# i-dentity: Innominate Movement Representation as Engaging Game Element

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## ABSTRACT
Movement-based digital games typically make it clear whose movement representation belongs to which player. In contrast, we argue that selectively concealing whose movement controls which representation can facilitate engaging play experiences. We call this "innominate movement representation" and explore this opportunity through our game "i-dentity", where players have to guess who makes everyone's controller light up based on his/her movements. Our work reveals five dimensions for the design of innominate movement representation: concealing the association between movement and representation; number of represented movements; number of players with representations; location of representation in relation to the body and technical attributes of representation. We also present five strategies for how innominate movement representation can be embedded into a play experience. With our work we hope to expand the range of digital movement games.

### Author Keywords
Movement representation; ambiguity; digital play; game design; engagement; social play; entertainment

### ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces – Interaction Styles

## INTRODUCTION
HCI designers often use unconventional approaches that turn interactive entertainment and interaction design on its head to enable the creation of new and unexpected play experiences, such as uncomfortable, intense and exertion interactions [4, 20, 22]. Strategies to achieve such experiences include creating ambiguity rather than offering clarity [10], withholding information to provoke interpretation [28] and deliberately engineering discomfort to provoke physical effort [21]. In this paper, we explore another unconventional strategy focused on digital play experiences: innominate movement representation. By this we mean a strategy in digital games where the design deliberately conceals whose movement representation belongs to which player.

**Fig. 1. Playing i-dentity**

Movement-based computer games generally utilize digital representations of players' movements, for example, most Nintendo Wii, Sony Move and Microsoft Kinect games feature digital representations of players' movements on the screen, often achieved through avatars. We notice existing digital games often make the association between movement and avatar obvious, so that players know whose movements control which avatar. This is congruent with established game design and HCI principles that teach that feedback to player actions should be clear and non-confusing [6]. In contrast, we propose that game designers can deliberately make associations between movement and representation unclear - in particular selectively conceal - in order to utilize it as a game element for engaging play experiences.

We created a game called i-dentity (Fig. 1) to explore this opportunity. By analysing our design as well as observations of gameplay and feedback from players, we gained insights on the role of innominate movement representation on peoples' play experiences. In result, we make the following contributions:

- We articulate five dimensions that span a possibility space for designers to think about when designing games that aim to utilize innominate movement representation.
- We present five practical design strategies to support the development of innominate movement games.


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With this work, we hope to extend the range of digital movement games, furthering the associated engaging experiences for players and ultimately the field of digital games.

## RELATED WORK

Research on digital games that engage with innominate or more broadly concealed data associated with players is sparse yet valuable. In Fish 'n' Steps [17] for example, a representation of a fish grows larger when 'fed' by a corresponding player's physical activity. The system innominates all players' movement data so as to hide whose represented fish belongs to which player. The system conceals this association to ensure the data associated with each player remains private, so others cannot work out who has performed less physical activity than others. This shows how systems can be designed to conceal data associated with players, in particular in regards to movement, in order to affect the player's experience. However, we still do not yet know how concealing data associated with players can be used to facilitate engaging digital play.

There are several examples of games that conceal player associations in the non-digital realm that have inspired our work. Many role-playing, card and board games conceal the player's association to a particular fantasy role, such as Werewolf, Celebrity Heads and Battleship [32, 5, 3]. Salen and Zimmerman [27] describe the engaging social drama that emerges in Mafia, where engagement results from the ambiguity around the unknown player associations with specific roles. The ambiguity and uncertainty that is featured in these games, such as the bluffing that occurs in Poker, builds tension and engagement between players thanks to the concealed associations [27]. These non-digital games show how ambiguity as a result of concealing player associations can facilitate engaging play, which we took onboard with our design. However, there is still a lack of understanding about how this ambiguity could be utilized when designing games that conceal player associations to digital representations.

We found that most existing games that conceal a player's association with a representation rely on game rules rather than it being a direct result of the player's actions (for example see [17]). This inspired us to explore an alternative approach where the players' actions determine the extent to which their associations to representations are made unclear. Whereas prior games have mostly either concealed or revealed associated data, we aim to explore "selectively concealing", where the division between an association being either concealed or revealed becomes blurred. This introduces a sense of ambiguity within the game's design.

