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Bodies-in-Space: investigating technology usage in co-present group interaction

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Summary

With mobile phones in people's pockets, digital devices in people's homes, and information systems in group meetings at work, technology is frequently present when people interact with each other. Unlike technology used by a single person at a desk, people, rather than technology usage, are the main focus in social settings. An important difference then between these two scenarios, individual and group, is the role of the body. Although non-verbal behaviour is not part of human-computer interaction, it is very much part of human-human interaction. This dissertation explores bodies-in-space -- people's use of spatial and postural positioning of their bodies to maintain a social interaction when technology is supporting the social interaction of a co-present group.

I begin this dissertation with a review of literature, looking at how and when bodies-in-space have been accounted for in research and design processes of technology for co-present groups. I include both literature from human-computer interaction as well the social sciences more generally. Building on this base, the following four chapters provide examples and discussion of methods to: (1) see (analytically), (2) notate, (3) adjust (choreograph), and (4) research in the laboratory, bodies-in-space. I conclude with reflections on the value of capturing bodies-in-space in the process of designing technology for co-present groups and emphasise a trend towards end-user involvement and its consequences for the scope of human-computer interaction research.

All of the research in this dissertation derives from, and relates to, the real-world context of an intensive care unit of a hospital and was part of assessing the deployment of an electronic patient record.

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> … "and yes I said yes I will Yes." (Ulysses, Joyce)

1:Finding a View

Relativity
M.C. Escher, 1953

RESEARCH VIEW

Figure 1: The traditionally motivating scenario in HCI research: a single user, seated at a desk, trying to be efficient.

The Human-Computer Interaction View

The primary scenario motivating Human-Computer Interaction (HCI) research questions in the field's early days, and still dominant in recent HCI textbooks, e.g. (Carroll J. , 2005), has been the office workstation featuring a single user, seated and doing a task that is made more efficient by using a computer. As technology moves off the desk and into the everyday environment, however, it is more frequently present during social interaction -- sharing pictures on a mobile, utilizing an electronic patient record to discuss patient progress with colleagues in a hospital, or playing a technology-enhanced children's game on a tabletop are a few examples. In these scenarios people are focused on their interactions with another person(s), rather than with a piece of technology.

An important part of social interaction, which is not a significant part of human-machine interaction, is the body. When more than one person is present, the spatial and postural relationships of their bodies have inherent meaning, whether it is to show active engagement, disengagement or some state in between. Co-presence creates a system of interaction, or non-interaction as the case may be, that people maintain through continuously adjusting their spatial and postural relationships (Goffman, 1959). As technology influences spatial and postural body relationships, it affects the social interactions of people who use technology while in a group. It is the body's role in technology-supported social interaction of a co-present group that I will explore in this dissertation.

The Practical View

I do this research in the context of a practical problem: the usage of an Electronic Patient Record (EPR) during multi-disciplinary ward rounds in a hospital. The ward round team in this case is a group of 8-10 medical practitioners who travel from bed-to-bed to decide on the patient care plans each day utilizing the EPR available on a display at the end of each bed. The primary goal is discussion and decision-making between the multi-disciplinary team members rather than use of the machine.

Nonetheless, the machine provides access to an indispensible source of data. The ward round team usage of EPRs then provides a number of related scenarios in which to explore how the body is used during social interaction of co-present groups that utilize technology. I begin each chapter with a 'Research Inspiration' section that specifies the practical problem.

The Bodies-in-Space View

Much HCI research that mentions the body focuses on information in a context of mobility or physicality, focusing on technology devices or the production and usage of information. Those using technology in groups however, are usually more concerned with their social interaction rather than their interaction with the technology. It is important then also to consider how the technology affects the social interaction. I therefore concentrated on the social interaction, which, as argued above, is mediated by the body. Taking a body-centric approach, I look at bodies-in-space, that is, people's use of spatial and postural positioning of their bodies to maintain a social interaction which is supported by technology.

I draw on research and methods from a variety of disciplines to capture and make palpable bodies-in-space as relevant to each particular research problem. Underlying the work in every chapter is the empirical work of interaction analyst, Adam Kendon (Kendon, 1990) who provides a structure for observing and describing co-present group interactional systems in his theory of the F-formation system. I also draw heavily on techniques used in dance to depict and elicit movement. Creative, or arts-based methods (Knowles & Cole, 2008), help capture the often taken-for-granted sensorial experiences of social interaction. As real-world problems are complicated, the methods I derive take inspiration from many fields but are focused to solve each research problem.

The Researcher's View

All of the research carried out in this dissertation, regardless from where the method has been drawn, is influenced by my training and experience in anthropology and dance. Although anthropology is a discipline, and like all disciplines has a shared discourse used to contextualise data, it could also be considered a mind set. I see it as an analytical process that teases out why people do what they do by examining the systems in which they participate. I gradually developed this mind set as an undergraduate when studying ethnomusicology, during which time I researched how artistic practices structured social interaction in the traditional music cultures of Scotland and Hungary. It is with this anthropological mind set and experience observing social interaction that I approach the research problems.

I also draw substantially on my professional training in contemporary dance. This training has provided me both with tools and skills. Dance as an art continually explores ways of perceiving, presenting, and manipulating the body, which although often not written down and referencable, can provide a practical starting point for doing the same in non-performance contexts. This dissertation is not the first time dance has been utilised to study the body in HCI contexts, e.g. (Hummels, Overbeeke, & Klooster, 2007) & (Loke, Larssen, Robertson, & Edwards, 2007). I also rely heavily on the skills that I have gained in seeing, remembering, and comparing detailed movement in my head. The methods sections of each chapter describe the process used to interpret movement, but it is likely to take more time for non-dancers to become proficient in these methods.

RESEARCH OVERVIEW

I begin this dissertation by examining a sub-set of relevant literature that provides the grounding for the methods chosen to explore bodies-in-space throughout this dissertation. The first sections of Chapter 2 – *Grounding Bodies-in-Space* -- examine Dourish's notion of embodied interaction (Dourish, 2001) and how recent literature in the CHI and CSCW conferences has treated the body. I draw out a number of trends showing how the body has been excluded and then look more closely at methods of analysing it when it has been included. The latter part of the chapter broadens the perspective to look at social science methods, focusing specifically on creative methods and interaction analysis. I conclude with a short summary of research on EPRs in HCI.

Chapter 3 -- *Seeing Bodies-in-Space,* a comparative study of paper and electronic patient records, is the first of four chapters that will demonstrate various methods developed to understand and explore bodies-in-space. This first study resulted from an invitation to observe practice in an intensive care unit that transitioned from a paper to an electronic patient record. The implementation steering group was concerned with how the technology might affect multi-disciplinary ward rounds. I therefore chose to answer the following question: 'How does interaction during the ward round change when paper, as opposed to electronic, patient records are used?' I focused on non-verbal behaviours and what they indicated about the social interaction, articulating theoretically, and demonstrating practically, a way to 'see' bodies-in-space.

Chapters 4, 5, and 6 build upon this first study. In chapter 3, I had the advantage of being able to use video. In most medical contexts the ethical approval process would usually make this difficult to arrange. Chapter 4 -- *Notating Bodies-in-Space,* a further study of electronic patient records in use, examines how one might notate non-verbal behaviour of groups while observing. I discuss notations of social interaction in HCI, as well as dance notation, before proposing a notation system. I conclude with the results of using the notation system in an intensive care unit. *Choreographing Bodies-in-Space,* chapter 5, grows out of a problem noted in both chapters 3 & 4, multi-disciplinary communication during the ward round when the team used the EPR. I discuss two interventions, the first one a discussion with the medical team and the resulting changes to the ward round and the second one, a proposal for an intervention using choreographic methods.

As a result of the analysis in chapter 3, I observed a conflict between the group's use of formation to negotiate their interaction and the set of formations imposed by their technology setup. I wanted to explore whether mobile devices might solve this conflict or create other interaction problems. As the critical nature of care in the intensive care unit made introducing experimental technology inappropriate, I had to find a way to study the phenomenon in the laboratory. The early part of chapter 6 -- *Bodies-in-Space in the laboratory* -- provides arguments regarding how complex social behaviour can be studied in the laboratory. The latter part of the chapter presents a study based on these arguments aiming to answer the question: *How does a team negotiate interaction differently when using a large display as opposed to individual, small displays?*

Chapter 7 – *Bodies-in-Space* -- concludes this dissertation with some reflections upon what this dissertation can tell us about bodies-in-space and what that adds to the field of HCI.

RESEARCH CONTRIBUTION

This dissertation draws on methods from social science and practical techniques in dance to inform research into how technology affects social interaction of co-present groups. I present four methods for examining this research theme from the angle of bodies-in-space. Each was used at a different stage of the deployment of an EPR and is described in that context. Together they provide:

- An example of how to analyse bodies-in-space during ethnographic research
- A discussion and an example of notating bodies-in-space
- A proposal for how users can incorporate the idea(s) of bodies-in-space when choosing and adapting (to) technology
- A theoretical stance and practical demonstration of researching bodies-in-space in the laboratory

Methods that draw upon other disciplines may be difficult to adopt immediately for those unfamiliar with the basic tenants of those disciplines. Just as it is difficult to get statistical methods right without studying statistics, the same is true for methods from the social sciences and the arts. Nonetheless, it is my aim that the methods presented in this dissertation: display some of the interesting social science research that could be more fully utilised in HCI; give inspiration for those developing research around bodies and technology; and provide a synthesis of bodies-in-space in the conclusion that can be drawn upon in HCI without deep understanding of the methods used to carry out the research.

These methods touch upon a large number of HCI sub-areas, including groupware, participatory design, tangible technology, studies of records, movement-based interaction and electronic patient records to name a few. The main analytical contribution however, is in embodiment for the design technology used by co-present groups. Nonetheless, some of the intersections of this research theme with the areas named above are briefly discussed in the conclusions of each chapter as relevant.

2:Grounding Bodies-in-Space

Pilobolos Dance Company
Photograph by John Kane

INTRODUCTION

Bodies-in-space, as defined in the first chapter, is comprised of the spatial and postural position adjustments people make to maintain a social interaction. Relevant literature could be drawn from many disciplines within, and outside of, HCI. This chapter does not aim to give a comprehensive review of all related literature, but captures literature that has provided inspiration for the research decisions made in this dissertation. I begin the discussion of literature with the often cited book about embodiment in HCI, *Where the Action is: the foundations of embodied interaction* (Dourish, 2001). I then discuss literature from Computer-Supported Cooperative Work (CSCW), the research area in which ward round usage of electronic patient records sits.

