006), 100-133.
3. Benford, S., Greenhalgh, C., Giannachi, G., Walker, B., Marshall, J. and Rodden, T. Uncomfortable interactions *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems*, ACM, Austin, Texas, USA, 2012, 2005-2014.
4. Benford, S., Schnädelbach, H., Koleva, B., Anastasi, R., Greenhalgh, C., Rodden, T., Green, J., Ghali, A., Pridmore, T. and Gaver, B. Expected, sensed, and desired: A framework for designing sensing-based interaction. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *12* (1). (2005), 3-30.
5. Berghel, H. Wireless infidelity I: war driving. *Communications of the ACM*, *47* (9). (2004), 21-26.
6. Bianchi-Berthouze, N. Understanding the role of body movement in player engagement. *Human-Computer Interaction*, *28* (1). (2013), 40-75.
7. Bianchi-Berthouze, N., Kim, W. and Patel, D. Does Body Movement Engage You More in Digital Game Play? and Why? in Paiva, A., Prada, R. and Picard, R. eds. *Affective Computing and Intelligent Interaction*, Springer Berlin / Heidelberg, 2007, 102-113.
8. Chalmers, M., Bell, M., Brown, B., Hall, M., Sherwood, S. and Tennent, P. Gaming on the edge: using seams in ubicomp games *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology*, ACM, Valencia, Spain, 2005, 306-309.
9. de Kort, Y.A.W. and IJsselsteijn, W.A. People, places, and play: player experience in a socio-spatial context. *Computers in Entertainment (CIE)*, *6* (2). (2008).
10. Dourish, P. *Where the Action Is: The Foundations of Embodied Interaction*. Boston, MA, USA: MIT Press, 2001.
11. England, D., Hornecker, E., Roast, C., Romero, P., Fergus, P. and Marshall, P. Workshop on Whole-Body Interactions *CHI'09: Proceedings of the 27th International Conference on Human Factors in Computing Systems, Extended Abstracts*, Boston, MA, USA, 2009, 1-4.
12. Gaver, W.W., Beaver, J. and Benford, S. Ambiguity as a resource for design *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM New York, NY, USA, Ft. Lauderdale, Florida, USA, 2003, 233-240.
13. Greenberg, S., Marquardt, N., Ballendat, T., Diaz-Marino, R. and Wang, M. Proxemic interactions: the new ubicomp? *interactions*, *18* (1). (2011), 42-50.
14. Hall, E.T. *The hidden dimension*. Anchor Books New York, 1969.
15. Heuten, W., Henze, N., Boll, S. and Klante, P., Auditorypong–playing pong in the dark. in *Proceedings of Audio Mostly the Conference on Interaction with Sound*, (2007), 134-147.
16. Hobye, M. and Löwgren, J. Touching a stranger: Designing for engaging experience in embodied interaction. (2011).
17. Höök, K. and Löwgren, J. Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Trans. Comput.-Hum. Interact.*, *19* (3). (2012), 1-18.

18. Huggard, A., De Mel, A., Garner, J., Toprak, C.C., Chatham, A.D. and Mueller, F., Musical embrace: facilitating engaging play experiences through social awkwardness. in *CHI'13 Extended Abstracts on Human Factors in Computing Systems*, (2013), ACM, 3067-3070.
19. Huggard, A., De Mel, A., Garner, J., Toprak, C.C., Chatham, A.D. and Mueller, F. Understanding a Socially Awkward Digital Play Journey *DiGRA 2013*, ACM, 2013.
20. Huggard, A., Mel, A.D., Garner, J., Toprak, C.C., Chatham, A. and Mueller, F. Musical embrace: exploring social awkwardness in digital games *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing*, ACM, Zurich, Switzerland, 2013, 725-728.
21. Jarnfelt, P., Toft, I., Naseem, A., Mechtchanova, L. and Hermansen, S. Jelly stomp, 2013. Retrieved from http://www.copenhagengamecollective.org/projects/jelly-stomp/.
22. Koster, R. *A theory of fun for game design*. Paraglyph press, 2004.
23. Manen, M.v. Phenomenology of practice. *Phenomenology & Practice*, *1* (1). (2007).
24. Montola, M., Stenros, J. and Waern, A. *Pervasive Games: Theory and Design*. Morgan Kaufmann, Burlington, MA, USA, 2009.
25. Mueller, F., Agamanolis, S. and Picard, R. Exertion Interfaces: Sports over a Distance for Social Bonding and Fun *SIGCHI conference on Human factors in computing systems*, ACM, Ft. Lauderdale, Florida, USA, 2003, 561-568.
26. Mueller, F., Edge, D., Vetere, F., Gibbs, M.R., Agamanolis, S., Bongers, B. and Sheridan, J.G. Designing Sports: A Framework for Exertion Games *CHI '11: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, Vancouver, Canada, 2011, 2651-2660.
27. Pielot, M., Krull, O. and Boll, S. Where is my team: supporting situation awareness with tactile displays *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, Atlanta, Georgia, USA, 2010, 1705-1714.
28. Rigby, S. and Ryan, R. *Glued to games: How video games draw us in and hold us spellbound*. Praeger, 2011.
29. Rubin, K. The Play Observation Scale, University of Maryland, 2001.
30. Salen, K. and Zimmerman, E. *Rules of Play: Game Design Fundamentals*. The MIT Press, Boston, MA, USA, 2003.
31. Sathu, H. Wardriving: technical and legal context. *WSEAS Transactions on Computers*, *5* (7). (2006), 1556-1561.
32. Schnaedelbach, H., Egglestone, S.R., Reeves, S., Benford, S., Walker, B. and Wright, M. Performing thrill: designing telemetry systems and spectator interfaces for amusement rides *Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, ACM, Florence, Italy, 2008, 1167-1176.
33. Segura, E.M., Waern, A., Moen, J. and Johansson, C. The design space of body games: technological, physical, and social design *Proceedings of the SIGCHI conference on Human Factors in computing systems*, ACM, Paris, France, 2013, 3365-3374.
34. Vogel, D. and Balakrishnan, R., Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. *Proceedings of the 17th annual ACM symposium on User interface software and technology*, (2004), ACM, 137-146.