Understanding Interaction in Hybrid Ubiquitous Computing Environments

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ABSTRACT

Different kinds of computing environment effect human interaction in different kinds of ways and understanding how different environments 'work', as it were, is important to their evaluation and ongoing design. Ethnographic studies of media spaces and CVEs, for example, showed that these kinds of environment introduce asymmetry and fragment the reciprocity of perspectives that is essential to human interaction. Users are therefore obliged to engage in 'compensation work' if interaction is to proceed. However, asymmetry and fragmentation are intentional features of the hybrid ubiquitous computing environments that have emerged over recent years, which is to say that they are deliberately 'built in' to the environment through the design of heterogeneous interaction mechanisms. Interaction in hybrid ubicomp environments therefore relies upon a *different order of interactional work*, namely 'reconciliation work'.

Author Keywords

Hybrid ubiquitous computing environments, asymmetry, fragmentation, reconciliation work.

INTRODUCTION

The rise of ubiquitous computing has brought with it a range of 'hybrid' [4] environments over recent years that combine the online digital interactions of remote users with the local interactions of users situated in real world settings [e.g., 10]. They exploit a *heterogeneous* array of interaction mechanisms to distribute interaction across physical and digital settings. Like media spaces and collaborative virtual environments (CVEs) before them, interaction in these environments is characterized by asymmetry [15] and fragmentation [16]. This paper extends prior research into the interactive character of hybrid 'ecologies' [9], or environments that span the physical and digital, to address the *distinctive* character of asymmetry and fragmentation within them.

Like previous work before it, this paper draws upon findings from an ethnographic study of a hybrid game [2, 9]. It is worth noting that the practice of re-using ethnographic studies is not one of self-plagiarism but of *re-examining findings*. As Hughes *et al.* [17] pioneers of the use of ethnography in design put it,

> "much [can] be learned, and at relatively low cost, by using available studies".

> "this use of ethnographic materials is especially useful where obtaining sight of general … principles is the prime goal".

Re-examining previous studies is an established ethnographic practice to see *what more* may be gleaned from what are, after all, relatively expensive resources. The *what more* of the matter in this case - the original contribution of *this* paper - is an understanding of the fundamental difference between asymmetry and fragmentation in media spaces and CVEs on the one hand, *and* in hybrid environments on the other.

Previous ethnographic studies have shown that asymmetry in media spaces and CVEs disrupts and fragments the common frame of reference or 'reciprocity of perspectives' that underpins interaction in face-to-face situations [14, 16]. If interaction is to proceed, users must repair the disruptive effects of the technology and they do this through 'compensation work' – talking through the meaning of gestures in media spaces [15] or the orientation of avatars in CVEs [16], for example, and in other ways compensating for actions that are mutually intelligible in face-to-face situations but which are not remotely. Hybrid environments go a step further, distributing interaction across heterogeneous interaction mechanisms, all but removing a common frame of reference from the use situation: users do not even see the same things, as they do in media spaces and CVEs. Instead, they are compelled to 'piece together' or *reconcile* the various fragments of interaction (such as location data, avatar movements, audio and text messages, etc.) made available by the heterogeneous mechanisms at their disposal to engage in *mutually intelligible* interaction and effective cooperation.

Re-examining a previous study provides ready insight into the distinctive interactional character of the 'work' underpinning the real world, real time use of hybrid environments and the competences implicated in the practical accomplishment of 'reconciliation work'. In doing

so, it also elaborates the real world, real time use of what have been called 'seamful' representations [4] – i.e., digital traces of interaction and system events – in this case by behind-the-scenes staff who are involved in orchestrating the particular hybrid experience that is the focus of our study here. The study reveals that the use of digital traces is bound up with distinct arrangements of interaction and its orchestration. We briefly consider the emergence of hybrid environments before moving on to examine reconciliation work in detail. We conclude by reviewing the marked difference between interaction in media spaces and CVEs, and in hybrid environments.

THE EMERGENCE OF 'HYBRID' ENVIRONMENTS
Mark Weiser [24] employed the notion of "embodied virtuality" to describe the distinctive nature of ubiquitous computing and the process whereby the essentially virtual character of computing "is brought out into the physical world". Although only "rudimentary fragments of embodied virtuality" were available to Weiser, he nevertheless envisioned a future in which computing permeated the physical fabric of everyday life. More than a decade on ubiquitous computing environments have emerged from the research lab [e.g., 10] to simultaneously distribute interaction across physical and digital settings 'in the wild'.

In such environments participants interact with others who are either online or in remote physical locations. Interaction is mediated by heterogeneous or *different* and *differentially distributed* interaction mechanisms. Thus, and for example, a visitor to a physical museum might interact with a virtual visitor via wireless headphones and a microphone coupled to an ultrasonic location system, electronic compass, and virtual map on a handheld PDA, whereas the virtual visitor might interact with the physical visitor via an audio connection, a 3D model of the physical space and its exhibits, and representations of the physical visitors movements [3].

