Interdependent Wearables (for Play): A Strong Concept for Design

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ABSTRACT

Typically wearable devices are conceived of and constructed as stand-alone, individually based technologies. However, in practice wearables become part of the social context and ecology of overall device use. We present a strong concept for design: Interdependent Wearables (for play): wearables designed to require shared attention and mutual awareness, with interdependent functionality that encourages and rewards collocated interaction. The concept arose through design, development, and public exhibition of Hotaru, a collocated social game that uses wearables as game controllers. Hotaru has been shown in festivals and also formally playtested with 62 individuals. To more fully articulate the Interdependent Wearables strong concept, we compared this system's design with wearable and embodied systems for play and other purposes, and drew upon relevant HCI theory. The work is of benefit to those in the HCI/UX community focused on the design and development of social wearable technologies, especially those interested in supporting collocated interaction.

CCS CONCEPTS

• **H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.**;

KEYWORDS

Social wearables, collocated interaction, strong concept, interdependent wearables, embodied interaction

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1 INTRODUCTION

Wearable technologies have been of interest to HCI researchers for many years (e.g. [7, 20]), and have become a robust commercial category in the last 5-10 years, with the introduction of smart watches and the increasing diversity of fitness tracking devices. The first wave of these devices was focused on quantifying data about the self [36], with some facility for sharing activity data with others. In the last few years, smart watches have begun to support networked social interaction through messaging, calendars, email, and other social coordination and connection tools [28], such as Snapchat Micro [10]. However, wearables have not yet begun to robustly support collocated social interaction—interaction between people in the same place [19]. In fact some commercial wearables have been critiqued for perturbing collocated interaction—some so dramatically as to lead to their ban from public spaces such as bars [18].

Wearables experts in the commercial sector have declared the next phase of development 'the social age of wearable tech,' envisioning "a future where wearing technology isn't just about measuring and monitoring, but instead about enhancing our body's ability to communicate, express, and empathise with others." [4]. Our research team believes that thoughtful and sensitive design can lead to the fruition of such a vision, producing wearable technology that truly augments collocated engagement rather than intruding upon it. We envision wearables that heighten expressiveness and allow additional layers of social signaling, which are artfully crafted so as not to interfere with, but rather to enhance mutual attention, collaboration, and play. To deliver this vision, we believe there is a need to reframe design practice to focus upon the unique opportunities that technology has to augment mutual engagement and attention [13]. In this paper we present a strong design concept [11] that can aid in shaping design practice to support collocated interaction of this kind: interdependent wearables (for play). The concept arose from insights we had during the design, development, and exhibition of a game that uses social wearables [14]. The primary contribution of this paper is the introduction of this strong concept to help shape research and design practice in constructing wearables to support collocated interaction. Though this strong concept arose in the context of play, we believe it can also hold value for social wearable design outside the 'magic circle' [5, 34] of games.

2 RELATED WORK

Höök and Löwgren [11] introduced the notion of strong concepts as a formulation for sharing generative intermediate-level design knowledge. Strong concepts combine a clear definition of a design idea with both vertical grounding through comparison and contrast with related systems, and horizontal grounding in relevant theory. We have followed this structure in framing the strong concept contributed in this paper.

HCI researchers have recently pointed out the value in focusing on supporting collocated social interaction with technology (e.g. [19]). Within the games community, a number of scholars