There are many interactive designs that explore the practical use of ambiguity to engage people with technological systems (e.g. [11, 15]). While conveying ambiguous information is traditionally regarded as a problem in the design of usable systems, Gaver et al.'s work [10] shows how incorporating ambiguity into the design of interactive systems can have intriguing, mysterious, and delightful outcomes: for example the ambiguity of using indirect sensor mappings of embodied interaction (e.g. [1]), unconventional mappings for reflection on the unexpected (e.g. [26]), or exploring the interpretive space of embodied and situated aspects of interaction that results in physical play facilitating discovery (e.g. [31]). Thus, we were inspired to extend the notion of ambiguous interaction design to the practice of movement representation to explore whether having an unclear relationship between movement and representation can facilitate engaging play experiences. In particular, we explore ambiguity as a result of having selectively concealed player associations to movement representations.

We learned from the new games movement [8] that we should explore the novel opportunities for play that digital technology can enable. We are inspired by its advocates such as Bernard DeKoven [16], who suggests that designers should renew their interest in play by reconsidering old playground games and explore how we play together. JS Joust [34] is an example inspired by this thinking that shows how digital elements can enhance a play experience by retaining non-digital elements of collaboration, light-hearted playfulness and face-to-face interaction. Technology support for such types of physical play experiences is mostly minimal, with an often-increased reliance on player judgement (e.g. [19]). We consider these non-digital elements important to our design for how selectively concealing digital representation can enable new opportunities for engaging play. However, we believe that selectively concealing whose movements are represented is not something that has previously been considered by designers of digital games.

In this paper, we look at how to design games where the player's actions can selectively conceal player associations to representations. In particular, we focus on movement representation and call it "innominate movement representation". We start to develop this understanding by designing and consequently studying player experiences with a game that uses innominate movement representation.

## USING INNOMINATE MOVEMENT REPRESENTATION AS A DIGITAL GAME ELEMENT

We now introduce a game that we designed, called "i-dentity", as a practical example of innominate movement representation. It is played with only a set of Sony Move controllers [24] and no screen.

### I-DENTITY

i-dentity is a collaborative movement-based game involving four players that benefits from being played in front of an audience. Players assume the role of an interrogator or one of three spies. The three spies each hold a Move controller, with one Move controller randomly selected by the game to represent the spies' leader. The leader's movements illuminate all three of the spies' controllers, while the spies' movements are ignored. Vibration feedback is discretely sent to the leader's controller to let them know their role in the game. A leader's role is only known amongst the spies.

The interrogator, whose goal is to identify the spies' leader, conducts or asks the spies to perform movements. For example, during playtests we have observed commands such as asking the group to jump up and down, they could be asked to "pretend they had just been shot", or to play air guitar. However, the interrogator can only address the spies together, as a group (so the interrogator cannot say "only the person in the middle should jump"). While the leader moves his/her controller in response to acting out a command, all the spies' lights turn on (Fig. 2). When the leader is stationary the lights go out. The spies copy their movements in an attempt to innominate the representation so the interrogator cannot work out whose movement controls the light (Fig. 3).


**Fig. 2. Interrogator asks the spies to stand on one leg to figure out who the leader is.**

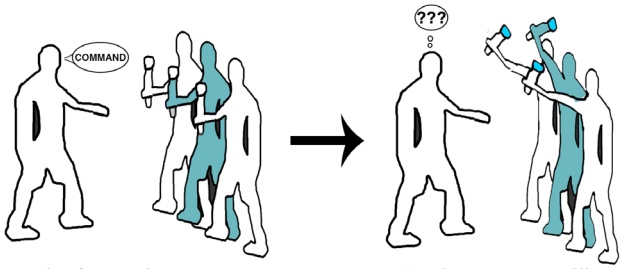


**Fig. 3. The interrogator commands, "Raise your arm!" The leader and his/her spies coordinate their movements so it is difficult for the interrogator to identify whose movements light up all controllers.**

The game continues until the interrogator believes she/he knows the identity of the spies' leader. At this stage, the interrogator points towards the leader. This player then waves their controller; if all spies' controllers illuminate, the interrogator wins and he/she switches roles with the leader, otherwise the leader and the spies win. Players often agreed to impose a limit upon the amount of commands that could be asked before requiring the interrogator to select a leader. This occurs during an "exposition" [4] stage before a game begins, where players negotiate specifics of the rules, such as how many and what types of commands the interrogator is allowed to use.

### Implementation

The players' Sony Move controllers are connected to a computer via Bluetooth. When the leader moves, all controllers light up with the same color. Controller orientation determines the light's color. Speed, measured from accelerometer and gyroscope sensor values, determines level of illumination, with fast movements resulting in brighter colors.