We refer to such environments as 'hybrid' [4] to distinguish them from ubiquitous computing systems that exploit context-awareness to push information to users and automated ubicomp systems that populate the world with smart appliances. We also refer to them as hybrid because they are composed of elements of different or incongruous kinds. This offers a broad characterization of a distinctive class of ubicomp environment which merges or combines the physical and digital in, over, and across the course of interaction. The question is, what does interaction in these environments look like? How do participants and behind-the-scenes staff practically merge and combine the physical and digital? What does the combination of different and incongruous interactional elements turn upon?

UNPACKING THE HYBRID MIXTURE
Fundamentally we are asking what is the nature of interaction within a distinctive class of ubicomp environment that spans the physical and the digital? What

makes them work? What kind of interactional work do they trade upon and what, therefore, would an appropriate conception of interaction in these domains have to address? In order to formulate answers to such questions we have re-examined and reflected on the findings to emerge from a recent ethnographic study of a mobile mixed reality game called *Uncle Roy All Around You* [2]. The initial study of Uncle Roy was conducted through standard ethnographic methods [6] and augmented through the use of system logs detailing player exchanges via audio and text messages [8]. When analyzing the data we have sought to make visible the methods that 'members' or users employ to conduct and organise interaction [11]. Our analytic concerns are with ethnomethodology then, which means we suspend theory and codification to account for interaction [13].

Uncle Roy All Around You
Uncle Roy All Around You is played online in a virtual city and on the streets of a real city. Online players and street players who have never met before cooperate to find the office of the fictional character Uncle Roy before being invited to make a one-year commitment to one another. For the artists involved in its design the game is an exploration of trust [22]. Technically it exploits GPRS data services to extend prior work on location-based experiences [1]. *Neither* the theme of trust or location-based positioning are explored here as they have been addressed elsewhere. Instead we adopt the strategy of re-examining an ethnographic study of the game's deployment in Manchester (UK) to inspect the real world, real time nature of interaction in a hybrid ubicomp environment deployed in the wild.

Over 1000 members of the public took part in an experience that spanned two weeks and ran for six hours a day over 9 days. Online play was free over the Internet and street players paid £3 to engage an experience heralded by art critics and journalists alike [23]. 415 street players took part in the experience and over 1200 games were played online. Having bought a ticket, street players are taken 'front of house' to the registration desk, where they have their photo taken and an online description is assembled of their appearance. Street players hand over all their possessions - phone, purse, bag, loose change, etc. – in return for a PDA. They are shown how to use the PDA, and are released onto the streets. They have 50 minutes to find Uncle Roy.
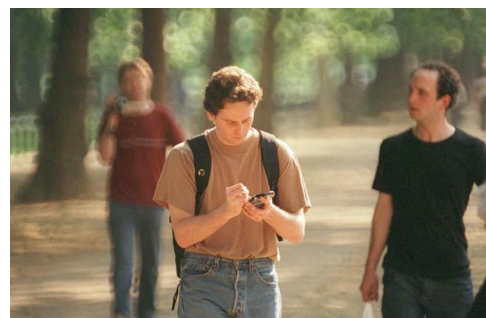

Figure 1. Street player.

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On the streets, the PDA shows a map and the names and positions of online players in the vicinity. The map is a partial representation of the game zone, which is approximately 1 square km of the actual city. The map can be dragged around to show other areas and players can zoom in or out but not to the full extent of the game zone. At the start of the game players receive a message or 'clue' from the game server which tells them how to start. As the game progresses, messages from Uncle Roy become increasingly cryptic and street players are obliged to decipher them to make sense of their instructions and find their way around the city. They may also interact with online players to navigate the city, recording short 7 second audio messages on the PDA, and are encouraged to do so.

Online players move around a virtual city which correlates with the real city via avatars. They are sent on a mission to meet Uncle Roy, which requires them to find one of four postcards located at specific locations in the virtual city. Initially they can chat with other online players via text messaging but cannot see or talk to street players. When a street player first declares his or her position a distinct avatar appears in the virtual world at that location. A street player 'card' also becomes visible to the online players and displays the street player's name, photograph, and a brief description of their appearance and clothing. Selecting a street player's card allows the online player to send private text messages to them. Only the most recent audio message from each street player is available online, each new message overwrites the previous one. Online players and street players are obliged to collaborate if they are to locate Uncle Roy's office. Not only must the online player locate their postcard in the virtual city, the street player must retrieve it in the real city. When this has been achieved, the game server issues instructions to the online player which are used to guide the street player to Uncle Roy's office.

Figure 2. Online player.

When a street player arrives at Uncle Roy's office, the online player who has guided them there is informed and invited to join them in the virtual office. Here they are asked a series of questions culminating in:

Somewhere in the game there is a stranger who is also answering these questions. Are you willing to make a commitment to that person that you will be available for them if they have a crisis? The commitment will last for 12 months and, in return, they will commit to you for the same period.