In addition to CSCW studies that have a specific focus on technology, I draw from a variety of social science disciplines that engage with the body, and specifically bodies-in-space. I begin by summarizing the field of interaction analysis, and particularly Kendon's work on F-formation systems (Kendon, 1990), defining a co-present interactional system and presenting his terminology for analysing one. I then explore the rationale behind, and examples of, creative methods, as they are used throughout this dissertation. Drawing the discussion of social science methods together, I briefly examine the epistemological background to a spectrum of qualitative methods and articulate where the research in this dissertation sits. I conclude with a brief overview of literature on electronic patient records.

EMBODIED INTERACTION

In his book, *Where the Action is: the foundations of embodied interaction* (Dourish, 2001), Dourish brings the body, as a research focus, to the radar of HCI research. He argues that computer science is based on pre-1930's philosophy with the result of aiming to "reduce high level behaviour to low-level mechanical explanations" (ibid. p. vii) through methods of formalizing behaviour that utilize scientific rationality. He claims that the ultimate outcome is a positivist and reductionist approach to design. His goal is to "uncover the philosophical assumptions that run throughout the theory and practice of computer science design" (ibid. p. viii) by focusing on action. In doing so, Dourish provides the reasoned arguments that validate new avenues of HCI research that differ from the established methods that utilize abstract reasoning.

Dourish emphasizes that an embodied perspective is particularly important to the new generation of technologies that are not used at a desk. He presents salient examples from ubiquitous computing, mobile devices, digital desks, virtual and augmented reality, and tangible bits that demonstrate that action is not "generated from, or is subservient to, abstract reasoning" (ibid. p. ix) and therefore requires a different research approach. He also proposes that 'social computing,' the study of the situated practices of technology usage is another aspect of this same (new) research agenda, as both tangible and social computing rely on embodied skills that people encounter directly through their experience in the world -- one physical, the other social.

Connecting the physical and the social through the concept of embodied skills is an important step towards understanding technology use during group interaction. As will be discussed later in this chapter, people negotiate group interaction in many ways. When face to face, the body is an important non-verbal resource for conducting social interaction, with significant consequences for

its outcome. In these instances, physical actions are social ones. Dourish however, makes the link between tangible and social computing for a very different reason. He does so in order to argue that although tangible and social computing are part of a 'new' area of HCI research, there already exists a literature in philosophy, that of phenomenology, to draw upon. The second half of his book develops the idea of how phenomenology can support the design of this new class of technologies.

Dourish begins the second half of his book by summarizing prominent philosophical stances in phenomenology for the HCI audience, emphasising the basic idea that no 'truth' is independent of experience. He then suggests that tangible computing can utilize ideas from Heidegger and Merleau-Ponty, who provide theoretical arguments about how the world reveals itself to people through their encounters with it. Social computing, he proposes, can draw upon Schutz, who sets down theoretical grounding for the idea of intersubjectivity, and how people come to share meaning in the world through action and interaction. With this summary, Dourish offers a useful set of theoretical principles to underpin new research methods for technologies not used at a desk.

In order to bridge the gap between theoretical principles and technology design, Dourish focuses his concluding chapters on the ramifications of phenomenology for understanding how 'meaning' is created in technology design. He describes three types of meaning that derive from people's interactions in the world: (1) ontology, or "how we come to understand the computational world;" (2) intersubjectivity, "understandings we develop of technological artefacts...that emerge in concert with other people;" (3) and coupling, that we cannot only understand, but "operate through [interactive systems]" (ibid. p. 153). He then gives examples of how these types of meaning are established in software design.

Dourish provides a strong case for an embodied perspective in the design of tangible and social technologies. He applies the theoretical contributions of phenomenology that he summarizes to examples of interactivity in software, but opens up a much wider prospectus. His general concern lies in the participative status that embodiment denotes and its consequences, but his arguments apply more broadly to the physical nature of interaction with tangible technology, and the physical nature of social interaction in social computing. Utilizing the robust arguments that Dourish makes for taking an embodied perspective, I focus on two related research areas of embodiment that he does not cover - the physicality of the body in social situations and how to account for that in the design process.

CSCW LITERATURE

The practical research problems in this dissertation fit within the remit of CSCW. I next review this area, focusing on general trends of how bodies-in-space have been considered. Wanting to draw inspiration rather than be exhaustive, I first consider a corpus of recent texts. I then summarise other literature that has had a significant impact on the research choices made in later chapters.

A Corpus Analysis

The Corpus

In order to examine common trends of how the body is considered in recent CSCW literature, I compiled a corpus of papers. Comprised of 52 papers written between 2003 and 2007, they are

drawn from the conference proceedings of European Computer Supported Cooperative Work (ECSCW), Computer Supported Cooperative Work (CSCW) and Computer-Human Interaction (CHI). I chose these three conferences because they represent the best work in the general field of HCI as well as the most specific sub-area under which co-present groups fall, CSCW. Their respective journals were also considered, but it was discovered that most of the relevant work published in these journals had been published in a smaller form in the conferences and was not developed to such an extent that it needed to be considered twice.

The corpus includes all papers, both long and short, that describe active co-present group interaction around technology, (or technology meant for such a situation). An active co-present group could be interpreted in several ways, but here was considered to be a group of people in (or trying to be in) a formation around a piece of technology, actively engaged in social interaction. This boundary was chosen to find papers that would give inspiration for appropriate methods, either by example or by demonstrating what the current methods lacked. The corpus is not an exhaustive review of CSCW literature, but meant to provide some context for the reader in later chapters in which alternative methods are introduced.

Papers, such as (Brignull, Izadi, Fitzpatrick, Rogers, & Rodden, 2004), in which a group of students in a school common room shift between using a multi-user interactive surface and doing their homework, were not included because the students were not always actively positioned around and using the technology. It was therefore considered sufficiently different from ward round to exclude. Related literature of this nature will be considered in the conclusion and used to contextualise the results of this research into the CSCW community.

Avoiding the Body

In the corpus, 70% (37/52) of the papers do not address the role of the body in relationship to the technology researched. This category includes papers in which the body is not mentioned at all, descriptions of new technologies that do not actively tease out the relationship between the body and the technology, as well as evaluation studies of technology that contain no measures related to the body. This large percentage suggests that even after the publication of Dourish's book on embodied interaction (Dourish, 2001), the general HCI researcher does not engage with issues of the body. The following paragraphs examine what these researchers alternatively focus on, and consider, albeit briefly, how results might differ if the body was not excluded. I have chosen to discuss specific papers as illustrations of more general phenomena in the corpus.

Theme 1: Design Rationale

A number of papers casually reference the body as design rationale without elaboration. Authors (Bastea-Forte & Yen, 2007), for example, claim that "working simultaneously on the same sketch at the whiteboard is awkward because people must stand close together..." (p. 2268). Their design solves this problem by giving group members personal TabletPCs that allow direct interaction with the whiteboard while seated around a table. Although there may be some scenarios in which the physical setup of the whiteboard causes awkward social moments, there are likely to be others in which the physical setup promotes social interaction, such as the negotiation of group dynamics through non-verbal behaviour. *The authors' statement reveals the problematic assumption that because we live in a body, we can make statements about it without the need for critical reflection.*

Common assumptions about popular research technologies, such as Tabletops and TUIs, can also discourage critical reflection about affect of the technology on social interaction. Authors use statements, such as,

1. "Tabletop technology encourages group interaction...allow face-to-face interaction..." (Piper, O'Brien, Morris, & Winograd, 2006, p. 1);
2. TUIs are "more suitable for collaboration..." and
3. the "physicality of the TUI model helps novices to learn how to use the system more easily..." (Kobayashi, et al., 2006, p. 978)

as design rationale and then not explore the role of the body further. Although these assumptions are certainly true sometimes, the body is 'situated,' and its use depends on contextual influences such as the personalities of the people involved and the work that they are required to carry out. For example, tabletops are touted for their support of face-to-face interaction, but if large amounts of information are provided to each individual using this technology, the desire to read it is likely to hinder face-to-face interaction. *Researchers that accept that these technologies support social interaction without further thought, rarely explore the role of the body in social interaction in depth.*

Another common assumption is: if digital applications mimic the physical world, they will be simple to use. (Apted, Kay, & Quigley, 2006, p. 781) suggest that it will be easy for the elderly to use, and remember (in their old age), the authors' application as it is "strongly influenced by the metaphor of physical photographs placed on the table." This, however, is naive. Without careful assessment of how the physical object or representation is supporting interaction, it is not certain, or even likely, that the most salient aspects of the physical medium will be translated into the application. The research of (Lindley & Monk, 2006) strengthens this point. Using body-focused methods when considering how people share photographs, they reach different conclusions than Apted et al. as also noted in (Blackwell, 2006). *The use of physical metaphors in design can stop the exploration of the effect of the body on interaction and lead to design decisions which are not necessarily helpful*.

Theme 2: Information-Centric Research

It is not surprising, given that technology supports the gathering, storage, manipulation, and display of information, that information is a central focus of many research papers. The result, however, is that much research ignores anything that does not have a direct effect on the flow of information. In many such papers, the focus is on the objects and representations of information, e.g. (Lee, 2005). Even in ethnographically-inspired studies, the information-focus draws attention away from the body and the larger picture. Using the example of (Coughlan & Johnson, 2006), who aimed to understand the creative process in order to inform the design of support tools for musical composition, I will illustrate how a solid argument made by only looking at information can be nuanced through including the body.

(Coughlan & Johnson, 2006) model collaborative composition and analyse the representational medium used. It is their desire to capture individual, social and collaborative aspects of creative work. This study is ethnographically-inspired, as "naturalistic contexts are important to obtaining valid results, especially when attempting to understand collaborative behaviour" (p. 533). Although ethnography is a suitable method for analysing the role of the body in social interaction, as Dourish pointed out (Dourish, 2001), the data in this paper includes only gestures – those found during playing an instrument or pointing to an artefact that contained or represented an idea.

Unfortunately, although the gestural data was reported, it was neither included in the analysis which defined cycles of ideation and evaluation, nor in support of design decisions of the prototype application.