### Design Process

We began designing i-dentity at the CHI "Game Jam" workshop [9]. The game jam development environment emphasized collaboration as well as rapid and experimental design of physical digital games. As part of the event, the developers observed 20 players' experiences of playing i-dentity as part of the design process. A total of 8 playtesting sessions took place at various stages of development beyond the Game Jam. We also conducted a more formal study, which we report next.

## STUDY

This section discusses details of our study, which aimed to gain insight into play experiences with i-dentity.

### Participants

25 participants played i-dentity at play sessions. 12 of these participants were interviewed. 8 rounds were played at each venue, at a total of 4 venues, with each venue having between 5-7 participants. Overall, this meant the game was played 32 times during our study.

### Procedure

A playtesting session lasted around 30 minutes. At the end of a game, participants switched roles with people who had not yet played a particular role. We ensured everyone played every role in the game, so that all players could reflect on these roles during the interviews. Our encouragement to play every role is obviously not present in non-study contexts; however, we believe the benefit of having everyone play each role gave us the advantage of a diverse range of feedback.

### Data gathering and analysis

Three different data sources were used to understand participants' play experiences:

- We took notes of our observations.
- We recorded video footage of play. The primary author then went through the videos, looking for what tactics players engaged in, what movements people performed, examining their social interactions including facial expressions and body language.
- We conducted semi-structured group interviews at the conclusion of the play session. We encouraged participants to discuss, reflect on and give feedback on their play experience. We also video-recorded these interviews. They were analyzed alongside the recordings of the participants during play.

Firstly, the primary author watched all video recordings of people playing i-dentity. The author took notes while watching the gameplay recordings 3 times as suggested by grounded theory [30]. Secondly, the author watched the video recordings of the interviews 3 times. Again, the author took notes. Finally, the author went back and


**Fig. 4: a,b,c. People had a fun, engaging and enjoyable experience with i-dentity.**


**Fig. 5: a,b,c,d. People playing the role of spy collaborated with other spies.**

watched the video recordings of people playing to check with notes taken during the interview recordings. After each stage of this process, the primary author gathered with the other authors to discuss the notes taken. At these meetings, interim analysis results were presented and debated. This helped to develop and refine findings. We used an open-ended process of rapid reflection [23] to discuss ideas and concepts that had emerged. The findings emerging from the data were extensively questioned, debated and discussed.

The resulting higher-level concepts were discussed amongst the group and then presented to 10 games researchers to gather feedback. The outcome was subsequently checked with 8 of the study participants (those who where available, so a selection bias might have occurred), refined and reviewed again by the authors.

## FINDINGS

We now discuss the findings of our study. We begin by describing reactions to the game.

### [F1] i-dentity is a compelling game experience

Participants found playing i-dentity to be a fun, enjoyable and engaging experience, replying with positive responses, such as:

> *P1: It was awesome.*
>
> *P6: It was fun both to move, be in front of each other and try and compete with each other.*

Participants would often verbally express their enjoyment while playing together and our observations of body language further support the occurrence of a sense of enjoyment from the game, with smiles and intrigued glances often displayed (Fig. 1, 4a, 4b, 4c, 6c).

### [F2] Innominate gameplay can stimulate verbal communication amongst the players

Participants on both sides verbally communicated with each other, aiding each other by giving advice or suggestions:

| [Interrogator with audience] | [Group of spies] |
|---|---|
| *P9: Who's moving?* | *P6: I want them to think it's you.* |
| *P10: I would say P8.* | *P11: Ready? 1, 2, 3!* |
| *P7: Yeah, me also.* | *P8: Let's do this!* |

Participants enjoyed this opportunity for verbal communication:

> *P1: I liked the game because it encourages, um, discussion amongst the players, cause I feel there's like this dynamic that emerges between the players who have the PlayStation Move controllers and the people who are trying to guess, I feel like both sides would try to deceive each other and trying to trick each other, um, I like that the game allows for that to happen!*
>
> *P3: Communication was another reason why it was fun.*

### [F3] Innominate gameplay can cause players to conceal verbal communication from other players

The two groups of players (spies & leader and interrogator & audience) would often separate to discuss strategies amongst themselves (Fig. 5a, 5b, 5c, 6b). Interestingly, people deliberately concealed these discussions from the other side, despite not being required to do so.