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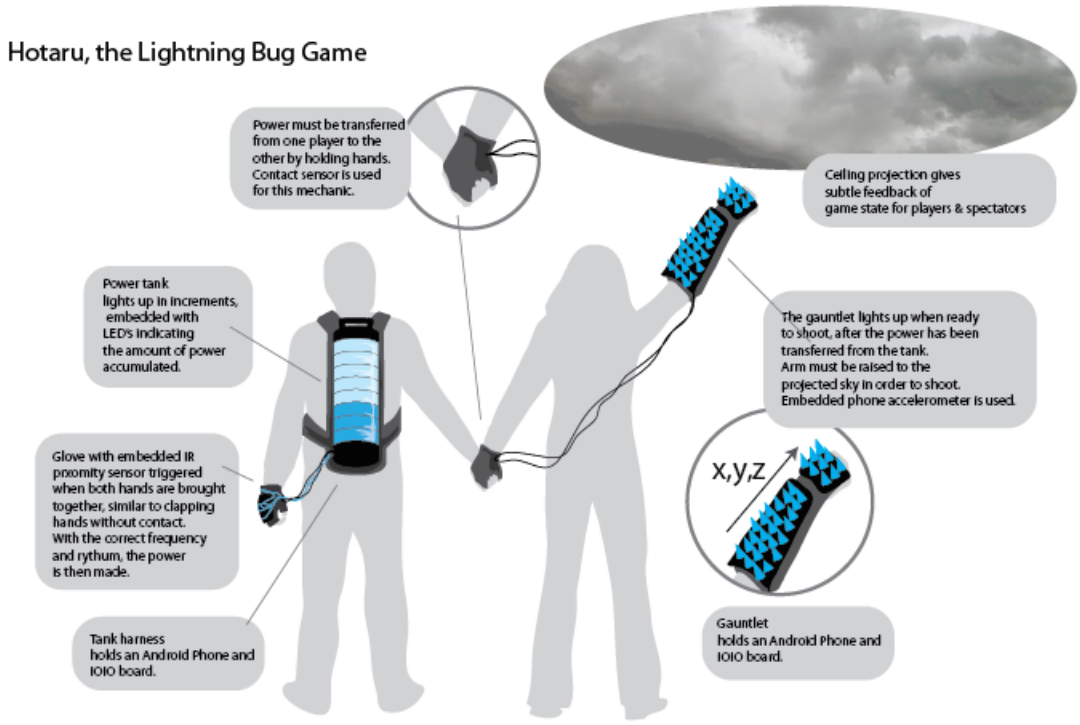

Figure 1: An overview of components of Hotaru.

have turned their attention toward support of collocated play in recent years [24, 25, 31, 35], with some preliminary work on both wearables and costumes as they relate to social play [14, 33]. HCI practitioners outside games have turned attention to managing ecologies of devices to take into account social dynamics, using frameworks such as proxemics (the study of interpersonal distance) [22] and the spectator experience (understanding how technologies influence those who observe an interaction) [29] . The current paper contributes a strong concept that can be of potential value to these ongoing research streams both within and outside games and play, particularly of use in thinking about social wearables. It is our hope that this strong concept can help spur ideation and prototyping of wearables to better support collocated social interaction.

3 HOTARU'S INTERDEPENDENT WEARABLES

We begin with a brief description of the system whose design inspired the strong concept. Hotaru was created by an accomplished independent game designer, Kaho Abe, with a specialty in movement-based social games. She developed the game working in collaboration with an HCI researcher interested in wearable computing to support and enhance collocated social interaction. The team received funding from an initiative aimed at pairing artists and researchers to investigate the future of computational fashion.

Abe was interested in combining costume and gesture, to create a physical enactment of the gameplay identities players take on when they engage in avatar-based play [13]. She was inspired by a Japanese television show with superheroes who have costumes with powers they unlock by making special gestures. The idea was to combine costume-like wearables and special collaborative gestures to unlock players' powers together, building camaraderie and connection through interdependence and shared mission. Hotaru means 'lightning bug' in Japanese. She conceived of a game in which the players seemed like fireflies battling together to keep smog at bay. She designed the wearable elements to be simple and evocative of this theme. (see Figure 1).

To play Hotaru, one player puts on a gauntlet, and the other puts on an energy collection 'tank'. Both wearables illuminate when 'energy' flows through them. The object of the game is to collect energy, then aim it at projected 'smog' to dissipate it. This requires the coordination of both players. The person with the tank moves their hands in an energy collecting gesture to 'fill' their tank. This is indicated by illuminating segments of the tank lighting up. This player cannot see the tank, so they need the other player to keep an eye on it and tell them when the tank is full. Then the players must hold hands for the energy to 'transfer' between them. The second player waits until their gauntlet fills with energy (indicated by all the spikes on the gauntlet illuminating). Then this player quickly raises their hand in the air to release the energy. This causes the gauntlet to emit a loud 'firing' noise. The end goal is to collaborate to release energy as many times as possible in a limited time window

Figure 2: We took snapshots of players before and after play.

