**Abstract**

This paper describes an exertion gameplay mechanic involving player’s partial control of their opponent’s sound localization abilities. We developed this concept through designing and testing "The Boy and The Wolf" game. In this game, we combined deprivation of sight with a positional disparity between player bodily movement and sound. This facilitated intense gameplay supporting player creativity and spectator engagement. We use our observations and analysis of our game to offer a set of lessons learnt for designing engaging bodily play using disparity between sound and movement. Moreover, we describe our intended future explorations of this area.

**Author Keywords**

Exertion games; bodily play; sound-mapping; spatial hearing; sensory deprivation, embodied interactions.

**ACM Classification Keywords**

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

**Introduction**

Spatial hearing enables people to identify the direction of sound sources. In stationary situations without distracting background noise, people with normal hearing abilities, can use just their ears to correctly
pinpoint sound sources to within a few degrees [2]. However, localization of sound is more typically performed in conjunction with other senses – predominately sight. Coordinating sound with vision, which in itself is a more reliable sensory modality for localization, results in further increasing accuracy [11]. The challenge of navigation without visual abilities may serve to explain some of the enduring appeal of games such as Blind Man’s Bluff and Marco Polo. These games limit the visual senses, but very much challenge spatial hearing abilities. Not least because human sound localisation abilities and reaction speeds are impeded by a listener’s own locomotion [11].

Wireless digital technology opens up new opportunities for enabling players to influence and manipulate the spatial hearing abilities of their opponents in movement based games. In everyday life, other people perceive the sounds we make (e.g. footsteps) as coming from our direction. However remote triggering of digital audio can loosen the coupling between the actual origins of sound and the perceived position of origin. Such decoupling or disparity between bodily movement and its perceived auditory positioning, we call “sound de-localisation”. We suggest that this is a promising game mechanic for social digital bodily play.

Related Work
Many movement-based games have recently explored using sound as an important aspect of game mechanics. This includes using audio to respond to a body’s internal state [10], as feedback on body movement [5] and to reveal the location of opponents [4].

Within video gaming, audio-only games such as Papa Sangre [3] and single player virtual reality experiences such as Blind Swordsman [6] have broken exciting new ground and gained much attention. An audio-only version of Pong is also intriguing. This offers players a variety of input mechanisms including body tracking. Auditory Pong features a direct mapping between player action and virtual positioning of player’s unseen in-game paddle [9]. However, we believe that our approach of participants effecting their opponent’s spatial hearing within multi-player physical games offers something rather different.

Our explorations began with designing a bodily play exertion game called “The Trials of Boy and Wolf”. Through our initial exploration in this area, we hope to inspire other researchers and practitioners to create engaging interactions using sound de-localisation.

Game Description: The Trials of Boy & Wolf
The game we developed consists of two players (boy and wolf) competing with each other in order to win. The boy is blindfolded and armed with a sword with which he tries to hit the wolf when approaching. The wolf’s goal is to try to grab the two “life points” hanging from a belt that the boy is wearing, without being hit by the sword (see Figure 1).

Implementation
In our prototype, our “sword” was a cardboard tube containing a PlayStation Move-controller. The Move-controller registers the sword swings and signals the computer to play an audio feedback. Also with every registered swing, the Move-controller provides haptic feedback for the boy through vibrations.
The wolf is wearing a helmet, which has a wireless Bluetooth speaker attached to it. The speaker is used to introduce the disparity gameplay element where the actual sound is separated from the action that provokes it. As the boy swings the sword, the speaker outputs a digital “swoosh” sound as a result, giving the blindfolded boy an indication of the location of the wolf (Figure 2). The speaker also outputs the sound of footsteps when the wolf moves. During play-testing the footstep sounds were implemented in the game using a Wizard of Oz style output controlled by a third person.

**Design Process**

We used a human-centered-design process where play-testing and feedback were core elements in the process. From the beginning, we aimed at designing an exertion game suited for outdoor play. The game should challenge the players [5] and intrinsically motivate them [14] to use physical movements and engage with each other by incorporating an element of risk [1][12]. Based on response to initial concepts, we settled on the idea of constraining a player with a blindfold and using chase-dynamics via a man versus animal theme. Incorporating sound de-localisation was conceptualized later in the process after a feedback session where augmenting game artifacts was discussed.

**Observations**

Throughout play-testing we wanted to explore how the use of sound de-localisation and the perceptual constraint (blindfolding) affected the gameplay experience. Fifteen adult users participated in testing the game and some tests were performed in front of an audience. Play tests were video recorded and players participated in semi-structured interviews after each round.

**Engagement**

The players were engaged and seemed to be enjoying themselves a lot. A blindfolded boy uttered, "Wow, this is intense" in response to hearing the augmented footsteps of the wolf. Others stated, “This is really fun!” and “Yeah, it’s great fun, but almost too hard for the wolf”.

**Exertion**

Most players moved a lot during the game. The wolf-players were often observed to be circling/running around the boy trying to create and find opportunities for attacks. A few boy-players were also moving around the play-area, but most stayed still focusing on listening to the sounds and swinging their sword. Some wolf-players were visibly exhausted by playing and were still trying to catch their breath several minutes after the game had ended.

**Different Strategies**

The simple rules and disparity of sound/movement combined with the blindfold constraint provoked players to device diverse strategies into the game, using their bodies and the augmented devices in various creative ways that added a positive element of unpredictability to the player and spectators experience.