### [F4] Ambiguity of the innominate gameplay can be engaging

Participants appreciated the sense of ambiguity that emerged from the innominate gameplay:

> *P1: I like the ambiguity of when you're not sure if people are actually trying to help, or if they are [the leader].*
>
> *P3: Yeah, it was like 'I think it's P1 but it's not him', and he knows it's not but he tried to convince other people.*
>
> *P5: But he could also be telling the truth, he wants his team to win so he's trying to help. I like the ambiguity as well.*
>
> *P6: It was most fun when it was hard to figure out, when we didn't know what was going on.*

Furthermore, players enjoyed how the spies often used body language to heighten the ambiguity of their relationship to the representation.

### [F5] Body language was used to deceive others

A tactic often used by the leader was to try to deceive the interrogator and audience to make them believe they were not the leader (Fig. 5d):

**Fig. 6: a,b,c. Interrogators using people from the audience to help them.**

**Fig. 7: a,b,c,d. People enjoyed the physical challenge resulting from the innominate gameplay.**

> *P3: We think its not a person, right, so we were like, okay it's not you, we will just focus on someone else.*
>
> *P6: We did that to you [points toward P1] and you were trying to pretend like it was you, right, and you tried to get back on the suspicion list.*

**[F6] Trying to conceal movement representation can lead to engaging performances**

Participants enjoyed the physical challenge of concealing movement representation, which led to enjoyment with the associated physical performances:

> *P3: It was interesting that I didn't like so much getting commands as I did executing it together as a group performing. You know, you get commands and do things that I ask you but at the same time try to do it as good as you can so they don't get anything out of it.*
>
> *P4: The funny movements were like a key part, with another person asking for a funny movement, and the other person trying to do that […] that was a lot of fun; the choreography was like dancing.*

Participants playing the role of spy enjoyed the sense of connection they seemed to share with other people's movements:

> *P1: What's so beautiful about the game is, when your teammates notice that you're moving and know you're going to give away yourself, and then they start going as well to copy you. I really like that.*

Spectators would often express their enjoyment together, with grunts, smiles, laughter and intrigued glances being shared while watching the game unfold (Fig. 1, 4a). We noticed spectators would often laugh when people performed silly or hilarious movements, such as hopping on one leg or performing dance moves (Fig. 1, 7a, 7b, 7d). These reactions suggest that enjoyment can emerge from people's engagement with concealed movement representation, both when performing and observing.

**[F7] The innominate gameplay motivated spectators to collaborate**

The interrogator often talked to audience members to get them involved. Rather than standing back and observing the movements being staged, we noticed spectators would often share conversations with one another and become involved in gameplay by advising the interrogator on who they think is the leader, or suggesting challenging movements that would help to reveal the leader (Fig. 6a). The interrogator often utilized the spectators by tasking them to assist, focusing their attention on observing the performance of a particular spy. The interrogator would often gather with spectators to discuss whom to select as potential leader, while also concealing this discussion from the spies (Fig. 6b). This suggests the involvement of others was important in helping them make a more informed decision.

**[F8] Participants enjoyed using different strategies and play styles to reveal the association of representation**

Participants liked how the game accommodated multiple strategies and play styles:

> *P3: I liked that you had, like, different strategies, right, so there's not like one particular way of playing, there are multiple ways of playing. By being, um, the person, the identity, being it and the other side as well.*
>
> *P1: I like that the rules are negotiated between all the players so that it fits everyone's play style.*
>
> *P3: I liked to find the flaws in the rules; try and make it impossible for the others to figure out.*
>
> *P6: Yeah, you tried to break the game. [Shared laughs]*

We observed players experimented with a range of tactics, such as deciding to have a spy look more suspicious then the other spies (Fig. 5d), or positioning spies so it was difficult for them to see each other (Fig. 7c). Participants found that confusing the spies with multiple commands at once could help get someone to move out of sync:

> *P2: [Point to the] ceiling, then point your controller down. Now, please. Look at the ceiling, look at the ceiling. [Group looks up] And now jump. [Group jumps] Look at the ceiling. Now move a little bit, with the control – P4 is already moving! [Interrogator and audience laughs]*

**[F9] Triggering accidental movements was used to reveal the association of representation**

An interrogator often tried to provoke accidental movements that could not be controlled by the spies, for example getting them to laugh:

*P5: I think you [the interrogator] got onto something when you made us laugh, I think that I always thought well it's going to be the deliberate movements, but it would actually be the accidental movements [that revealed the leader]. […] So once we got onto something as personal as a laugh, it was beyond choreography.*