The researchers focused on the representation and evaluation of ideas captured that were either verbal or written. Non-verbal ones were not included. For example, the authors noted that the composers gestured at representations, but they did not indicate the spatial placement of people and objects and how it influenced the organization of ideas. Non-verbal evaluations of one composer's idea by the other, such as body position or facial expression, were also not explored. If these had been included in the analysis, as they were in (Healey, Leach, & Bryan-Kinns, 2005), one of the benefits might have been an application which did not exist only on the screen. Design attention towards the physical representation and manipulation of ideas might have been considered as well as the physical setup of the technology, allowing people to communicate more easily while using it. *Including the body in analysis supports design creativity outside of the traditional on-screen application.*

Theme 3: The Virtual Box

The 'virtual box' refers to research which bounds itself to happenings on the screen – to the virtual without regard to the physical. Often this kind of design research suffers the same problems highlighted in the above two themes. A virtual focus often means an information focus, e.g. (Tsandilas & Balakrishnan, 2005) who focus solely on the design of menus to mitigate interference between co-located people using a Single Display Groupware (SDG) application. The use of physical metaphors is also common. (Tse, Histon, Scott, & Greenberg, 2004), for example, suggest that social protocols can be used to relieve issues of close proximity when using an SDG application and therefore do not need to be considered as a design issue. A virtual box approach to research is particularly problematic in evaluating technologies that are not desk-bound.

(Ryall, Clifton, Shen, & Morris, 2004) is an example of the problems that occur when designing evaluation research with a virtual box approach. These authors present an experimental study of a tabletop application, investigating the effect of size and group number on task speed, distribution of work, shared resources and user preference. The first criticism from an embodied perspective is that the goals of the study are aimed at properties desirable in the work-place – speed and group size -- but say little about collaborative social interaction, the most common design rationale for using tabletops. Moreover, the task related qualities, such as searching and passing information, are about the information properties of the device rather than how it facilitates interaction between people. By deriving both the research questions and the properties of the task with the notion of the virtual box, the authors avoid addressing a significant aspect of how the technology is used – during interaction with other people.

The authors of this same study suggest a number of factors to consider in their analysis which are related to the body – physical reach across the display, visible availability of information, social interaction and to some extent, resource management. The measures, direct observation, logged performance measures and questionnaires, however, do not capture the role of the body in social interaction. For example, work distribution is determined by the ratios of the numbers of touches of the table each participant made. This measure, however, cannot capture work divided between two people (e.g. one doing the mental work and the other the manual). Nothing about reach, moving

around the table, or social interaction was mentioned. *By choosing measures that are primarily in the virtual box, it is not possible to explore social interaction.*

Summary

The above paragraphs describe three ways in which bodies-in-space has been omitted from the design and evaluation process of technologies used by co-present groups. These include: the absence of critical reflection on common assumptions or metaphors about the body (theme 1); the lack of awareness of the contribution that understanding bodies-in-space provides in the design process (theme 2); and inappropriate research methods for studying bodies-in-space (theme 3). *These reasons suggest that research that demonstrates the relevance of bodies-in-space in the design process, and supplies appropriate methods for including it, could benefit the part of the HCI community that invents new technologies for co-present group usage.*

Considering the Body

There are a number of research papers in this corpus that account for the body and offer insight into bodies-in-space as well as methods to explore them.

Partial Analysis of Bodies-in-Space

There are a number of studies that focus on just one aspect of the body. (Newman & Smith, 2006) for example, assess conversation engagement in meetings when laptops are used, and include gaze direction in their analysis. Along a similar line, (Rogers, Hazlewood, Blevis, & Lim, 2004) look at how fingertip interaction on a tabletop display supports turn-taking in conversation. (Tang, Tory, Po, Neumann, & Carpendale, 2006) carry out a detailed study of how position around a table relates to involvement of group members in each others' work. (Morris, Huang, Paepcke, & Winograd, 2006) examine gestures done by more than one person simultaneously to manipulate data – such as pass documents or exit the program. In each of these cases, established methods are extended to include the body in the analysis or design, acknowledging that it plays an important role in social interaction.

In other cases, the type of application forces the researchers to account for the body. (Benford, et al., 2005), for example, built a location-based game which required children to come together as a group in order to carry out certain actions in the game. They realized after testing a prototype that the way that 'group' was encoded in the system was too rigid to suit the children's interactions and hindered the game. In another example, (Ringel, Ryall, Shen, Forlines, & Vernier, 2004) wanted to make interaction 'intuitive' by incorporating gestures that mimic the usage of paper. Both of these cases would have benefitted from knowledge of bodies-in-space. The former group of authors may have anticipated the need for a design change and the latter would have had a solid basis for designing gestures. As mentioned above, physical metaphor is not always a helpful starting point for design.

Territory is another area of recent research that engages with the physicality of the body. It was first introduced in a study of traditional tables (Scott, Carpendale, & Inkpen, 2004) which aimed to determine answers to design questions that related to information manipulation for digital tabletops. In particular, the authors were interested in the coordination between people using the table. The authors plotted each person's interaction with information on the table, looking at the spaces on the table that were used for various activities. They then drew conclusions of how the placement of these activities relate spatially to the participants' bodies. People, for example, are most likely to interact with information that is in front of them. This paper demonstrates a useful

way of visualizing physical relationships to information, but does not say much about how that affects social interaction.

Full Analysis of Bodies-in-Space

The following three research papers provide a full analysis of bodies-in-space in different ways. (Rodden, Rogers, Halloran, & Taylor, 2003), through their ethnographic and design investigation of face-to-face sales transactions, discover that the physical placement of technology often hinders collaboration by asymmetrically giving physical and representational informational access to one party. They describe an existing technology setup and how the various parties need to physically arrange and move themselves to interact. They conclude that this is socially awkward and requires the customer to wait for long periods of time. The design of the multi-display solution is discussed in terms of the physical positions of the people and what this allows them to do. It is then evaluated in practice in these terms, assessing whether the social awkwardness had been solved. This paper offers an example of accounting for bodies-in-space throughout the design process.

The following paper is similar in its use of observational methods, but the end result of the analysis is more abstract. In order to derive requirements for electronic photo sharing media, (Lindley & Monk, 2006) describe photo-sharing with data from contextual interviews. They discuss how different arrangements of 'photo-showing' satisfy various 'social affordances,' such as the ability to converse or the ability to control the interaction. They highlight, for example, incidents of pointing and gesture and relate these to verbal utterances. They also distinguish the 'hover,' in which one person is behind the other looking over the shoulder, from the 'huddle,' in which everyone is side by side. They note that the hover makes it difficult to see and touch the photos and is considered unpleasant, while the huddle is not. This study is notable in that it links the physicality of the body, in all its aspects, with the consequent social ramifications of its usage and proposes concepts to support technology design.

Hornecker, in (Hornecker & Buur, 2006) and (Hornecker, 2005), takes the study of the body to a more theoretical level when she presents a framework of physical space and social interaction. Her focus is to gain a meta-level view on the design properties of tangible (and ubiquitous) technologies. Following the review of other systems, the first paper describes four themes ranging from ways of talking about the tactileness of interaction and how tangible representations are expressed, to how the embedded nature and configuration of space affects group interaction. For each, the author(s) describe comparative examples from a wide range of technologies in order to draw out 'design sensitivities' that encourage designers to reflect upon the influence of their technology on the body and social interaction. She emphasizes the value of these heuristics to designers for practical application domains.

Summary

The set of examples in the first sub-section demonstrate a number of cases in which there is a clear desire or need to include bodies-in-space in the research or design process. The second sub-section highlights three ways in which this has already been done: the first gives an example of including bodies-in-space in observational research and design; the second, transferable concepts for talking about the use of the body when groups interact with technology; and third, design heuristics for increasing collaborative interaction. There remains more scope for research and design methods that capture bodies-in-space. *The areas that I will focus on are: (1) to provide a structure for*

analysing bodies-in-space; and (2) to investigate how an understanding of bodies-in-space can be included in the design process.

Other CSCW Literature

The previous section indicated that there remains a need for methods that capture certain aspects of bodies-in-space. I articulated two of these that I will focus on in this dissertation: seeing bodies-in-space and designing for bodies-in-space. In the next section, I present three pieces of research that provide the basic principles for developing methods appropriate to these goals.

Workplace Studies

Workplace studies (Heath & Luff, 2000) is a common method for doing structured observation in CSCW. It is an analytic perspective that draws heavily on ethnomethodology (Heritage, 1984) and conversational analysis (Sacks, Schegloff, & Jefferson, 1978). It aims to understand how technology features in the production and coordination of workplace activities. Unlike more mainstream areas of sociology, the goal is not to describe a technical or human system, but to comprehend how social interaction and its organization is constituted through the activities of people. Workplace studies emphasizes the need to look at work in situ (embedded) and understand how action is made accountable, or understandable to the others that are present.

The research process of workplace studies is also clearly specified. A workplace situation is chosen and a cycle of field work, videoing, video analysis, and more field work is done. The first round of field work is undertaken to understand the nature of the work and the areas in which closer scrutinization would be beneficial. Videos are then filmed and analysed by a group of researchers, gradually pulling out invariant interaction or unexpected relationships between tools and interaction through multiple viewings. They focus on: (1) a desire to understand the resources through which participants produce intelligible actions and recognize the actions of others during interaction; (2) detailing the talk, bodily actions and tools as a way of accomplishing action; (3) looking at the sequential and emergent characteristics of interaction. Field work may be repeated in order to further contextualize the phenomenon seen on the videos.

Workplace studies provides the rationale to do research in-situ and offers guidelines on how best to carry out that process which I follow for the observational research in this dissertation. The approach that workplace studies takes towards its visual data however, is too highly structured for examining bodies-in space. Researchers that identify with workplace studies and/or adhere to the epistemological stance of ethnomethodology create very detailed transcriptions of talk and 'bodily action' of short clips of video in their data analysis. The emphasis is on talk and the primary analytical tool is conversational analysis. Body movement is only noted when it is part of the development of the conversation in some way, such as facilitating coordination or turn-taking.

This approach constrains investigation of bodies-in-space. It isolates singular body movements, such as a gesture, from the wider physical context of the body and it restricts analysis to the linear nature of the conversation, making it difficult to look at non-verbal behaviour as a system of interaction in its own right. Inspired by the research of (Suzuki & Kato, 1995), I looked toward Kendon for an analytical approach that sees the body as a component of a system of interaction.

Finding Kendon

(Suzuki & Kato, 1995) present an evaluation of a TUI collaborative programming language for children called, AlgoBlocks. In their introduction, they stress that it is important to have two levels of design: "One is the interaction level design and the other is the social level design" (p.2). In reference to the latter, they state that one of the advantages of TUIs is the use of the body to interact with them, which provides information about the state of the (social) interaction to co-learners. This article is unusual in that despite its publication in 1995, it was already concerned with the ramifications of technology design on a social situation and the role that the body plays.