Figure 3: a,b. Sample post-play images. 3a shows no signs of connection, whereas players in 3b are physically close, lean toward one another, smile, and use similar, energetic poses.

(please also see uploaded video, and a prior paper describing the overall installation [14]).

4 TOWARDS A STRONG CONCEPT

Hotaru has been a success from the perspective of the independent games world—it has been shown at IndieCade, the premier venue for independent games in the US, as well as a variety of international festivals. We conducted and documented more formal playtests with 62 individuals as well, to explore the effects of the design upon their experience. Insights from festival showings as well as these playtests helped shape the strong concept presented in this paper. Here, we briefly describe the playtest procedure and results, as supportive evidence for the usefulness of the ideas and tactics that were realized in this design, which are at the core of the strong concept. A primary question of interest in the playtests was whether playing the game increased feelings of connectedness, as we had intended would be the case with the design.

4.1 Study Participants and Procedure

We conducted three public playtests of the game in March and April of 2015, which were approved for data collection by our human subjects board. There were a total of 62 unique players who participated for a total of 33 rounds of play. We did not collect self-identified gender data, however a visual review of the logs indicated 28 unique male-seeming participants and 34 unique female-seeming participants.

We video recorded play, and also asked participants to take a moment to have 'before' and 'after' photos snapped of them standing together (see Figure 2). Afterward, each player completed a paper-based survey. This survey asked players which wearable they chose (to link their answers to videos/photos for later analysis), then asked them to clarify what, if any, prior relationship they had to the person with whom they played. They were asked if they thought playing the game had influence on their trust, liking, or connection to the person they played with, and if they answered yes, prompted to explain how so. They were also asked how it felt to play the game, with room for open-ended response.

4.2 Results

We looked at how many participants responded 'yes' to the question of whether they game influenced their trust, liking, and connection to the person with whom they played the game. Of 66 unique answers (4 players completed multiple rounds of the game with different partners), 48 were 'yeses' (73%). The 27% who said 'no' did not report bad experiences with the game, and did not show any pattern of either being strangers or well-known to one another. Of players who did not know each other at all before play (a total of 12), 9 answered 'yes' (75%). Free text responses to the prompt 'If yes, please tell us how so,' elicited several common themes related to connection:

Relying on one another and communication: Thirteen players pointed to the way the game required them to rely on one another as a strategy for encouraging connection. For example, "we had to rely on each other for a common goal," "must rely on the other one to complete the task, can't without them," "there was, for the gauntlet wearer, a reliance on the tank." Several players pointed out that the game encouraged communication in order to accomplish the common goal: "we had to communicate with each other about the game," "we learned how to communicate more," "I had to let her know when she was fully charged."

Physical contact: Five players pointed to the physical contact from hand holding as something that caused an increase in trust, liking and connection. "Holding hands makes trust better ESPECIALLY when you get the high score!" "Hand sweat sharing, physical contact." As one player eloquently put it, "The connected, cooperative energy of playing the game created an isolated moment where working together was the apex of expression. We have now done something together, where holding hands was the only way to connect."

Working together: Sixteen players more generally referenced working together toward a common goal, as the reason for increased trust, liking, and connection. Example statements included: "Working together, I think, created a stronger connection." And "we had a common goal so wanting to achieve the goal brings us together even more."

There are various cues of trust, connection, and liking that can be observed from body postures and facial expressions [21, 22]. These include decreased distance between individuals; coordination of gestures and poses; increased smiling and more energetic body poses; and turning and leaning more toward one another. Overall, only 4 out of 33 pairs showed none of these signs of increased connection when comparing their before and after photos (see figure 3 for a comparison of an after-play image with no signs of connection and closeness versus one with many signs—see also figure 2). (Note: We were not able to discern from players' survey responses precisely why these few pairs did not show signs of increased connection).