*P2: Exactly what I was scared about - laughing, you know cause laughing was the only way that I can [hand shaking motion] ha-ha, laughing was impossible for me to avoid.*

*P6: If you're laughing, then make sure everyone moves.*

*P1: They would get you holding your hand up for 2 minutes, and your whole arm aches.*

*P3: They would abuse you to actually do a workout there.*

*P6: Yeah, that was quite a good one to do, just make them hold their hand up until they wobble.*

**[F10] Access to movement representation can be part of the game's challenge**

The interrogator did not seem to have many problems in retaining focus on both movement and representation at once. However, we did notice two instances when an interrogator found it difficult to see all of the lights at once. Sometimes this occurred when a spy faced an opposing direction to an interrogator, as their body blocked the interrogator's access to their light unless they physically moved around the space. Other times, a strategy a spy used against the interrogator was to restrict access to their light: a spy would physically concealed access to their light by covering the sensor with one of their hands, or holding their controller behind their back so that it could not be seen. This suggests that while the close proximity of physical and digital made it relatively easy to focus on movement, this also resulted in times where it was challenging to see how a spy interacted with their controller.

**[F11] Using technical characteristics of the movement representations was a strategy to reveal association**

We noticed a strategy the interrogator often used was to spin the spies around in a circle. Interestingly, the interrogator most often did not move around with the spies while doing so. This suggests the type of display used had an affect on how difficult it was for people to access the representation; in our case the Move controller lights made it easy for people to see the representation from where they were standing, except for times when other bodies obscured their view. This was a popular tactic people enjoyed.

**[F12] Manipulating representation response time is an option to adjust the game's challenge, however can also cause confusion**

The Move controller generally provided a near-instant response to represent movement. However, there were a few times when the response would slow down during the game. This mostly occurred when there were a large number of movements being performed at once. This was due to the Bluetooth connection. When this happened, the players became confused, which suggests they expected an instant response, and that not providing this instant response had a negative impact on their experience.

## DIMENSIONS FOR THE DESIGN OF GAMES USING INNOMINATE MOVEMENT REPRESENTATION

We use our findings as well as our design experience of i-dentity to derive five dimensions for designing games using innominate movement representation. We use these dimensions to highlight a range of possibilities for the design of new games in this space.

## DIMENSION 1: CONCEALING THE ASSOCIATION BETWEEN MOVEMENT AND REPRESENTATION

Our first dimension looks at the extent to which the game design facilitates concealing movement associations to representations. The two poles of this dimension are made up of the system concealing player associations to representations on one end and the player's movements concealing these representation associations on the other. While most movement-based systems are designed using a direct mapping of the players' movements to digital representations, i-dentity extends the notion of ambiguous design to show how this mapping can be purposely obscured to facilitate an engaging play experience. This rather unconventional method of mapping input to output reminds us of Rogers et al.'s Snark system [26] that uses ambient technologies to explore the concept of the unexpected to foster reflection. Similarly, Gaver et al.'s work on ambiguous design [10] suggests benefits of employing ambiguity in mappings between input and output when designing interactive systems, with an example being Antle et al.'s whole-body system [1], which deploys ambiguous design through indirect mappings of embodied interaction. We extend this thinking to game design and showed with i-dentity some benefits to having movements conceal associations between movement and representation, as it stimulated verbal communication (F2, F3), collaboration (F7) and engaged players through body language (F4, F5) and physical performance (F6).

### *Dimension 1.1: Concealed by system*

The system could determine how and when associations to representations are concealed. In i-dentity, the system assists the players to conceal the association by copying the light functionality across to the other controllers. Alternatively, systems could be designed to ensure player associations to representations remain concealed to encourage thoughtful reflection of physical activity [17], however this may limit opportunities for strategic gameplay.

### *Dimension 1.2: Concealed by movements*

In i-dentity the players with controllers can selectively conceal the represented player. Other players could not interpret whose movement was represented while the group retained synchrony with one another's movements. This approach can engage players via ambiguity and strategic gameplay (F3, F4, F5, F9, F10).

## DIMENSION 2: NUMBER OF REPRESENTED MOVEMENTS

Our second dimension looks at the extent to which designers adjust the number of represented vs. non-represented movements. The two poles of this dimension are made up of either having one player's movement represented on one end or having multiple players' movements represented on the other. Although we opted for a single player's sensed movement representation to be copied across to other players' controllers (Fig. 8), designs could alternatively represent all players and just be unclear as to who is controlling which representation. Prior work has shown how multiplayer movement-based games use interactive technology to enable rich social play [14] and this can occur by giving players shared control of one representation (e.g. [13]). We now describe different options designers have for mapping input to output by having either one movement representation or multiple movements represented.