If they agree, the online player is invited to enter their postal address and can then see the street player via a web cam. On a table in the real office is a postcard with 'When can you begin to trust a stranger?' printed on it. A message from Uncle Roy on the PDA asks the street player to answer the question and keep it with them. There is also in a phone in the room. After a while it rings. A voice tells the player to exit the office via the fire escape and get into the white limousine waiting outside. A man gets into the car and asks the street player the same series of questions that the online player has answered. If the street player agrees to make the commitment to a stranger then they are paired with the online player who has also agreed. The street player is then returned front of house to collect their belongings and exchange player addresses.

Interaction between street players and online players is orchestrated, and not only in terms of learning to use the technology as the game unfolds, delivering clues, searching for postcards, etc. Orchestration also extends to the streets, where a team of 3 street performers are distributed to covertly monitor street players and intervene if players go out of the game zone or to restart the PDAs if the technology fails. Monitoring is technically supported by walkie-talkies and several game management interfaces in the control room, which provide such information as connectivity (on the left of Figure 3, green icon indicates connection, orange disconnection), location (map in the middle of Figure 3), clues received and chat between players (on the right of Figure 3), and so on.
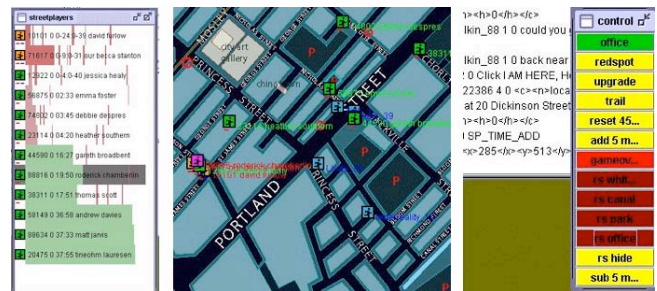

Figure 3. Management interfaces.

Below we examine the interaction that typically occurred between players before moving on to consider the behind-the-scenes work involved in orchestrating the experience.

INTERACTION BETWEEN PLAYERS

We focus here on extracts from the study that detail the 'lived interactional work' involved in following clues and finding postcards. The five-minute sequence presented here illustrates the nature of interaction when things run smoothly (that is, without the need for intervention). The

sequence is derived from transcripts and descriptions taken from video recordings and extracts from system logs which contain audio files and text messages. In order to make visible what data came from what source regular text represents ethnographic descriptions, "text in quotation marks" represents street player audio recordings; **bold text** within the quotations represents the actual recorded content of audio files (what online players heard). *Italic underlined text* indicates the contents of text messages sent by online players and the game server (aka Uncle Roy). Patrick is the street player and Nicole and Dave are online player's with whom he is interacting. The sequence begins with Patrick (like any other player) having to make sense of the clues provided by Uncle Roy:

#1 Patrick has just declared his position and received a new clue: *Wai Yin. Translate: men cannot enter. Make appropriate move. 23 minutes remaining*. Wicked, right, China Town.

Patrick interpreted the clue by drawing on local knowledge of the physical setting - like many players, he knows that China Town is a prominent landmark in Manchester, that it is somewhere nearby, that the clue is to be read as a direction to another location from where he is now, and that given the content of the clue, China Town is a reasonable candidate for the next location to which he must make his way. What happens next and over the rest of the sequence shows us something of the work that occurs at the intersection between following a clue and finding a postcard. Segment 2# shows that interaction between players is first initiated through the co-production of greetings:

#2 Patrick starts walking towards what he hopes is China Town, looking at the PDA as he goes.
Nicole: *Hi Patrick, that jacket looks cool*.
Patrick laughs: Someone's telling me I've got a nice jacket on.
Patrick selects audio record: "Thanks **Nicole, it's very comfortable and it's keeping me very warm tonight, so thanks for that.**"
Patrick: It's bizarre isn't it (he starts walking down the street again).

The doing of greetings, while relatively trivial, is indicative of the *ordinary ways* in which interaction even in novel computational environments is undertaken and proceeds. We can also see that initiating interactiontion intersects with the work of following a clue, which continues in ordinary ways on the streets:

#3 Patrick turns towards a man and woman walking towards him: Excuse me? Do you know where China Town is?
Man: That way (points to a street across the road).
Patrick: Right down there. Wicked. Cheers mate. It's where there's the big gate.

Having determined what his destination is, the player must find his way to it and, as we can see in segment #3, an ordinary method of way finding consists of exploiting *other people's local knowledge*. Following a clue by asking others the way and by subsequently being instructed in the way is a method of navigation commonly employed by street players and what engagement with the game relies upon to some significant extent. Ordinary methods of way finding are also exploited online to get the work of finding a postcard done:

#4 Having crossed the road towards the 'big gate' Patrick stops and looks at the PDA.
Dave: *Go into the graffitied phone box by the railings*.
Patrick: Right, Dave's just sent me a message - Go into the graffitied phone box by the railings. So I'm going to send him a little message now.
Patrick stops walking and selects audio record: "Dave, **can you direct me to it. I'm outside the red phone box outside er – oh bollocks** (looks around for a street sign) – **outside Reyner Street**. So yeah, if you want to direct me there that would be wicked. Cheers mate."