In one of their sections of analysis, the authors offer a description of how the members of the group control the collaboration, or as I have called it in this dissertation, negotiated the interaction, by changing the positional and postural relationships of their bodies in relation to each other and the technology. They draw upon Kendon's concepts of F-formation and transactional space (Kendon, 1990) to support their descriptions of the interaction. This approach is successful in communicating the system of behaviour between the group members, indicating when one person's behaviour affects another's and why. They use verbal descriptions to do this and do not utilize the transcriptions that they present or any notation. I take a similar approach in this dissertation, but develop Kendon's theory of F-formation systems in several directions as required by the research scenarios.

A Mixed-Methods Approach

The above two sub-sections described the starting points in this dissertation for developing observational methods that include bodies-in-space. A further aim of this dissertation is to investigate how to consider bodies-in-space in the research and design process. (Rogers & Lindley, 2004), exploring collaboration around vertical and horizontal large interactive displays, present a practical strategy of study design. Studying how physical affordances affect cognitive and social interactions, their study uses a mixed-methods approach, "trying to strike a balance between some of the control possible in laboratory studies and the ecological validity afforded in naturalistic studies" (p. 1136). This can be seen in the task, which is open-ended but done in a laboratory, as well as in the results, which combine quantitative and qualitative measures.

Although mixed-method studies are becoming increasingly common in the social sciences (Brannen, 2005), they are noteworthy in the HCI community which tends to be polarized. Perhaps most notable about this paper is the clarity with which the authors argue their study design decisions. The paper begins by defining ambiguous terms that are frequently applied to collaboration through formal definition and example, such as 'fluid.' The result is that the authors are able to choose four precise criteria on which to base their analysis. This approach provides structure in qualitative work and facilitates the use of appropriate analytical perspectives, 'interactional resources' (Goodwin & Goodwin, 1996) and 'informational resources' (Heath & Luff, 2000) in this case.

The authors are not committed to certain methods or an epistemological stance, but carefully argue their choice of methods depending on the research scenario and goals of the research. I do the same for the methods developed in this dissertation. Many of the ideas that contribute to the development of these methods are from examples in the social sciences. I introduce them in the following section.

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Figure 2: Unfocused Interaction on a busy street in Dublin

SOCIAL SCIENCE METHODS

The Study of Non-verbal Behaviour

There is a large body of research in the social sciences that focuses on non-verbal behaviour. (Weitz, 1974), in providing an overview of this research, makes a helpful distinction between structural and clinical approaches to the study of the body. Researchers in the structural category "see each movement as part of a greater whole but do not seek to attach any externally based meaning" (ibid. p. 88). Researchers in the clinical category "anchor the body movement in some external reference system, usually a psychological one" (ibid. p. 88). One of the differences between these two poles is the unit of analysis. In the former, it is an interaction, in comparison to the latter, in which it is the person. *I have chosen to draw upon the research of those who do structural analysis, particularly interaction analysis, because it facilitates looking at how technology fits into the interactional system.*

Interaction Analysis

One of the foundational concepts of interaction analysis is Goffman's frame analysis (Goffman, 1974). He argues that whenever two or more people are co-present, that is, within the perceptual field of one another, they enter into a behavioural relationship. Whether people are sitting at opposite ends of a fishing pier, or walking on a crowded shopping street, they make up a behaviour system. This can be seen by how they indicate non-interaction, as in Figure 2, by assuring that their orientation and gaze do not align with others' (Kendon, 2009). These are called unfocused

interactions. Even though there is no exchange between people, their behaviour is affected by those within their frame.

Focused interactions, in contrast, are ones in which people share a common focus, such as a conversation Figure 3a, or an activity Figure 3b. People tune their frames of attention to indicate this focused interaction through the way in which they use their bodies and non-verbal behaviour. This attention atunement is adjusted throughout the interaction in order to maintain it, creating a system of behaviour. For example, if one person shifts their posture, the others will adjust in order to maintain the focus of the encounter. The shifts made will depend upon the surroundings, including the number of people and the furniture. The latter, furniture, can facilitate or hinder adjustments that enable people to create a focused interaction. It is these systems of interaction that I will describe in this dissertation with an emphasis on how the technology, like furniture, facilitates or hinders adjustments of people to tune a frame of interaction.

Figure 3: Focused interactions: a) conversation, b) activity

The majority of interaction analysts looked at seated groups, recording utterances (conversation), upper-body orientation, posture and gesture, e.g. (Atkinson & Heritage, 1984). Some also looked at entrainment, the synchrony of movement, e.g. (Macrae, Duffy, Miles, & Lawrence, 2008) and the role of information sources in interaction, e.g. (Goodwin & Goodwin, 1996). In each of these cases, the result is to demonstrate the subtle, but systematic, ways in which people organize their interactions through responding both physically and verbally at precise points during the interaction. Kendon was the principal one of the interaction analysis group to look at body-movement in standing interactions. It is his work that I will draw on primarily.

Kendon

(Kendon, 1990) in his theory of F-formation systems, details the spatial organization of social encounters. The name derives from the use of the word formation to describe spatial relationships in the military and from their focused (as opposed to unfocused) nature. “An F-formation arises whenever two or more people sustain a spatial and orientational relationship in which the space between them is one to which they have equal, direct and exclusive access” (p. 209). An F-formation is an important means of maintaining both the identity and focus of an interaction in a public space. In the following paragraphs I will describe its parts, possible arrangements, and its maintenance.

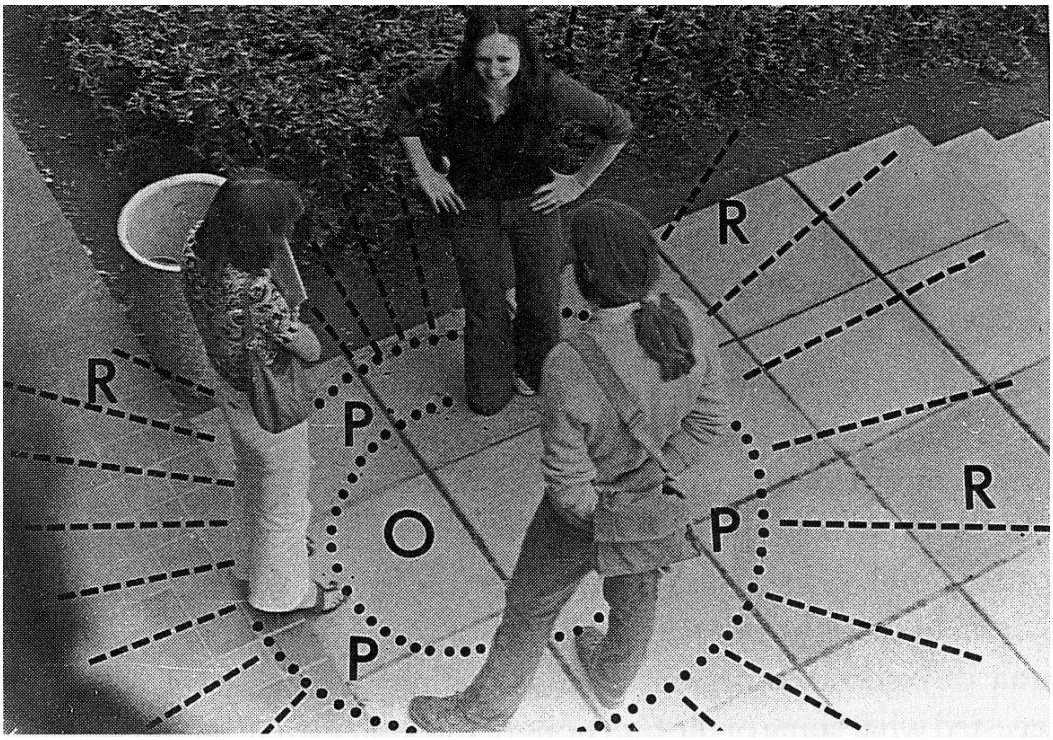


Figure 4: Diagram of the spaces of an F-formation System, reproduced with permission from (Kendon, 1990, p. 235).

Each individual has a *transactional segment* which is the space that one needs to carry out a particular activity. For example, a man watching TV needs the space between himself and the TV in order to watch TV and will react if somebody stands in that space. That man will indicate to others the space that his transactional segment occupies through his posture. As Kendon says, "the location and the orientation of the transactional segment is limited by how the individual places his body, how he orients it and spreads his limbs" (p. 211). When people form a group, their transaction segments overlap to form an o-space in which they can jointly interact. If they cooperatively maintain this o-space, they establish systematic behaviours which is what Kendon calls the F-formation system as in Figure 4. Despite often frequent changes in stance, orientation and position in space, the group maintains a working consensus of the interaction space.

There are many possible arrangements: circular, semi-circular, side-by-side, and L-shaped to name a few. The shape taken will depend on the surroundings, such as number of other people and furniture. The spatial arrangement is defined by the lower body, as the upper-body can re-orient without the person leaving the F-formation. However, people are unlikely to turn their heads (and upper-bodies) more than 30 degrees outside their transactional segment for long periods of time without reorienting their lower-bodies as well. Distance and angle of orientation are also spatial dimensions that are likely to be adjusting to tune an interaction frame. In this dissertation, I will examine how people adjust and maintain systems of interaction that include technology, using the F-formation premise as a starting point.

Creative Methods

(Gauntlett, 2007) proposes that creativity has an important role to play in collecting data. Giving examples of students making their own videos and adults using Lego to express themselves, he suggests that creative activities give people time to think about, reflect upon and formulate their responses to researchers' questions, a difficult job if the topic is abstract or not usually formulated in words, such as expression of identity or the use of non-verbal behaviour. He also notes that time given for reflection allows ideas to ferment underground, or in the unconscious, and slowly percolate upwards. This process, he argues, is facilitated by using the hands, or the body, as the sensory-motor system stimulates the thinking process in an unusual way.

Gauntlett provides a rationale for utilizing physical methods for exploring concepts that are difficult to articulate. (Eiser, 2008), a proponent of arts-based methods, further develops these arguments. She suggests that there is more than one way of knowing. Focusing on empathetic or intuitive knowing, as opposed to verbalized knowledge, she argues that such knowledge is expressed differently and therefore must be accessed, or collected, in non-standard ways. Non-verbal behaviour is one such type of knowing that is rarely articulated in words. Creative methods, drawing on dance for example, can be used to elicit such data (Blumefeld, 2008) or present results (Pelias, 2008). I draw upon dance and choreographic techniques as a way to access data about bodies-in-space.

It is important, I believe, to distinguish between the collection and presentation of data. As it is not appropriate to express my results physicality, I use visual methods (Banks, 2001) alongside verbal descriptions to help capture bodies-in-space. (Prosser & Loxley, 2008) argue that:

> Simply put visual methods can: provide an alternative to the hegemony of a word-and-number based academy; slow down observation and encourage deeper and more effective reflection on all things visual and visualisable; and with it enhance our understanding of sensory embodiment and communication, and hence reflect more fully the diversity of human experiences (p. 4).