**Fig. 8. We had only one of the controllers sensing movement.**

*Dimension 2.1: One movement represented*

Designers could have one player whose movements are represented. In i-dentity, one player's movement representation was duplicated multiple times across to the others' sensors.

*Dimension 2.2: Multiple movements represented*

Designers could have two or more players' movements represented. For example, there could be many players whose movements are all represented differently, with everyone else being required to move together at the same time to selectively conceal who controls which representation.

## DIMENSION 3: NUMBER OF PLAYERS WITH REPRESENTATIONS

Our third dimension concerns the number of players with representations. The two poles of this dimension are made up of either a large or small group of represented players. In i-dentity we had one small group of three players with controllers. A larger group expands the scope of possibilities for movements that could be represented. This means a person is less able to observe all the movements at once. Designers can accommodate more players by breaking up the players into multiple groups. In our case we decided a single group of three was an appropriate group size for the small number of participants so that it would challenge those observing without becoming too overwhelming. Alternatively, networked games such as SpyParty [29] and Assassin's Creed 3 [2] show how designers can combine player-controlled avatars with computer-controlled non-player characters (NPC's) and challenge the players to complete objectives while remaining inconspicuous to other players and NPC's.

*Dimension 3.1: Larger group of players*

By adding more players, this expands the scope of possibilities for represented movement. More players would take longer for a person to work out the represented from non-represented players. Players may become overwhelmed by all the possibilities that they resort to random guessing.

*Dimension 3.2: Smaller group of players*

Fewer players with representations limit the scope of possibilities for represented movement. In i-dentity a small group meant players had to be careful with their movements, as a represented or non-represented player was more likely to be spotted if they moved out of sync.

*Dimension 3.3: Multiple groups of players*

Designers could break up the players into multiple groups who then take turns to perform movements. This can be a good option for designers to manage a larger number of players, rather than having a single group so large it impacts observers' ability to interpret all of the movements.

## DIMENSION 4: LOCATION OF REPRESENTATION IN RELATION TO THE BODY

Our fourth dimension considers the notions of proxemics [12], embodiment with tangible interfaces [7] and the effect of technology-mediated performative interactions on a spectator experience [25]. These help to describe the extent to which players are represented in relation to their bodies. In our case an embodied digital interface facilitated engaging physical performance (F6). Designers should consider where representations are in relation to a player's body, as these can affect people's ability to interpret differences between movement and representation. On one end of the pole of this dimension the representation is away from the moving bodies, as seen in many movement-based games such as Wii Sports [33]: the avatar is usually 2-3 meters away from the moving body. On the other end, designers representing movement can place this representation on the body, as seen in i-dentity and JS Joust [34]. To describe design options along this dimension, we borrow from two distinct proxemics interaction spaces based on distance of technology to people in physical space: Public and Personal Interaction Space [18].

*Dimension 4.1: Away from bodies (Public Interaction Space)*

There is a physical disparity between movement and representation when screens are positioned away from bodies. This can affect the ability of players to focus on both movement and representation at the same time. Designers could use this effect if they would like to challenge players by requiring them to quickly shift attention between movement and representation. However, having developed an earlier version of i-dentity with a separate screen (the Move controllers only sensed movement - no lights were used – while all innominate data was displayed on a shared laptop screen), we identified having a large physical disparity can demand players to switch from representation to movement and back to an extent where it distracted from the innominate representation challenge itself [9].

*Dimension 4.2: With bodies (Personal Interaction Space)*

In i-dentity, screens (the controller's light) are combined with movements (i.e. the player holds the screen) to orchestrate people's focus towards the players' movements. The small disparity between movement and representation allowed focusing on the gameplay challenge. However, there was still some physical disparity: the distance between hand and the Move's light is about 10cm, allowing for a small wrist movement to result in a larger (i.e. more visible) controller movement. We can envision games where representations are even closer to their origin, for example by utilizing displays that are directly attached to the body, enabled by technological advances such as display tattoos. In i-dentity, the emphasis on the players' bodies appeared to facilitate engagement through their body language (F4, F5), which stimulated discussion (F2, F3). However, such a body focus may cause self-consciousness issues for some players, although we didn't encounter this during our study.