In segment #4, Dave issues Patrick with an instruction but it *lacks 'ecological'* or topographical *validity* as it were. Thus, it is not clear from Patrick's position on the streets where the graffitied phone box or the railings that he has been directed towards are, and he asks Dave to clarify the instruction. The request for clarification is framed in terms of Patrick's *'ecological relevancies'* - his current physical location, what is notable around him, and what to look out for from here (his physical coordinates, as it were). The work of instruction continues as the players seek to locate a postcard:

#5 Patrick crosses the street and heads towards a red phone box on the other side. He stops outside the phone box and checks his PDA again.
Dave: *Have you found the postcard on top of the phone?*
Nicole: *Hi Patrick, my postcard is at this phone box. There is something on top of the phone box*.
Patrick: Is he trying to goose me here. He's telling me that I've got to have a look on top of the phone box. And Nicole, who likes my jacket, is saying that her postcard's here as well.
Patrick opens the phone box and looks inside: There's nothing in there. (He looks around and notices a postcard on the floor outside the phone box, which he picks up).
Patrick: All right. It says tell me about someone from your past who never leaves you. Right, OK.
Patrick: Right (he selects audio record) "Nicole, **tell me about someone from your past who never leaves you. That's what it says on your postcard** and it's on (he looks around for street sign) Charlotte Street."

Segment #5 shows that the work of instruction consists of *directing* the street player to *search a location* on the one hand and (if the search is successful as it is here) of eliciting personal information from an online player as per the postcard's instructions and providing a location report. The work of instruction is distributed and cuts across different players, each having different concerns at different times. Thus, while one card might have been found, another has yet to be retrieved:

#6 Patrick moves away from Nicole's phone box and looks at the PDA.
Dave: *You need the phone box on Portland Street by the tower*.
Patrick: Right, and apparently there's another one. There's a phone box - Dave's telling me there's a phone box over by Portland Tower. (Having just come from there, Patrick knows where Portland Tower is and so he turns around and heads towards it).
Patrick comes across two more phone boxes on Charlotte Street across from Portland Tower: Ah right (he selects audio record) "Dave, **is it the one over the road from Portland Tower**." (He walks around the phone boxes and stops to check his PDA, then continues on his way towards Portland Tower, stops to cross the road and checks his PDA again).
Dave: *OK mate well done. I'm waiting for directions*.

Segment #6 shows how online players clarify prior instructions to respond to a street player's ecological relevancies by providing the street player with a concrete destination: the phone box on Portland Street by the tower, rather than the graffitied phone box by the railings. Again the player exploits local knowledge of the physical ecology, this time his own (where the player's local knowledge fails, then the local knowledge of members of the public may be consulted instead) to follow the instruction. Thus, Patrick makes his way towards Portland Tower (which is just at the bottom of Charlotte Street, past the junction of Reyner Street, where he has just come from). The instruction is read for its *coordinate features* and the immediate physical ecology around Patrick - the street he is located on and that his actions are embedded in - is *scanned for potential candidates*. Two phone boxes on Charlotte Street adjacent to Portland Tower are identified as potential candidates and Patrick asks Dave to confirm their candidacy while proceeding on his way to Portland Tower. Along the way, and as segment #7 shows, Patrick is obliged to clarify the meaning of the retrieved postcard to Nicole:

#7 Patrick is looking at his PDA as he waits to cross the road.
Nicole: *Huh … um someone from my past … is it a riddle?*
Patrick selects audio record: "No Nicole. **Nicole, it's not a riddle. It's - er - it's the clue that's on the postcard on the - er - Charlotte Street phone box**. Do you want to text me the name of someone from the past who never leaves you."
Nicole: *OK my best friend Royce. He is so great and has always stuck by me*.

After complying with the request to provide personal information, Uncle Roy will provide Nicole with instructions to guide Patrick to his office. First however, and as we can see in segment #8, Uncle Roy needs to know where Patrick is and he instructs Patrick to declare his position.

#8 Patrick crosses the road in front of Portland Tower, heads towards another phone box, and checks his PDA again.

Uncle Roy: *Where are you? Press ACTIONS then choose I AM HERE to let me know. 18 minutes remaining*.
Patrick: Right, Uncle Roy's getting a bit annoyed because I'm not telling him where I am. (He declares his position and receives another clue furnishing him with further instructions).

It is not that Uncle Roy or rather, control room staff who operate the game server, think that the player is lost but that they are aware that the player is being distracted. Patrick has already located a postcard for an online player and he does not need to find another one. The pursuit for further postcards is leading Patrick astray and there is a need to get him back on track before time runs out.