The qualities listed above, specifically understanding sensory embodiment and communication, are important to communicating the role of bodies-in-space and the rationale for using visual methods, including: annotated pictures, notation and visual case study, in this dissertation.

Another important benefit of creative methods is their ability to engage participants. (Prosser & Loxley, 2008) note that "some creative methods have a close affinity with photo and graphic elicitation but extend the participatory principle by emphasising respondents' ownership and agency through the act of creation" (p. 33). Engagement is an important part of doing real-world research that has an impact, but is an epistemological stance that not all social scientists share. The following section will discuss the range of methods that exist in social sciences and epistemological commitments that each has, teasing out the ones that are central to this dissertation while emphasising the flexibility of my research stance.

A Discussion of Method

Conception of Culture

Ethnography is the process of describing a community through the collection and analysis of material products, social relationships, beliefs and values (Angrosino, 2007, p. xv). How this is done,

i.e. the research questions and methods, is strongly influenced by the conception of culture. (Angrosino, 2007) lists eight socio-cultural theoretical perspectives commonly taken. On one end of the spectrum is structural-functionalism which likens societies to biological organisms, whose structure can be empirically studied through close observation. Ethnographers of this school study social institutions to uncover underlying patterns and general order and believe that any properly trained researcher can achieve the same result. There is a sense of universality which leads to the idea that social institutions with equivalent structures are found throughout the world.

On the other end of the spectrum is the post-modernist stance. From this perspective, ethnography is not seen as uncovering 'the' structure, but examining the many views held about a topic in a society, including that of the ethnographer. In this context, ethnography is not meant to produce an objective and replicable document, but more often a literary text employing metaphor and other devices to help bring a sense of the culture, or political issue, to the reader or audience. This research stance assumes that every situation is different and that the goal of the research is change. These two extremes differ in how they conceive the end result of the research, diverging in whether the result is a description of a universal, or a particular, phenomena, and whether its presentation is meant for general knowledge, or for change to a specific circumstance.

The approach in this dissertation lies in between these two extremes. Like the structural-functionalists, I take the position that there are systems of interaction that can be studied, as pointed out and detailed by (Kendon, 1990). These systems have regularities that can be deduced, as well as disturbed, something technology usually does. Yet, this perspective is only the starting point, as each situation has its own peculiarities as the post-modernists argue. To account for the individual nature of a situation, I also look at tools that users can deploy for themselves.

Data Analysis

Data analysis is inevitably influenced by how the researcher perceives the situation that she is studying. There is, unsurprisingly, a spectrum of analysis techniques that correspond with the above spectrum of conceptions of culture. For example, those who consider their phenomenon of study to be a system are likely to adhere to empirical orthodoxy when they approach their data. In this way, collecting and analysing visual data is done "by paying close attention to procedural reactivity and transparency" (Prosser & Loxley, 2008, p. 10). The result is careful documentation of method and an explication of the data without reference to a broader picture from which the data is collected, as exemplified by the video analysis techniques of (Jordan & Henderson, 1995) and workplace studies (Heath & Luff, 2000).

The opposite end of the spectrum "is marked by fervent phenomenological introspection underpinned by ontological idealism and epistemological relativism" (Prosser & Loxley, 2008, p. 10). This type of research offers a single interpretation of the data in a broad context which is probably best for situations of action research in which change is the main goal. This technique is less common in HCI, but was used by (Dourish & Bell, In print) in *"Resistance is Futile": Reading Science Fiction Alongside Ubiquitous Computing*, in which discussions of TV series are used to give an account of interface/device innovation in computer science. As with the conception of cultures, these two approaches are the extremes, serving a very specific end goal– either a claim of 'scientificness' or an argument for change.

Methods can be easily mixed to collect and analyse data appropriate to the research problem at hand. (Prosser & Loxley, 2008), like (Brannen, 2005), warns against polarity of epistemological commitments, the former saying: “There are no sound reasons not to combine positivist empirical visual methods with interpretive visual methods when the circumstances warrant a mixed-methods approach” (p. 16). The approach in this dissertation is to use the type of data analysis best suited to the research problem in question, mixing as appropriate. In the first chapter, for example, I combine video analysis with ‘thick description’ in order to describe systematic behaviour of bodies in a way that is palpable to a clinical audience.

User Engagement

A significant difference with social science research as it was traditionally done and how it is often practiced today, is how the researcher engages with the participants (or in this case users). Ethnography has traditionally been based on the words that the researcher records of her own observations of notable events or moments while in the field. More recently, people have begun to draw directly on the words of participants themselves. One example is ethnography from a feminist perspective which often relies on life histories as the medium for dialogue between researcher and respondent. “This shift towards more collaborative and participative modes of research...have seen a growing interest across social science disciplines to undertake research which is more equitable in relation to the distribution of power and knowledge between researchers and participants” (Prosser & Loxley, 2008, p. 18).

There are a large variety of visual methods that engage users in different ways. An ethnographer could use pictures that she has taken to question people in the community about what is happening; by doing so, she can capture some of the subtleties of how people in that community think. Or, respondents might be asked to photograph or draw their response to an ethnographer’s question. As a theme of the research in this dissertation is to actively engage with the clinicians with whom I work, the methods presented balance between my view as an outsider and engaging their inside view. Such an approach is helpful to gather data as well as increase the success of any changes implemented as a result of the research.

Summary

HCI has frequently emphasised certain qualitative methodologies over others, as demonstrated by (Crabtree, Rodden, Tolmie, & Button, 2009). I argue that the above descriptions of spectrums of research choices demonstrate that there are many valid methods. Choice of method is best evaluated then, in terms of the desired outcome. If the goal is change, a different method is needed than if the goal is to characterise a universal phenomenon. I would further stress that it is not necessary, or even helpful, to stick to a single method and its epistemological commitments, but to choose based on the goals of the research. Indeed, it is becoming increasingly common to use mixed methods to research socially complex, real-world problems. Each chapter of this dissertation therefore explains and justifies the background material and methods used for each research problem, rather than the dissertation adhering to a single epistemological stance.

A final piece of background, presented in the next section, is that related to electronic patient records and why they are a good practical focus.

ELECTRONIC PATIENT RECORDS

In 1998 the British government decided to modernize the national health service (NHS) through technology. In 2002, it tendered one of the largest and most ambitious software development projects in history, dubbed NPfIT (National Program for Information Technology). One of the central aims of this project was to make EPR ubiquitous. The project proposal suggested both clinical and administrative benefits, including reduced prescription errors, improved quality of audit, and a data bank for nationwide research. The process of implementing the NPfIT agenda, however, has been fraught with technical and organizational difficulties, with many medical practitioners rejecting the new plans. Despite these problems, a recent review by the House of Commons health committee emphasized that experts in the UK and abroad continue to stress the benefits of EPRs if developed well (House-of-Commons-Health-Committee, 2007).

There is a large amount of EPR research in the health informatics literature. The majority of it looks at the value of EPRs through costing, patient outcomes, and efficiency. A review of this literature suggests that results are ambivalent (Clamp & Keen, 2005). There are also a small number of articles in medical journals. Articles written for this audience usually employ quantitative measures. (Hassey & Gerrett, 2001), for example, ascertain the validity of EPRs used in general practice by measuring their completeness, accuracy, validity and utility. In contrast, (Laerum, Ellingsen, & Faxvaag, 2001) compare three different EPR systems by investigating quantified usage for specific tasks. There is also one example of a qualitative study which looks at organizational factors in the failed implementation of an EPR in the United States (Scott, Rundall, Vogt, & Hsu, 2005). The focus of these articles is not on the interaction of people with the machine.

There is a growing literature in HCI, particularly in CSCW, on EPRs however. Some of this literature focuses on the design of the EPR. This includes research that looks at the design process, e.g. (Bossen, 2006), which describes the difficulties in building a complex system, and organisational influences that affect that process (Martin, Rouncefield, O'Neill, Hartswood, & Randall, 2005). (Cabitza, Sarini, Simone, & Telaro, 2005) is an example of research that investigates the paper artefacts to inform the design of a digital system. In complement, (Reddy, Dourish, & Pratt, 2001) are illustrative of research that considers EPR design by studying and reflecting upon systems in use. Some researchers also build new systems and evaluate those, such as (Tang & Carpendale, 2009). This research, for the most part, is oriented towards the better development of EPRs and will be discussed in more depth in the third chapter.

There is also literature that focuses more strongly on deployment issues. Examples included: (Bjorn & Balka, 2007) who examines reasons for resistance to an electronic triage system, noting that it does not derive from resistance to change but a way of disputing the assumptions about professional practice that are embodied in the system; (Ellingsen & Monteiro, 2006) look at socio-technical issues that arise when trying to deploy systems across several organisations; (Pinelle & Gutwin, 2006) take a proactive approach drawing on known problems in loosely coupled systems and groupware to provide a framework for the deployment of groupware systems in loosely coupled healthcare organisations. These are just a few of the papers that provide a conceptual background to the discussions about EPRs and their use and will be used to reflect more deeply on the results of this dissertation in the final chapter.