## DIMENSION 5: TECHNICAL ATTRIBUTES OF REPRESENTATION

Our final dimension is concerned with the extent to which technical attributes of representation have an affect on the level of challenge presented by the innominate gameplay. In particular, we found that designers should consider the impact of visual fidelity, response time, display characteristics and non-visual representation. Advanced sensing technology such as motion capture is capable of detecting subtle changes in movement. This can produce highly accurate visual representations of movement and games often strive for realism. In contrast, in i-dentity, we reduced the fidelity of representation so as to increase the innominate gameplay challenge. We therefore confirmed that using low fidelity representations could engage players with other players' movements [9]. Movement-based games typically provide near-instant feedback in response to movement; in our case we found a significant delay in response to have negative impacts (F12). When representing movement on screens, designers should also consider how display characteristics could affect the extent to which people are able to access the representation (F11).

*Dimension 5.1: Visual fidelity*

In most Kinect games, a player's avatar quite accurately mimics a player's movements in virtual space. These games often aim to engage high visual fidelity, in part through enhanced representations that aim to represent even the subtlest movements (fuelled by technical advancements such as the successor Kinect One). In contrast, i-dentity used low fidelity representation to make it harder to discern differences between movement and representation.

*Dimension 5.2: Response time*

Designers can choose to have technology respond quickly to movement to make it easier for those observing to match movement with representation. Alternatively, designers can manipulate the response time as a measure to increase the challenge, for example for more experienced players.

*Dimension 5.3: Display characteristics*

Designers should consider the type of representation display used, paying attention to size, viewing angle and brightness characteristics to make the display more or less accessible. For example, playing i-dentity with mobile phone displays instead of the Move controller would make it harder for an audience to access the representation, as the representation would not be viewable at all angles and beyond close proximity. In i-dentity we used the almost 360 degree Move controller lights, which made it relatively easy for people to access the representation (F11).

*Dimension 5.4: Non-visual representation*

Designers could choose to not visually represent movement, or combine visual with non-visual representation. We did not explore this much, however, we found that a non-visual representation could be useful even when it does not have a direct effect on the innominate representation challenge: our vibration feedback let a player know their role as the leader without the others' knowing. This caused concealed discussion prior to the game (F3).

## STRATEGIES FOR IMPLEMENTING INNOMINATE MOVEMENT REPRESENTATION

We now provide a set of design strategies that we derived from our study of using innominate movement representation to facilitate an engaging play experience. While the above design dimensions provide a framework for thinking about digital games using innominate movement representation informed by our experiences with i-dentity, the following strategies complement those dimensions by offering practical lessons from our study on how to build better digital games in this design space.

### Number of represented movements

*Have only one player's movement represented*

In i-dentity, we gave all players a controller, however only one of those had their movement represented. Having more than one player be represented would give people a greater chance of correctly guessing someone who was represented. To accommodate a larger group of people, designers could experiment with having multiple leaders be represented (D2), or multiple groups (D3). However, in our case we decided to limit this so there was only ever one leader; we found having more leaders would make the game too complex and confusing for audiences. Having one player's movement represented can also simplify implementation: for example, we can imagine a game of i-dentity with 100 players, where only one player needs to be sensed.

### Technical attributes of representation

*Provide a quick response to movement (response time)*

In i-dentity, the technology represented a player's movement with near-instant response. Any delay in the technology's response time between movement and representation made it more challenging for those observing (F12). People used this quick response to their advantage to provoke accidental movements, which often proved to be an effective strategy (F9), we therefore recommend to designers to provide a quick response time.

*Use a low fidelity representation (fidelity)*

Most digital games represent movement with relatively high fidelity. In contrast, i-dentity uses a low fidelity representation. There is only one 'pixel' that represents movement: the light at the end of the controller. We believe it can be important for designers implementing innominate movement representation to consider how the level of fidelity in the representation affects the ability for people to discern the differences between a person's movement and the representation. We originally experimented with more high fidelity representations (a graph representing movement displayed on a laptop) [9]: it appeared this made it more challenging for others to uncover the actions responsible for the representation. In contrast, in the final i-dentity implementation, players appreciated the challenge presented by the low fidelity representation, as it caused engagement with the ambiguity of innominate gameplay (F4, F5) facilitating assistance from an audience (F2, F3).