Some Salient Features of Interaction
The extracts make it visible that interaction in hybrid environments is not only mediated by differentially distributed interaction mechanisms – such as text messages, audio, avatars, and location reports - but that those mechanisms introduce *communicative asymmetry* into the use situation. Interaction mechanisms are not only heterogeneous in such environments then, but also asymmetrical in their use. Communicative asymmetry has been acknowledged as a problematic issue for media spaces and CVEs [15, 16]. However, it appears not to be a problem here in anything like the same way. Over 80% of players found their way to Uncle Roy's office, which suggests that like Patrick a great many players are more than capable of handling this asymmetry.

The reason for this is that unlike media spaces or CVEs, the interaction mechanisms exploited in hybrid environments do not 'disrupt' interaction [14]. They do not do so as the symmetry exercised in face-to-face situations, and presumed in facsimiles of face-to-face interaction, is *not* a key feature of interaction in hybrid environments generally or of gameplay in this particular case. The generality of the matter turns on the recognition that unlike media spaces and CVEs, the design of heterogeneous interaction mechanisms does not seek to mimic existing symmetric models of communication. Rather, it is accepted at the outset that asymmetry is a *key feature* of the interactive arrangement. As a result of this, the interaction mechanisms 'at work' in hybrid environments intentionally fragment cooperation. By this we mean that through design, interaction is distributed across separate, distinct, and disparate interaction mechanisms, which mediate interaction in varying degrees of physicality and virtuality (e.g.,talk and text respectively).

As a result of intentional asymmetry in design, interaction in hybrid environments requires that participants *reconcile* the distinct fragments of interaction at their disposal, and that they do so in the actual *in vivo* course of using those fragments if interaction is to proceed any further 'here and now'. The work of reconciliation enables participants to handle and/or resolve the communicative asymmetries produced through the use of disparate interaction mechanisms. This is particularly evident in the extracts,

where we can see at-a-glance the fragments of text and talk that participants are obliged to work with. Somehow these textual and auditory fragments, such as "Go into the graffitied phone box by the railings" and "can you direct me to it. I'm outside the red phone box outside er – oh bollocks – outside Reyner Street", are turned into coherent objects *of* interaction, such as instructions that furnish directions to specific physical locations and coordinates to specific objects. *Somehow* is key.

Reconciling Fragments of Interaction
When we look to see *how* it is that participants reconcile fragments of interaction, it becomes clear that reconciliation work relies on 'articulation' and the exercise of 'vulgar competence'. By articulation we refer to the ways in which "cooperating workers have to … coordinate, schedule, mesh, [and] interrelate … their distributed individual activities" [21, 19]. By vulgar competence we refer to the mundane, taken for granted, ordinary competences that people routinely and *methodically exercise* to concert their activities [12, 7]. The suggestion is that fragments of interaction are reconciled through articulation, which consists in the methodical exercise of vulgar competence.

Thus, and with respect to the extracts above, we can see that the reconciliation of fragments of interaction consists of the following courses of articulation: interpreting clues, initiating interaction, way-finding, searching for a postcard, locating a postcard, clarifying the meaning of the postcard, keeping on track. Furthermore, we can see the methodical exercise of vulgar competence which articulation consists: we can see that the interpretation of clues is done through the exercise of local knowledge developed prior to and during the experience; that interaction is initiated in ordinary ways through the doing of greetings; that the ordinariness of interaction continues as players draw on the local knowledge of members of the public to find their way around the streets; that searches for postcards require the ecological validity or topographical reference of instructions be established; that clarifications describing ecological relevancies and furnishing distinct coordinates be issued to find candidate locations and objects; that the streets be scanned to identify candidate locations and objects. This is the 'vulgar work of the streets' [13].

It reveals, in the case of *Uncle Roy All Around You*, that the reconciliation of fragments of interaction revolves around the formulation of adequate instructions/directions to places and objects, and coordinates locating places and objects. While online players track street players through a virtual facsimile of the street player's physical world, the two parties do not share the same orientation to places and objects. Successful cooperation relies upon players' ability to overcome communicative asymmetry and establish a *mutually intelligible orientation* to places and objects. That orientation is not produced through 'compensation work' [16] prevalent in media spaces and CVEs (as there is no symmetry), but is co-produced through reconciliation work.

This work consists of articulation and the methodical exercise of vulgar competence whereby fragments of interaction are practically reconciled and transformed into coherent objects of interaction.

INTERACTION BEHIND-THE-SCENES
Over the course of the game contingencies arise that impact upon gameplay and require some form of intervention. There is need for a street player's progress to be monitored (especially as they have no money or means of remote communication) and this is done covertly through behind-the-scenes work that is for the most part invisible to street players. The following extracts show the work involved in monitoring street players. They involve front of house, control (also referred to as Martin on occasion), and street performers John, Caitlin, and Adam. Other named people are street players. Monitoring is provided for by the distribution of the 3 street performers at particular locations around the physical gameplay area and trades, in the first instance, on their ability to *recognise* players.