The boy’s strategies revolved around the sword and how and when to use it. Some players were swinging the sword much less than others. Such players were focusing on listening to the footsteps to locate the wolf. Others were relying more on using the sword to locate the opponent. One player reversed the roles, and

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*Figure 2: Sword-sound mechanic.*
hunted the wolf around the arena using the sound feedback from excessive swinging of the sword. One did not use the sword at all, because he did not want to “hurt the other player”. The wolf strategies ranged from running/trying to circle around the back, doing quick counter movements while approaching the boy to get behind him, and sneaking up on the boy in prone position from the front. Also cunning strategies like leaving the speaker helmet on the ground and using spectators to aid the wolves’ cause by shoving them in front of the boy or encouraging them to cheer and distract the boy were used (as seen in Figure 3).

**Spectator value**
Player responses to sound de-localisation and sensory constraints in the gameplay led to comical relief to the spectators. Situations in which the wolf tried to outsmart the blindfolded boy resulted in many smiles and much laughter from most audience members.

**Game-Play Challenges**
In our play-testing trials, we discovered that adjusting the mapped sound levels for different game situations proved to be a necessary aspect in making the gameplay experience balanced and unbiased. If the mapped sounds were too loud it was easier for the boy to detect the wolf. Some wolves felt the game was biased in favor of the boy, mainly because of the sword extending their reach.

**Sound de-localization for bodily play design**
Through our game design process, we have confronted various challenges of incorporating sounds and disparity using them to alter the gameplay. There were common issues we had to tackle in order to improve the gameplay experience. Based on our experience, we present the following lessons learnt for game designers:

1. **Synchronising (or not) movement and sound**
The efficiency of the body movements’ sound feedback had substantial effect on the playing experience felt by the players. If the sensors are not working properly and there is considerable lag, the gameplay experience can suffer and the player can feel powerless. In the Boy and Wolf game, the disparity between the sound from an action and its output location made the gameplay experience more bodily intensive as the players had to focus more on their movements and their impact on each other. However, deliberately varying relay rates of audio samples may also offer interesting possibilities for game designers.

2. **Design for different sound volume levels**
The volume of mapped sound effects played from speakers had a great effect on the gameplay. Quiet sounds together with blindfolding and sense-limiting gameplay mechanics force the players to concentrate more and use their senses more carefully in order to win the game. The correct volume of the sound is also highly dependent on the play setting. With a big audience, mapped sounds need to be higher to compensate for the noise the crowd makes. In more quiet settings a lower volume can be used.

3. **Amplify or distort sounds**
Using everyday normal sounds and amplifying them via output from a different source can lead to a different gameplay experience. This way of separating the sound from the actual source and amplifying its power can lead to designing new gameplay mechanics where normally silent sounds are more pronounced or loud.
noises are muffled with counter-noises. The challenge of sound de-localisation, and its evocativeness can thus be varied through choice of audio content.

4. Consider implementing constraints
Our game appeared to spark creative play because the blindfold “forced” participants to use the augmented sounds in navigation and strategy. We suggest considering how similar possible constraints can amplify or lessen the impact of sound de-localisation.

5. Embrace ambiguity and risk
The blindfold-constraint created ambiguity for boy players not knowing the precise location of the wolf if they cannot hear him/her, which in return could lead to an element of perceived risk and suspense for the boy. For the wolf, the sometimes-unpredictable sword swinging from the blindfolded boy could lead to feelings of suspense to the wolf, as well as a risk of being physically hit. We therefore recommend considering how incorporating similar thrills and intrigue can help motivate players attempts to engage with, master or ignore sound de-localisation.

6. Involve spectators
The use of constraints and disparity can allow spectators to know something that players do not know and transforms the observation of the game to feel more akin to watching a performance. In comic terms, these situations are equivalent to scenes that rely on incongruity in order to create amusement for the audience. Situations like this can engage audiences by their knowing something that an observed party in a scene does not know, possibly making the audience feel superior and amused [8]. In connection with such playful epistemics, consider also if audience members are able to follow the details of sound de-localisation. Sound De-localisation can also enable spectators in the gameplay itself. A louder crowd either deliberately or accidentally further impedes the spatial hearing of the boy. However, whichever side audience members take, fostering the audiences to be noisy may all players concentration and engagement [10].

Future work
In our game, we directly mapped the actual footsteps to an equal number of footstep sounds. Exploring more indirect mappings seems promising. For example, inversely mapping the number of steps to the volume. This could be used in order to increase the exertion in the game play because the faster the wolf moves, the quieter his steps will be. Combining direct and indirect mapping, e.g. in which the boy’s more swings of the sword would increase audio volume, could motivate exertion for the boy as well and possibly make the players compete on endurance.

The competitive nature of our game led players to exploit the sensory constraints and disparity of their opponent. Future work could investigate using sound de-localisation in a more complex collaborative setting. For example, a game with more than one wolf where they help each other with their movements to better locate the wolf. It could also be played with more than one boy, for instance where only the wolf nearest to the boy would be transmitting sounds. This could bring a collaborative element to the wolves, and heighten experiences of intensity for the blindfolded boys.

Future work could also investigate use of disparity along with other types of constraints, for instance non-physical cultural constraints to explore social
conventions in games. Bodily sounds (for instance burps and farts) uttered by coincidence or purpose can cause embarrassment for the doer and amusement or outrage by those overhearing the sounds. Would a game, in which players control which sounds is transmitted from other player’s bodies, alter how players feel about making the sounds or how spectators perceive players whose bodies cause or output the sound? Combining sound de-localisation with augmented reality also offers intriguing possibilities.

Conclusion
We investigated the use of sound de-localisation and how this gameplay mechanic could be used as an engaging element in exertion games and bodily play. We used the observations from our playtests to propose a set of lessons learnt for game designers to consider when designing interactions that uses physical disparity between movements and sounds.

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