DISCUSSION

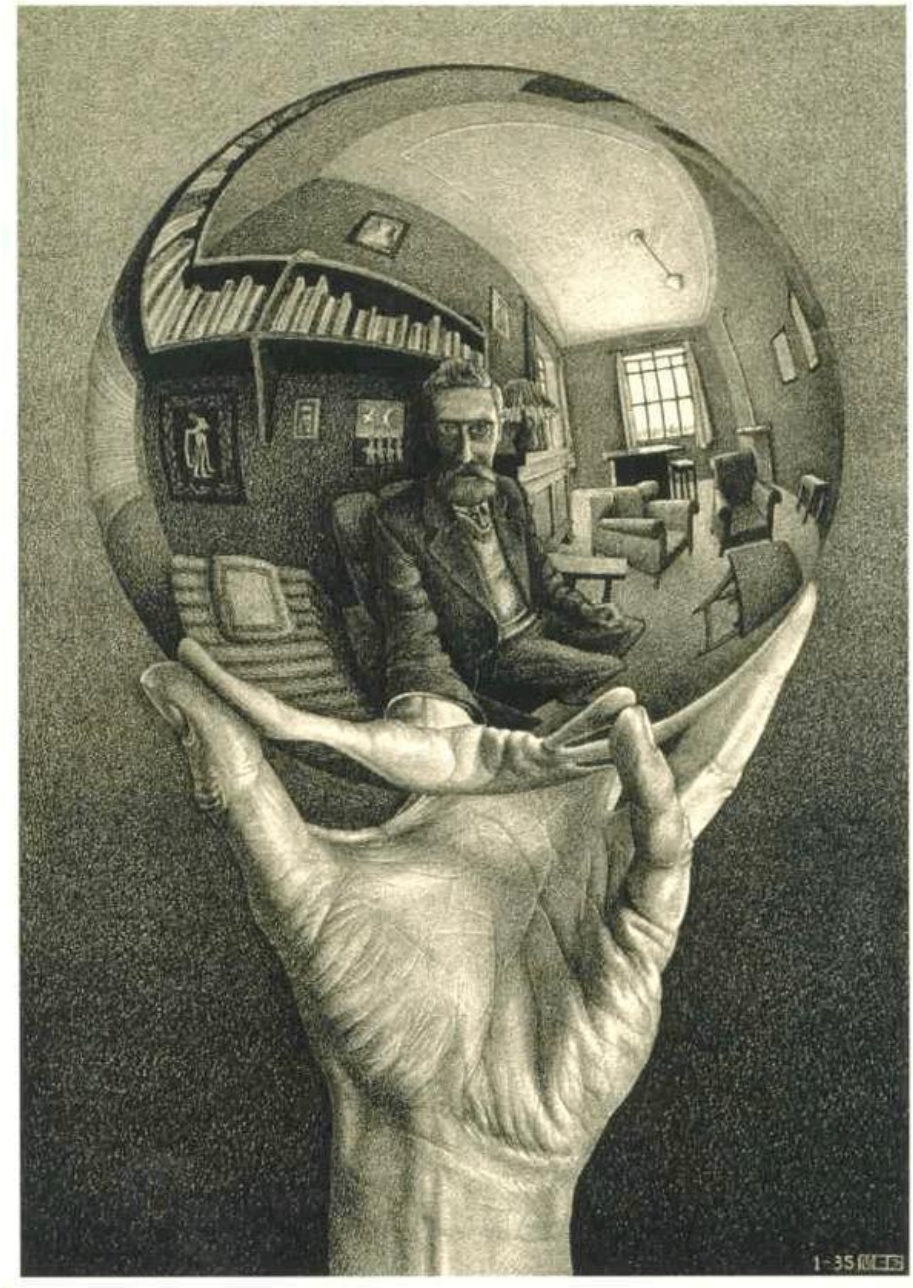
The beginning of this chapter starts with Dourish's articulation of embodiment and suggests that the foundation that he lay to investigate interactivity in software applications can also be applied to other areas of technology design. This dissertation focuses specifically on how the physical nature of the body affects social interaction and hence the design of technology for co-present groups. To provide inspiration, both positive and negative, I examine a corpus of related CSCW literature, pointing out that the body often goes unanalysed and authors utilize an information centric view, a virtual box view, or common, non-critical assumptions about the body, instead. Having an understanding of what might be useful in this area, I review existing methods, pulling out their strengths and articulating the scope for further methods.

I then looked at three pieces of research that provide the starting points for the methods developed in this dissertation. I present workplace studies and its research ethos that emphasises in-situ research, video analysis and a close scrutization of how people accomplish interaction. I adopt a similar stance for observational research, but argue that its linear, textual approach to visual analysis is not appropriate for bodies-in-space. I then provide an example of an analysis of technology supporting social interact that successfully highlights the role of bodies-in-space using the theoretical work of (Kendon, 1990) and suggest it as a more suitable way of thinking about bodies for the aims of this dissertation. The last piece demonstrates that through clarity of purpose, methods can be mixed to suit the research goal.

The last two sections of this chapter provide helpful background for the rest of this dissertation. The first focuses on social science methods, presenting some of the basic principles of interaction analysis and the F-formation system theory. I also introduce creative and visual methods and the rationale for their use in studying non-verbal interaction. I complete this section with a discussion of the epistemological stances that exist in social sciences and the range of methods that has resulted. I pinpoint the stances that I take and emphasise that it is reasonable to mix them depending on the research goal. I finish with a short introduction to the variety of literatures of EPRs, which are introduced more thoroughly as required in the later chapters and the conclusions.

I do not present an over-arching philosophy of the body or a singular dominant methodology in this chapter. A great number of philosophers have argued about how the connection between the mind and body should be perceived. Three such examples are phenomenologist Merleau-Ponty (Merleau-Pont, 1945 (1962)), dance philosopher Sheets-Johnstone (Sheets-Johnstone, 1999) and theory of mind theorist Mark Johnson (Johnson, 1987). Likewise, discussions of how the scientific method, and its property of verifying universal knowledge in the natural sciences, should be applied to the social sciences are also becoming increasingly common, e.g. (Slingerland, 2008). Although I am aware of this literature, I prefer to focus on the research problems that arise in the hospitals, which requires a practical, rather than theoretical, stance towards the body and a flexible, although not inconsistent, approach to method selection.

3:Seeing Bodies-in-Space



Hand with Reflecting Sphere
M.C. Escher, 1935

RESEARCH INSPIRATION

In summer 2006, the intensive care unit of a nearby hospital invited a multi-disciplinary research team from the Crucible network (Good & Blackwell), including the author of this dissertation, to monitor its switch from a paper to an electronic patient record. The switch was intended to improve record keeping matters such as prescription legibility, as well as encourage adherence to guidelines, and provide research and development opportunities. There was concern however, that work practices might be disturbed. The research team was asked to observe and record work practices pre and post change and report to the implementation steering group (ISG) on a regular basis to help ensure a smooth migration from one type of record to the other. The team was strictly in an observational role and all changes to practices or technology were at the discretion of the ISG.

The ISG was particularly focused on how the new system might impact job satisfaction and communication between various medical practitioners. In response, the research team proposed a three-layered study to address these questions during the change-over period. The first study, a survey, was to examine macro changes in job satisfaction. The second study, interviews with staff members in different roles, aimed to note particular problems and provide direct usable feedback to the ISG. The third study looked at changes on a micro-level, comparing ward round interaction with both records. The methods and results of the third study alone are presented in this chapter, but not without acknowledging that it was part of, and certainly influenced by, the larger study.

INTRODUCTION

The study presented in this chapter, as indicated in the research inspiration section, derived from a practical problem and indeed has a practical result, answering the question: *'How does interaction during the ward round change when electronic, as opposed to paper, patient records are used?'* Looking at bodies-in-space, I focus specifically on non-verbal behaviours. I begin however, by describing the intensive care unit (ICU), in order to highlight the issues that shaped the research focus and method. I then describe how I adapt video analysis techniques to study bodies-in-space using Kendon's theory of F-formation systems. Using this method, I present an analysis of ward round interaction with paper, followed by electronic, patient records. I conclude with reflective comments on the study of bodies-in-space.

Background

The Unit

This study took place in the ICU of a cardio-thoracic specialist hospital transitioning from a paper to an electronic patient record. The majority of the patients in this unit have had major, invasive surgery, such as heart transplants or bypass surgery. The nature of the recovery process means that patients are unconscious on their arrival at the ICU and perhaps for some days after. Treatment of patients therefore does not rely on doctor-patient interaction, but rather happens through analysis of such data as heart rate, blood results and urine output coming from the many machines to which the patient is attached. The individual work of the doctors and medical staff is for the most part information centric, with perhaps the exception of the bed nurses who monitor the comfort of the patients.

The ICU is a relatively large unit consisting of twenty-five beds and approximately two hundred staff who care for the patients. They include: doctors, registrar (junior) and consultant (senior), and a medical staff of three levels of nurses (head sister, bay nurse & bed nurse), a dietician, a pharmacist, a microbiologist, and a group of physiotherapists. At any given time as many as ten different people might be involved in a patient's care and due to the rota, they change configuration regularly. To maintain continuity of care, a lot of emphasis is placed on communication between practitioners, the primary vehicles being the patient record and conversation during the daily ward round.

The Ward Round

The morning ward round brings together all of the relevant medical personnel to discuss each patient's progress and decide upon future care. The group, consisting of representatives from each discipline with a total of eight to ten people, travels from bedside to bedside to discuss the daily patient care plan, spending between five and fifteen minutes at each bed. The team arranges itself around the nurse's table containing the patient's paper record or after the deployment of the EPR, around the computer trolley. The round begins with one of the registrars presenting the most relevant information about the patient. The consultant then works methodically through a general set of issues leading the discussion.

That the ward round interaction happens smoothly and efficiently is particularly important to the collaborative medical process. It is essential that all relevant information is shared to achieve a proper diagnosis and inform every one of their daily tasks. However, the discussion of any one patient should not be any longer than necessary to allow all of the expected activities to be

completed in a shift. This challenging balance requires a significant amount of negotiation of the interaction – that is, who speaks and what is spoken about. This can be problematic in the hierarchical environment of a hospital.

Despite the emphasis on, and opportunity for, communication, traditional medical hierarchy can confound doctor-nurse communication (Manias & Street, 2001). Although nurses do not have the same degree of formal training as doctors, they often have considerable, possibly superior, practical experience. They also spend the most time with the patient. They are the most likely to notice problems in treatment or inconsistencies in doctors' orders. Realizing this, the head of the ICU, not surprisingly, has attempted to flatten the normal hierarchy in order to increase nurse participation in the ward round. Despite his best efforts, many of the nursing staff still feel intimidated by most of the doctors. Nurse-doctor communication then remains a delicate issue in the ward round.

Research Focus

As encapsulated in the description of the unit above, and expressed by (Atkinson, 1997) & (Luke, 2003), successful ward round communication is essential to good patient care. On the one hand, it provides the necessary information exchange as well as the range of expertise needed to interpret that information, i.e. treatment options from the doctor and the nurses' experience of the patient's comfort. Yet, as also mentioned, the ward round is a careful negotiation, and appropriate doctor-nurse communication can be difficult to achieve. It would be unsurprising if a new information artefact disturbed this delicate balance, particularly when presented on a physical technology setup designed for a single user, a 19" display and single mouse. The aim of the research presented in this chapter then is to answer the question:

'How does the physical technology setup of the two records, paper and electronic, affect the negotiation of interaction during the ward round?'

RELATED RESEARCH

Electronic Patient Records

In the research field of HCI there are a growing number of studies investigating technology usage in hospitals. Much of this related research focuses on the difficulties of designing EPRs. (Bossen, 2006), for example, illustrates the differences in what doctors report that they do and what they actually do in practice to demonstrate why an EPR, based on the formalized process that the doctors' reported, failed in practice. (Martin, Rouncefield, O'Neill, Hartswood, & Randall, 2005) and (Martin, Procter, Mariani, & Rouncefield, 2007) look at organizational factors, including timing and contract, in negotiating the design of an EPR to be used by diverse groups of practitioners, a common phenomenon in national healthcare systems.