Recognising street players might seem a relatively mundane and straightforward matter of 'seeing a person carrying a PDA'. However, recognising a player is more complicated than that as the game takes place on busy city streets where it is not at all uncommon for people to be walking around with mobile devices in hand, such as phones, MP3 players, PDAs, etc. There are several interrelated ways in which recognition is achieved, the first of which is through *instructed looking*. In the course of registration, front of house broadcast that new players are entering the game via walkie-talkie. While front of house's talk is usually directed to control, it also serves to announce to street performers that new players will soon be coming out onto the streets:

Front of house: Front of house, we have 3 players in the game - Katherine, Kate and Paula.
Control: All 3 PDAs are connected front of house.

By listening to messages from front of house, street performers know that players are connected and that they should start *scanning the streets* for them.

It may be the case, of course, that in scanning the streets, performers recognise player's *at-a-glance*. This consists of seeing people doing such actions as carrying a PDA and a stylus, interacting with the PDA via the stylus, talking into the PDA, and aligning the PDA with their surroundings, visibly navigating the streets around them. To the attuned eye players may be recognised hundreds of feet away on busy streets and not only when they are "in your face". However, it is not always possible to recognise player's at-a-glance, whether at a distance or up close as the following extract indicates:

John is watching a woman as she walks down Whitworth Street. She turns right down Princess Street, which will take her out of the gameplay area if she is playing the game.

John (not on walkie-talkie): I don't think she's one of ours – it didn't look like a PDA she had there. Might have to just check.
John: John to control.
Control: Go ahead.
John: Can you just confirm whether one of the girls was Asian, over?
Front of house: Front of house to control, none of the women was Asian.
John: It's OK. Don't worry, over.

This extract shows that recognising a player, or someone who might be a player but turns out not to be, exploits a distinctive arrangement of interaction between the street performer, control, and front of house. That arrangement is mediated by walkie-talkie communication and exploits online player descriptions assembled during registration, which are available to both front of house and control.

It is also the case on occasion that players are simply not recognised on the streets. They do not pass *unnoticed*, however, even though they have not been seen.

John is scanning Whitworth Street, looking for a player whose release was announced some time ago. He broadcasts the news on his walkie-talkie that he has not seen David come past him yet and then walks down the street searching for him.
Caitlin: John, did you find him?
John: No, but he's not on Whitworth Street. I'm just wondering whether he's gone out the wrong way on Whitworth Street or Oxford Street, over.
Caitlin: Yep, I'm going to go that way. I'm on Portland Street now. Do you want to stay in the game and I'll walk down those two streets.

The extract indicates the importance of *time and pace* in interaction. Street performers have a sense of how long it should take a player to come into their zone and failure to comply with this expectation - failure to recognise a player having been instructed to look – triggers an unfolding course of work exploiting various arrangements of interaction that transforms the player into a *lost object to be found* within the physical setting of the streets.

In the first instance, failure to recognise a player leads the performer to notify other performers and behind the scenes staff of the situation. Performers then move beyond scanning the street from their particular vantage points to *trace* the player's expected pathway through the game space. This entails walking the streets the player is expected to be on and scanning them to establish whether he or she is there or not. If it is established that the player is not where he or she should be, then *potential pathways* the player might have taken are considered and the performers concert their actions via walkie-talkie to execute the search:

Caitlin to Adam: I want you to check around G8, around that area, for a guy called David. He's the only male player with a PDA in the game. Can you just go up there, he may be up there, I might have missed him.
Adam: Head down to Portland Street, that area?

Caitlin: Don't come down onto the southside. Stay on the north, 'cause we're down south.

In addition to the walkie-talkies street performers employ grid references (e.g. G8), which are detailed on a small card that each performer carries and are also displayed on the gameplay interface in the control room. These are exploited to concert the search for lost players. G8 is in the middle of the gameplay area and a location that provides "good views" across large sectors of that area. As such, performers often go there to look for lost players. Nevertheless, if tracing a pathway or potential pathway fails to locate a player, performers must resort to *trawling the streets* to find a recognisable player. Then, of course, there is always sheer serendipity.

The concerted search for lost players does not always run smoothly, as the following extract indicates when a player (Yasmeen) is not recognised following the scanning of pathways and trawling the streets:

John: Can you just reconfirm her description, over?
Control: Yasmeen is female, middle-aged, long black hair, brown blazer, blue jeans.
John walks back to his vantage point on Whitworth Street looking out for Yasmeen on the way.
John: John to Caitlin. Are you sure she's not going down Whitworth Street West (a nearby but different street) and still playing the game as if she was in the area, over?
Caitlin: Caitlin to Martin (control), can you give me an update on Yasmeen please?
Control: She's in K11. I don't think we need to find her.
Caitlin: I don't think so either John, I think she's fine.
John: She's not in K11. I'm standing there now. She's nowhere near that area. It's the car park area K11 and there's no one of that description, over.
Caitlin: She's still connected and she's still playing – I think she's fine.
Control: She's getting clues.