4.3 Discussion

As we had anticipated, players reported that the game helped them to feel more connected to one another, and this was also visible in the difference between the before and after photos of pairs. Many attributed this to specific aspects of the game's design (hand holding, interdependence, collaboration). Players enjoyed taking on interdependent roles, and working closely together physically. Of course, these playtests and the questions accompanying them were just a start in terms of fully understanding the impact of the system and teasing out the details of why and how players were affected. We intend to further analyze the video record in future toward a more nuanced understanding. And we could certainly refine the survey instruments that we used in these playtests for future iterations.

For the purposes of elucidating the strong concept introduced in this paper, designing, tuning, then observing the results of the game for players in these playtests (and at festival showings) led us to conclude that the designer's intuitions about the potential for and value of creating interdependence through wearables had born fruit, and could perhaps be useful to others in the HCI community. We engaged in a literature review of related theory and systems alongside the design and playtesting of the game, which also helped us to articulate an appropriate strong concept to encapsulate and communicate these design insights.

5 STRONG CONCEPT ARTICULATION

We propose the strong concept of Interdependent Wearables (at play). By interdependent, we mean wearables intentionally designed to require shared attention and mutual awareness, offering interdependent functionality to users that encourages and rewards collocated interaction. We propose that wearables designed with these characteristics can help build camaraderie and connection in collocated interaction, and that this is a valuable strong concept to influence next steps in wearable design.

Taking Hotaru as an example, players need to keep a close eye on one another's wearable to figure out what to do next and to succeed in gameplay. The gauntlet wearer watches the tank to see when enough energy has been collected. Then the tank wearer watches the gauntlet wearer to know when it's time to begin collecting again. Each wearable element depends upon the other for completion of the game task, including the necessity for joining hands to 'transfer' energy. The wearables encourage and reward close collaboration and coordination, eliciting mutual attention, and building connection and camaraderie.

Vertical grounding: Strong concepts should be articulated using other relevant system examples as vertical grounding. There have been other experiments in the indie game world with creating interdependent wearables, though these games have been competitive rather than collaborative in nature. For example, in Swordfight [27] players strap Atari 2600 controllers onto their crotch region and attempt to use their joystick to press the other player's button first. In Hit Me! [1], players wear hardhats with cameras mounted on them. Each player tries to push the doorbell-style button at the top of the other's helmet to snap a photo and win a point. These games have custom-built wearable elements that require close mutual attention and they do engender a form of collaboration and camaraderie in the service of the competition. Earlier wearable game systems in HCI such as Wriggle [16] and Emroll [37] encouraged close coordination, but did not require shared attention and mutual awareness in the same ways as the other games mentioned. Both Emroll and Wriggle require close attention to a large shared screen, taking player attention away from one another's bodies. There are other collocated physical games that use held controllers rather than wearables, such as Musical Embrace [12] and Intangle [8]. These games also require close coordination and social use of physical controller devices, though the devices are not worn on the body. Finally, there are games that explore the artful crafting of mutual attention through networked physical/digital interaction, such as Can You See Me Now [2], a game in which online players were chased by 'runners' who had to sprint through real city streets.

Working from these examples, we believe a strong component of successful interdependent wearables is the thoughtful management of co-present gaze, a notion that can be seen in other writings about the support of collaborative play [31, 32]. It is also worth noting that though our concept focuses on wearables (devices worn on the body), these examples suggest a continuum of devices the concept could apply to, which might include tangibles and body-focused sensor-based interactions. We focused the concept on wearables in particular as an area that can benefit from this articulation the most.