Some papers focus specifically on the design of the information structure, drawing upon observations of practitioners using paper patient records. (Cabitza, Sarini, Simone, & Telaro, 2005) describe the parts of the paper patient record and the positive and negative redundancy that occurs from moving information between them. In a similar vein, (Tang & Carpendale, 2007) look at information flow during nurse hand-over. (Munkvold, Ellingsen, & Monteiro, 2007) investigate not the medium of the patient record, paper or electronic, but the idea of planning that the record embodies and how that can be incompatible with current work practices. In a related area, (Wilson,

Galliers, & Fone, 2006) examine the impact of large displays on communication during shift handover in a medical setting.

There is also work evaluating EPRs. (Munkvold, Ellingsen, & Koksvik, 2006) confirm the argument put forward by (Cabitza, Sarini, Simone, & Telaro, 2005), showing that redundancy removed in the design of an EPR is re-introduced by using supplementary paper**.** (Reddy, Dourish, & Pratt, 2001) examine how an EPR, as a common information space, is incorporated into diverse work practices. In contrast to the above articles, which focus specifically on the design of the interface and underlying information structure, there are several articles that explore the choice of device on which to deploy an EPR. (Skov & Hoegh, 2006) look at the value of context-aware mobile computing, but deem it inappropriate given that nurses often move while working. (Tang & Carpendale, 2008) discuss when and how nurses used an electronic patient record mounted on a cart.

As (Gurses & Xiao, 2006) pointed out, EPRs are generally designed for the single user, and I would add, a user who is seated at a desktop with the EPR as the sole focus of his or her attention. However, the mobile environment of a hospital and the collaborative nature of medicine mean that this is often not the case. Consequently, it is important to attend to the design of the device on which the EPR is used in addition to the information structure and interface design. (Tang & Carpendale, 2008), for example, discuss the avoidance of the COW, a mobile cart from which the EPR could be accessed, because the physical design made it difficult to manoeuvre within the hospital unit. This chapter, pursuing this direction, looks at how the physical setup of the EPR affects collaborative group interaction during multi-disciplinary ward rounds.

Group Interaction

Workplace Studies

The workplace studies community has done a large number of studies that look at the effect of technology on co-located group interaction, e.g. (Heath & Luff, 2000). The focus in this research area is to understand how technology features in the production and coordination of workplace activities. A relevant example is (Heath , 1986), which presents a close analysis of doctor-patient interactions in primary care situations, based on both paper and electronic records. Heath draws the reader's attention to the role of the paper, and how its tangible nature supports turn-taking. I therefore suspected, and observation confirmed, that the physical setup of the two patient records, one tangible and the other not, would play an important role in the interaction. However, unlike the groups portrayed in Heath's work, the ward round team is standing around a table or computer screen and thus is semi-mobile. This allows them to use their whole bodies, not just paper, gaze, and speech, to negotiate the interaction.

(Hindmarsh & Pilnick, 2007) have published an analysis of interaction between a standing medical (surgical) team. They describe a number of non-verbal behaviours, including the orientation of instruments or various postures, as indicators used by team members to coordinate their work efficiently. Although Hindmarsh & Pilnick examine the role of non-verbal behaviour more completely, they do so as it supports conversation. Their analysis is therefore linear and the implications are for a particular situation. In contrast, starting with bodies-in-space, I describe more generally how non-verbal behaviours relate people and information. I build upon the work of (Kendon, 1990), for reasons put forward in chapter two, to provide the scaffolding for observing and

interpreting non-verbal behaviours and understanding how they affect entry into, and advancement of, group interaction.

'Thick Description'

Although I utilize the theory of F-formation systems to observe how technology influences non-verbal behaviours in an interaction system, I present my analysis through 'thick description,' an anthropological technique used to highlight a phenomenon by generalising over several incidents. Introduced to anthropology by (Geertz, 1973), 'thick description' is the difference between noting a behaviour and reporting its cultural meaning by providing context – the difference between a twitch and a wink. Although they are mechanically the same, "the winker is communicating, and indeed communicating in a quite precise and special way" (p. 4) 'Thick description' provides the context to interpret the wink and not just report the twitch.

METHOD

Theoretical Framings

Non-verbal Behaviours

Kendon (1990), as presented in chapter two provides a means to study the negotiation of interaction of semi-mobile (standing) groups by observing their formations. His theory of the F-formation system describes how groups form, adjust their formation, and disband, when interacting. His examples demonstrate that adjustments, such as a step forward or a turn of the body, are part of the negotiation process for who can speak and how the topic is progressed, a primary concern in understanding multi-disciplinary interaction.

He proposes that these formations are made up by individuals overlapping their personal 'transactional' spaces, that is, the space that a person maintains in order to carry out an activity. The size and shape of this space is determined by the task and the associated needs of looking, speaking, or accessing objects and is indicated by the person's orientation and spread of limbs (posture). When individuals overlap to make an F-formation, whether it be a line, circle, or other grouping, they adapt the size and shape of their personal 'transactional' space. The beginning formation then, reflects the group's negotiation of each member's perceived interactional needs for participating in, and monitoring, the conversation.

If the formation is a horseshoe, for example, members can most easily see the person at the bend of the horseshoe and least easily the person on the end, changing the comparative influence of these two people. If the formation is a circle, everyone can equally see everyone else. Kendon notes empirical evidence of the effect of a person's position within the formation on his/her ability to participate. *Formation, then, can be observed to understand relationships--of person to group and between people in a group*.

Within a formation, individuals have some ability to adapt the size and shape of their personal 'transactional' spaces. This can be done with upper-body orientation, for example, to include another person more directly in their personal space and form a sub-group or discussion. Posture can be used in a similar way, to invite or close off interaction with a person or information. *Upper-*

body orientation and posture, can be observed to understand the connections between people or to information.

Kendon's analysis specifically describes social groups, without reference to information artefacts. (Heath, 1986), however, demonstrates the importance of gesture, most frequently pointing and the manipulation of objects, such as paper, during interaction. *Gesture and object manipulation can be observed to note when a person invites the attention of another to an information artefact.*

The previous paragraphs name five types of non-verbal behaviour useful to identify: group formation, upper-body orientation, posture, gesture, and object manipulation. The italicised sentences indicated what inferences can be expected from their observation, naming various relationships between people and to information.

Observing Non-verbal Behaviours

F-formations are not static, but adapt throughout an interaction. To change speaker for example, one person might step slightly forward, perhaps breaking the formation, to indicate a desire to speak; the others rearrange themselves to create an appropriate formation. To gesture to something might require someone to change upper-body orientation, and, consequently, place in the formation. That said, the original formation might constrain an individual's opportunities to make such changes. There are then relationships between the non-verbal behaviours. In the spirit of Kendon's suggestion that the shape of a given formation depends on, as well as reflects, the relationship of its members to each other and to non-members, I explore what inferences can be made from the interdependencies of non-verbal behaviour.

Looking at the interdependencies of the non-verbal behaviours assists in portraying the trade-offs that group members employ during the negotiation of interaction. These interdependencies can be depicted using a circular, bi-directional chain as shown in Figure 5. The chain can be read in either direction: clockwise – the formation determines body-orientation and posture, and thus available gestures and object manipulations with consequent access to information and the conversation; or counter-clockwise – the formation grows out of the group members' negotiations of their gestural and object manipulating needs. The direction chosen in analysis depends upon whether the intent is descriptive or evaluative.

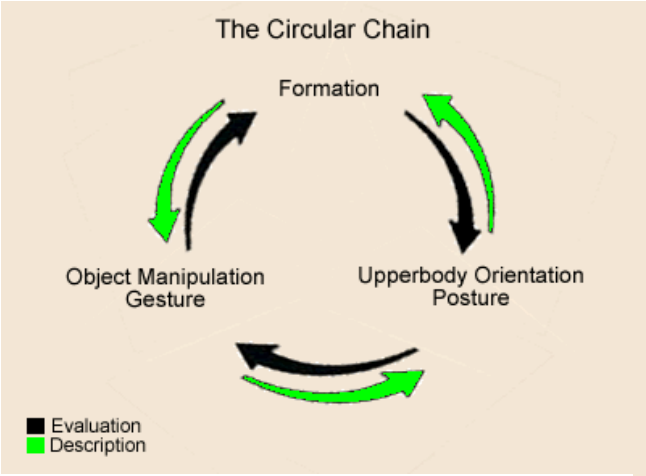


Figure 5: The Circular Chain

Descriptive analysis, applied to groups using an established physical setup of an information system, utilizes the counter-clockwise chain. This type of analysis details how the group has negotiated its formation such that each member has the gesture and object manipulations they feel that they need given the possible choices and trade-offs in the circumstances. Negotiations might include adjusting the formation, adapting the information resources, or resolving conflicts through social processes (e.g. having a rule that the pharmacist has priority access to the drug chart). All three of these are interesting starting points for descriptive analysis of an interaction. The clockwise chain, in contrast, can be used to evaluate new physical setups or information system. In this case the aim is to determine whether the formation restricts the use of other non-verbal behaviours and hence limits the interaction possibilities.

Data Gathering

This investigation took place over a period of 13 months in the ICU of a specialized cardiac and lung hospital. During this period, the ICU made a transition from a paper patient record system to an electronic one. In order to do detailed analysis of the interaction, I based my findings on video with the support of field notes. Video recordings were obtained at three points throughout the study period: (1) 1 month prior to deployment of the EPR; (2) 4 months after deployment; and, (3) 1 year after deployment. Each time, six separate, randomly-selected patient discussions were filmed for a total of 3 hours of video. To enable comparison, those patient discussions selected for analysis were always managed by the same consultant. Note that only the data from the first two points is presented in this chapter and data from the third point, at the beginning of chapter 5.

Video footage was complemented by observation during the above three periods both at the time of filming and on another day. This was done to ensure that the video lens did not limit the analysis. Further observation of the target consultant took place the week after deployment, and of other consultants throughout the duration of the study. Further background for the video analysis was gained by participating in seven interviews of practitioners spanning different disciplines at each of three time points mentioned above that were carried out by another researcher on the project. I also made an effort to informally speak with practitioners, during lunch or while waiting for the ward round attendees who entered isolation rooms to emerge.