Yasmeen did not get lost as it happens but the experience of trying to find her shows more of the interactional arrangements *and* orchestration practices through which 'losing a player' is handled. In situations where players have not been recognized on the streets, then they may be *recognised virtually* by appeal to fragments of interaction within the digital setting which show such things as location, connectivity status, and clue trail. These fragments of interaction are provided by control's view of the game. That the player is reporting location, connected, and "getting clues" settles the matter: the player is not lost but in the game and "fine", even if one member of the team (wrongly) disagrees with the call.

Recognition practices are central to monitoring players. Recognition is not simply a matter of seeing in various ways that players are playing the game or that they are lost, but also, of recognising that they are "confused", as the following extract elaborates:

John (not on walkie-talkie): There's one now, heading towards us in green.

John (not on walkie-talkie): Looks like she's a bit confused. The player is standing in the street, looking at the PDA and at her surroundings. John is about 50 metres away, covertly monitoring her actions. The player turns and starts walking towards John. She stops again, turning around and looking at her PDA and her surroundings.
John (not on walkie-talkie): Right, I'm going to – oh no, she's off (the player sets off back in the direction she has come).

This extract shows that while consulting the PDA and her surroundings, the player's accompanying actions, particularly her changing orientation to the streets, suggests to the street performer that she is encountering some kind of practical trouble that is "confusing" her. The extract also shows us that recognising confusion is not as straightforward as it might first appear. That the player looks confused because of her changing orientation to the streets – particularly her changing bodily orientation (from left to right, back to front, etc.) and constant consultations of the PDA that accompany these bodily orientations to the street - does not mean that she is confused. Or rather, and more to the point, such outward signs of confusion do not mean that the player is encountering an obdurate trouble that is likely to effect the playing of the game.

The nature of confusion only becomes apparent to street performers after watching an unfolding series of player actions on the street and it is with this knowledge in mind that street performers often exploit a practice of *shadowing* players, monitoring them from a distance and following them around if needs be, to establish whether or not confusion is being encountered. Shadowing a player is a covert activity that involves interaction with control and other behind-the-scenes staff. The primary purpose of this interactional work is to find out if the player is experiencing any obvious technical difficulties or whether the state of confusion is interpretive in character: that the player has taken an incorrect bearing and aligned the map wrongly, misinterpreted the clue, is trawling the streets to develop enough knowledge to make sense of the clue's instructions, or is quite simply and utterly lost. Interaction with others in the division of labour allows performers to rule in or out technical sources of confusion, then, and to elaborate candidate sources of confusion.

Recognising confused players is essential to gameplay – in the absence of such recognition, play would breakdown, players would get lost and find themselves stranded and alone in the city. Recognising confusion not only warrants investigation then but intervention as well, which prevents terminal breakdown. Intervention is done for three main reasons: to keep or put players back on track, to remedy technical faults, or to address contraventions to the "rules of the game", typically where two or more players collaborate having purchased only one ticket and share one PDA without prior consent (consent would be given to parents with children, for example, but rarely for adults). Whatever the case, intervention relies on interaction with control and the technologies at his disposal, and with other performers

to locate players and determine the most appropriate course of action.

Some Salient Features of Interaction
Interaction between players is concerned to handle the contingencies that affect the following of clues and finding of postcards. Those contingencies revolve around problems of orientation, where street players align the map wrongly, go off track, get lost, and even walk out of the game zone; problems of interpretation, where players have insufficient local knowledge to make sense of a clue or an online player's instructions; and technical problems, where the street player's equipment breaks down in various ways. Contingencies are handled through a family of orchestration practices – specifically, recognition practices - that provide, when needs be, for effective intervention.

Recognition practices articulate distinctive arrangements of cooperation between street performers and other behind-the-scenes staff. Those arrangements are distributed across discrete physical settings: on the streets, front of house, and control. The work done within them constantly draws upon fragments of interaction from within the digital setting (player descriptions, location reports, connectivity status, place in the clue trail, etc.) to monitor street players. Indeed, in situations where physical recognition practices *fail*, they fall back on digital recognition practices and fragments of interaction from within the digital setting to monitor players. In turn, the situated use of fragments of interaction from within the digital setting enables behind-the-scenes staff to 1) *produce and maintain awareness* of a street player's physical status and to 2) *coordinate appropriate responses*.

Reconciling Fragments of Interaction
Central to this achievement are a series of 'seamful' representations [4] that make interaction in the digital setting and other system events visible and available as a resource. The notion of a seam typically refers to "gaps and breaks in functionality" which "show through in user's interaction" (ibid.). A much-used but readily intelligible example of a seamful representation is the signal strength indicator on a mobile phone. Historically, the focus on seamful representations has been on revealing breakdown between the components of wired and wireless networks, especially those that result in a loss of connectivity, and on making these available as a resource to interaction [5].