*Use a display that is highly accessible to others (display characteristics)*

In i-dentity, people could see the representation even if they were a far distance away (F11). Unlike most conventional displays that place a restriction on where to stand in order to see the representation, the Move controller's light has an almost 360 degree viewing angle, which enabled audiences to stand almost anywhere and still be able to see each representation. This was welcomed, as it drew a crowd (F7) and facilitated engagement with physical performance (F6).

### Location of representation in relation to the body

*Give a player control across multiple representations*

Games typically have player actions only represented on one screen. In i-dentity, the represented player was given the ability to control multiple screens all situated within a close proximity to one another. This meant observers had to spread their attention across all of the movements and screens. Designers should be mindful about how the physical distance screens are from one another affect a person's ability to balance representation and movement awareness, as having them further apart could made it more difficult for observers to keep attention on all of them at once (D4).

## EXTENDING THE APPLICATION OF INNOMINATE MOVEMENT REPRESENTATION IN GAME DESIGN

We now articulate how the idea of innominate movement representation may be used to inform the design of a whole range of novel play experiences beyond i-dentity. We sat down and envisioned a number of different application domains, then described why innominate movement representations could be beneficial to the game's design.

### Extending innominate representations through shared avatar control to facilitate social play

We see an opportunity for movement-based systems to explore having innominate representations when multiple players are given shared control of a virtual avatar on a single public display. For instance, we can envision a 4-player Kinect game in which players have to quickly identify who controls which limb of an avatar in the game. Like i-dentity, this game uses innominate movement representations, yet engages different technology (Kinect) with representations on a shared screen as well as different sensed body action (every person controls a different limb) (D2.2).

### Using innominate representations to foster awareness of physical activity while addressing privacy concerns

Innominate movement representations in public settings could be used to inspire more thoughtful reflection on people's physical activity by keeping personal data private yet accessible to others, inspired by the Fish 'n' Steps system [17]: for instance, we can envision a 1000-player game where every player in a village wears a Fitbit pedometer that measures step-count. The goal is to identify which family does the most steps in a month displayed on a large public outdoor display (D5.3) that shows each family's step-count, but does not show which data belongs to which family (D1.1). This game also uses innominate movement representation, while again engaging different technology (Fitbits) with team representations of a different body action (steps) involving a much larger player count (D3.1) than i-dentity.

### Extending innominate gameplay through orientation of bodies in relation to a screen as engaging element

Proxemic interactions [18] suggest design opportunities when using sensing technologies to influence how players are oriented in relation to one another. Building on this, we can envision a 2 to 4-player Kinect game where players assume the role of leader or 1-3 followers. A leader stands closest to the Kinect and tries to avoid colliding with falling obstacles represented on a screen. Followers stand in a line behind the leader and try to avoid being detected by the Kinect by moving their bodies with the leader (D1.2). Only the leader's movements are represented by the system as an avatar on the screen (D2.1). Rather than using movement to conceal roles from other players, our innominate mechanic has followers move in sync so the system's Kinect camera does not sense their movements, with no face-to-face play due to the screen's location away from bodies (D4.1).

### Extending innominate interaction design with alternative input methods while facilitating knowledge of own and another's body

Although our work focuses on movement representation, the notion of innominate game mechanic can extend to encompass alternate forms of sensed input, such as button presses, heart rate data, touch-screen or voice input. Game controllers could combine motion data with sensors that measure, for example, breathing data and have an avatar respond differently to each input. We can envision a group of 2 players each with these controllers: the first player's movement data is mapped to the avatar's movement direction and speed attributes while the second player's breathing direction and force controls attacks on enemies. The game uses our innominate mechanic as players synchronize their interactions to conceal from others who

controls what from the other team, facilitating collaborative engagement with a combination of input methods.

In sum, these proposed concepts (ranging from very similar to i-dentity to rather different) aim to demonstrate that the idea of our innominate mechanic can be generalizable to a wide range of games and we believe it has much potential that is yet to be explored.

## CONCLUSION

In this paper, we introduced innominate movement representation as an unconventional form of digital play to facilitate engaging experiences. We implemented i-dentity, a game using innominate movement representation as a novel game element, where players selectively conceal whose representation belongs to whom. We reported on our findings, which show that innominate movement representation can facilitate an engaging play experience.

We also contributed a design space for games that use innominate movement representation. We articulated ways how designers can think about innominate movement representation through five design dimensions. We also presented game designers with a set of practical strategies for implementing innominate movement representation. We hope that our work contributes to game design research and practice by providing insights into how innominate representation can be leveraged in future designs of movement-based games.

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