To demonstrate the potential and reach of the concept outside the realm of play, we note that Mitchell [23] points to a number of non-game interactive art and media pieces that make use of touch and wearable elements, many of which elicit mutual attention and interdependence. Löwgren's Mediated Body system can also be considered an exemplar [11], as can Schiphorst's exhale [30]. In exhale, for example, participants don flowing silk skirts with linings that 'breathe' (using fans and vibrators) and make subtle sounds in response to the breathing of all of the participants in the exhibition (each person wears a breath sensor around their rib cage). These sensations induce mutual attention upon breathing rhythms by bringing the impact of these rhythms from others closer in to one's own body. Synchrony of breathing is a natural part of engaging in attentive interaction [26] that is thus heightened by this system, enhancing mutual awareness of this social cue. Changes in any one person's breathing affects the movement of everyone's garments, enhancing mutual awareness through interdependence.

Gemio is a recent commercial example of a wearable that starts to approach this strong concept [3]. Gemio bracelets are composed of programmable 'gems' that can respond when friends are near (and also to messages sent through Snapchat). Light patterns can project 'secret' signals readily decodable among collocated friends. The bracelets have other sensors that could allow for rich collocated interaction: "An optical colour sensor means users can point the bracelet at what they're wearing and have the device automatically match the hue. There's an accelerometer and also a microphone so that the smart jewellery can light up in time to music." [3]. Contrast these affordances with the typical social features of most current generation wearables such as smart watches, which support text or audio messaging through a small screen not as well suited to engaging and directing shared attention and physical collaboration.

All of these systems demonstrate qualities highlighted in the strong concept that have been percolating in the design research and practice community, and which are just beginning to appear

in commercial wearables. We believe articulating and sharing this strong concept will help to scaffold future efforts in this direction.

Horizontal grounding: Strong concepts should also be explicitly related to relevant theoretical constructs. To us, the most closely related concept in the HCI literature is ([21], [22])'s notion of supporting human proxemics within an ecology of devices. These researchers propose that ubiquitous systems should attune to human proxemics (management of interpersonal distance and orientation) to better engage in appropriate and adept human computer interaction. Game researchers have extended this notion of proxemics into choices about designing collocated games supported by technology [25] and have taken a look at interpersonal bodily interactions and how best to facilitate positive social experiences in games that extend all the way to bodily contact [8] . Game researchers have also emphasized the importance of giving players a 'head-up' positioning, putting the focus on other players rather than on individual technologies [31, 32]. We see Interdependent Wearables as a concept that deals with a particular subset of these interrelated proxemics and co-presence concepts—offering guidance and insights about the interplay between devices distributed among people in a given collocated setting.

A related strong concept is the Suppleness use quality proposed by [15], which frames a use quality that depends upon subtle social signals, emergent dynamics, and the privileging of moment-to-moment interaction. Suppleness offers experiential values, but does not articulate specific mechanisms for achieving those values. We see Interdependent Wearables as one particular strategy for achieving Suppleness.

Finally, we situate Interdependent Wearables within the larger turn in HCI toward considerations of embodiment [6]. We see this strong concept as adding considerations of explicitly designing for embodied co-experience in collocated settings—creating devices that provide affordances for encouraging mutual embodied awareness and interdependence.

6 CONCLUSION

We have introduced a strong concept that arose from design and development of a game played using social wearables. The concept—Interdependent Wearables (for Play)—offers HCI researchers and practitioners a generative lens for designing to support collocated social interaction using wearable technology. We believe this concept can help us to break out of certain hidden assumptions that get designed into wearables unconsciously—that the device should be for a single person's focused attention, that the device's signaling should be attuned to that individual person rather than also communicate gracefully with others, that the device's primary task is to aid the individual in efficiency and networked communication. We developed this strong concept during the creation of wearables designed for play, as part of the Hotaru game. While these wearables are fanciful and exaggerated, and thus more suitable for game settings, early commercial prototypes such as the Gemio show the potential of a non-game design space that can be further opened up in part through taking up this strong concept. Whether for work or play, it is our belief that Interdependent Wearables offer the potential to build camaraderie and connection by design, and to improve collocated social atmosphere and co-engagement. We are currently iterating upon the work begun with Hotaru, creating further social wearables to investigate the potential in this design space.

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