The flip side of the coin is that in order to represent breakdown between components then the link between them must also be evident at some level (think of the signal strength indicator again). Environments like Uncle Roy practically (i.e., in the observed course of use) reverse the notion of a seam from something that articulates breakdowns to something that articulates the *links* between the various components of wired and wireless networks [24]. In action, seams including GPRS connectivity, location data, the clues a player has received from the game

server, and the messages online players and street players have sent and are sending to one another between physical and digital settings, evidence the *links* between the various components of wired and wireless networks and 'speak' not only of breakdown but of *proper functioning*.

Such representations provide different but complementary views on interaction in hybrid environments [20]. By drawing on a range of fragments of interaction that are distributed across wired and wireless networks (rather than just representations of gaps in connectivity) the seams between various elements of the network as a whole are made transparent and are open to reconciliation with one another. They enable *inferences* to be drawn and the 'state of play' on the ground to be reasoned about. Ultimately, such representations enable behind-the-scenes staff to combine connectivity data with other system-based information and so provide for the *traceability* of players across physical settings.

As with players' interactional work, the reconciliation of fragments of interaction from within digital settings by behind-the-scenes staff with what is happening on the streets is done through articulation and the exercise of vulgar competence to arrive at a shared sense of 'just what is going on' in the game. The work of reconciliation is done – even when it is disputed - through the *constant production of accounts:* status requests, queries, assistance calls, player descriptions, reports based on fragments of what's happening online, etc. These accounts *embed* fragments of interaction in orchestration of the user experience. They are indexical to a distinct family of recognition practices and distinctive arrangements of interaction which not only provide for the monitoring of street players, but also serve to articulate a shared (if occasionally disputed) representation of where in the game we are right now, what needs to be done next, what troubles are to hand, who is on track, what is outstanding, and so on.

CONCLUSION

The basic premise of this paper is that interaction in hybrid ubicomp environments is fundamentally different in nature to that in media spaces and CVEs. Interaction in media spaces and CVEs is shaped by a common scheme of reference, 'a reciprocity of perspectives', which reflects the symmetrical character of interaction in face-to-face situations and provides a foundation for it [14]. Media spaces and CVEs sought to build on this foundation and construct unified and seamless environments where participants' different perspectives on interaction become practically irrelevant. Thus, the fact that you are 'there' and I am 'here' should be unproblematic in interaction conducted within media spaces and CVEs, just as it is when conducted face-to-face in physical settings.

Rather than replicate face-to-face conditions however, it turned out that media spaces and CVEs introduced "certain asymmetries" into interaction, which "disrupt" and "fragment" the common scheme of reference [15, 16].

Consequently, it transpired that what you see is subtly different to what I see in a media space or CVE. Consequently, the reciprocity of perspectives does not hold in practice and so it has to be continuously *repaired* through 'compensation work' [16]. Asymmetry and fragmentation are thus (and quite rightly) seen as foundational problems to be addressed through continued research and development [e.g., 18].

The issue here is that asymmetry and fragmentation are fundamentally different in hybrid environments. Fundamentally, there is no common scheme of reference to disrupt or fragment in hybrid environments. The differential distribution of heterogeneous interaction mechanisms in these environments means that the symmetry which is essential to interaction in face-to-face situations, and which users constantly have to repair in facsimile environments, *is absent*. Rather, asymmetry is a 'built in' feature of interaction in hybrid environments. It is not there by accident but through the intentional design of heterogeneous mechanisms which distribute different fragments of interaction – e.g., map-based movements, audio, avatar movements, and text – around digital and physical settings. Heterogeneity precludes a common scheme of reference at the outset of interaction and requires instead that users work together to *develop* one.

Unlike interaction in media spaces or CVEs, users are not engaged in 'compensation work' [16] to repair the adverse effects of technology on the symmetrical foundations of interaction then, as there is no symmetry to repair. Rather, and from the outset, they are engaged moment-by-moment in *producing* a reciprocal, mutually intelligible perspective. Users are not compensating for the effects of the technology on interaction then, but working to pull very different interaction mechanisms together so that they can interact and cooperate. This requires that participants in hybrid experiences – both end-users and behind-the-scenes staff, if they are involved - *reconcile* the various fragments of interaction at their disposal.

Ultimately, the nature of asymmetry and fragmentation in hybrid environments is markedly different from that in previous computational environments. Here interaction is not characterised by 'compensation work', where users seek to repair the adverse effects of technology on the reciprocity of perspectives, but by 'reconciliation work'. That work is concerned with the *production* rather than the repair of a reciprocity of perspectives in environments that intentionally preclude a common scheme of reference through the design of heterogeneous interaction mechanisms.

It is not that users don't need to establish a common frame of reference, but that they do so differently in hybrid environments. Reciprocity *is* after all a foundational element of interaction and unpacking the ways in which it is produced is essential to understanding the impact of heterogeneity in design. The observations offered here

furnish some insight into the foundational way in which reciprocity is achieved in hybrid environments. It does not critique the achievements of prior research into the nature of asymmetry and fragmentation in media spaces and CVEs. Rather, it builds on those achievements and seeks to extend them as the computer "is brought out into the physical world" [24].

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