Extensive field notes were written up after each day spent in the unit. These notes included verbatim quotes that I jotted down while on the ward, summaries of interactions seen, a running characterisation of the ward and a list of issues to explore in the next observation session. These notes provided useful examples when discussing data with colleagues or practitioners, but their main aim was as a personal tool. I used them to consolidate my understanding of the social system that I was observing and as a way to note what factors caused change in the system. Over time my field notes helped focus my attention on key issues to enable greater discrimination during observation, looking for interactions that discredited or further nuanced my understanding of the system.

Data Analysis

The data analysis took two forms: video analysis (Jordan & Henderson, 1995) and field notes. The latter were kept throughout the 13 month period and shaped the perspective from which I did the video analysis. They provided a framework for interpreting interactions, as well as sensitised me to salient issues that arose in the video. The video analysis was a more concrete process through which

I gradually articulated the interdependencies of non-verbal behaviours and unravelled what they revealed about the interaction. The resulting analysis was recorded as part of my field notes. I elaborate on these processes more specifically in the following sub-sections.

Video Analysis Process

Each video was watched twenty to thirty times, with a gradually narrowing of focus -- from tracing the formation, to drilling down, to finally, noting interdependencies. These steps are described below.

Step 1: Tracing the Formation

Tracing the formation gave a reference frame for all of the other non-verbal behaviours. I asked the following questions when watching the video: What was the initial formation? How did the initial formation come about? What changes to the formation occurred during the ward round? How did the formation disband?

Step 2: Drilling down

After I established a frame of how the formation moved, I looked at each layer of non-verbal behaviour in turn. I took note of the non-verbal behaviours seen, and looked for why they were used. Was the non-verbal behaviour a reaction to another's non-verbal behaviour? Did it have a meaning in the context of events? Did it have a meaning in the social system articulated in the field notes during the observational period? I successively looked at each discipline.

Step 3: Noting Interdependencies

Once I had a detailed understanding of one interaction, I looked at the interdependencies between the non-verbal behaviours, asking questions such as: What does formation tell me about the relationship of the people in the ward round and does that contribute to an understanding of the negotiation of interaction. These questions were drawn from F-formation system theory (Kendon, 1990) and are italicised in the previous section. In the descriptive analysis I started with formation and worked counter-clockwise in the circular chain, and in the evaluative analysis, clockwise.

This kind of analysis took place for each of the six ward rounds recorded. Notes were made in the form of hypotheses, examples, occasional drawings, and further questions. No specific coding scheme was used per se. The notes formed a similar purpose of the field notes described above to support the iterative viewing of the video. The analysis was carried out intensely, spanning three to four days for each set of video in order to support the drawing out, and connecting, of salient issues. For reference purposes, an example of field notes can be seen in Appendix C.

Analysis Process

The aim of this analysis was to find generalisations across the data about the use of non-verbal behaviour in negotiating interaction. This differs, as discussed in chapter 2, from some techniques which limit the analysis to systematic properties that can be seen on the video. The narrow focus of the latter strategy, as seen in workplace studies, results in a concentration on micro phenomenon, useful for precisely delineating work practices. The research presented in this chapter however, is at a larger granularity and combines contextual knowledge with the careful analysis of non-verbal

behaviours seen on the video. The approach in this chapter aims to ground arguments about the role of non-verbal communication in the ward round social interaction system in the video data.

Similarities across the six videos were probed and explanations sought from the context provided by the field notes. Differences were also scrutinised to see whether they came from a change to the way the interaction was negotiated or were adjustments to the surrounding. For example, the change of position of a registrar was an important indicator about status and information, while variation in configuration of the second line of the formation around the EPR was only to adjust to the environment, such as to let a patient trolley pass. I often used a white board to map out these connections, while others with less experience in watching movement, may find coding helpful. When complete, the analysis was verified with another researcher on the project and with the ISG.

The analysis is structured in two ways: (1) by sequence, and (2) by medical position. The former assists in portraying the flow of events and how they are affected by the two records, while the latter points out how the hierarchy affects those events. This main analysis depicts events that are representative of what I saw, but does not detail specific single episodes. This is complemented by uncommon incidents which help clarify the boundaries between acceptable and unacceptable interaction, posed in the form of 'what if' questions. In addition, I begin each section by describing the physical technology setup of the record as well as the starting formation.

DESCRIPTIVE ANALYSIS OF PAPER RECORD USAGE

Paper Patient Medical Record

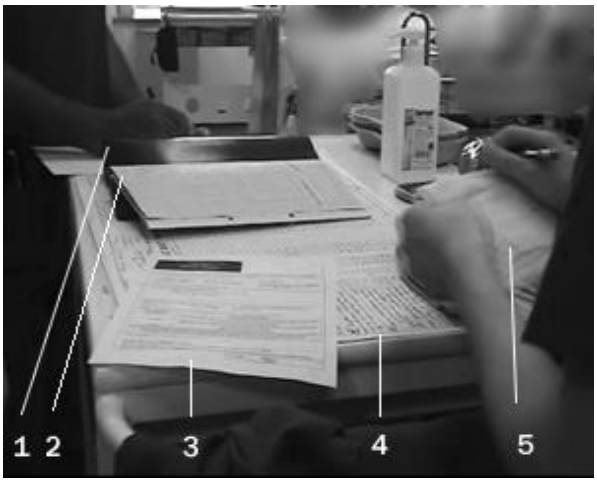


Figure 7: Paper Patient Medical Record: 1. Binder; 2. Drug Chart; 3. Patient Plan of the Day; 4. Observation Chart; 5. Personal Notes

Figure 6: The ward round with the paper patient record: 1. Head Nurse; 2. Consultant; 3. Registrar; 4. Bay Nurse; 5. Dietician; 6. Bed Nurse

The paper patient record, shown in Figure 7, consisted of three specific types of form (the observation chart, the drug chart, and the plan of the day) and a folder or binder for miscellaneous and patient-specific forms and papers. The observation chart was A3-size paper and lay flat on the nurse's table. The nurse plotted vital signs on it regularly, recorded blood test results, wrote other medical notes, and kept non-medical care information on the reverse side. A new chart was used each day and was placed on top of the old one. This chart gave a quick overview of the state of the patient and was usually the first reference for the consultant. The drug chart, a fold-out yellow card stock document, had the prescribed drugs written on it. Specific drugs were crossed out after they were no longer needed. The patient plan of the day had directions for medical procedures, such as extubation, to be carried out that day. Other papers, held in a binder, might contain previous history or be related to specific conditions, and were rarely referenced. This collection of forms and papers was the central focus of the ward round discussion for each patient.

Formation (with paper records)

The consultant, arriving at the bed first, initiates the group formation around the nurse's table that displays the paper charts by taking the position directly in front of the charts and facing the patient. The medical staff stand to either side of the consultant, forming a horseshoe. As shown in Figure 6, the registrars take a position on either side of the consultant (only 1 registrar is visible here), slightly behind with their feet angled in to maintain the curve of the formation. The head nurse and bay nurse each stand next to one of the registrars looking sideways onto the charts. The remaining medical staff, the dietician, pharmacist, and bed nurse curve around the table next to the bay nurse, the dietician often slightly behind the formation. The ward round participants begin oriented towards the paper, their bodies slightly leaning inwards.

"What if the consultant does not arrive first?"

The medical staff always wait for the consultant's arrival in order to form the group. This indicates that each person is taking a place in the formation in relation to him and their expected interaction needs. The orientation of the group towards the charts contrasts with that when participants are free standing (usually before the ward round). At this time, they orient themselves towards the bend of the horseshoe shape (often where the consultant is standing) rather than to the space in the middle (where the charts are during the ward round). It seems that this is done by cue of the consultant as will be seen later.

Ward Round Interaction (with paper records)

Consultant

The consultant's central position in the formation gives him a number of resources for leading. His prominent position makes his magnified postures and gestures visible to everyone in the group as he follows the information relevant to the conversation on the charts. His success in guiding the focus of the group was demonstrated by all of the medical staff following his gaze throughout the presentation of the patient. There were very few turns of head and when they did occur there was an immediate focus back to the charts rather than a straying of eyes which would happen if the person found it difficult to re-join the conversation. The consultant's reactions to the presentation of the patient and associated data were also available to the medical staff (but not the registrars) a phenomenon that will be discussed later.

The consultant uses gesture and object manipulation to guide the content development of the conversation. As the registrar presented the patient information, the consultant followed the relevant data by pointing to it on the chart with his finger. The registrar adapted his presentation to suit the indicated data; the most notable example was a very rapid change of focus of the registrar from the distant space in front of him to the hand of the consultant during which time the audio indicated a shift in topic. The charts provide a similar resource for the consultant to indicate a change in topic. For example, while the consultant was talking to the head nurse, he began to draw the drug chart over the vital signs and the nurse quickly brought the topic to a close and the discussion switched to drugs.

Body-orientation and posture also play an important role in the consultant's ability to regulate who speaks. His forward leaning posture during the presentation of the patient makes it difficult for anybody to catch his eye to indicate a desire to speak. Frequently, however, after the presentation is complete, he straightens up slightly (not completely) making non-verbal requests feasible. I observed several times the head nurse lean inward and tilt her head towards the consultant, causing him to re-orient both his head and upper-body to her and start a conversation.

"What if a nurse spoke without requesting the floor?"

Nurse interjection is discouraged. The bay nurse, for example, spoke without going through the process of requesting the floor. The first time this happened, the consultant turned his head towards her briefly, and then continued looking at the data, letting the registrar answer the question. The second time, he did not acknowledge her at all.

Registrars

The registrars have a seemingly contradictory set of communication possibilities. Theoretically, the registrar can present the patient and develop the topic of conversation as s/he would like. As was shown above, however, the consultant can regulate this talk. The registrar has few counter-measures since the posture of the consultant with his hands spread across the charts makes it difficult to point at data or reach for a chart without asking for it. This does happen on occasion, but not easily. Moreover, it is rare that the medical staff orient towards a registrar when s/he speaks. They tend to keep their focus on the charts or the consultant.

Interestingly, the registrars' position facing the data from the same angle as the consultant seems to give them an advantage in that they interject in ways the medical staff do not. It is not clear whether this is a matter of their position in the formation or their status. As (Lindley & Monk, 2008) noted, when people reminisce about photos (ones that they all have information about) they are less likely to need the face-to-face contact that is required when there is a 'story-teller'. It is possible that the same effect is seen here, as the registrars are more likely to have background medical knowledge comparable to the consultant and in contrast with the medical staff.

"What if the registrar changed position?"

On one occasion, I saw the positional inversion of registrar and consultant. The registrar was highly-experienced, having already completed his training. On arriving first at the bed, he took up the traditional spot of the consultant in front of the charts facing the patient. Unlike the consultant, the registrar did not lean over the charts but stood upright so that he could monitor the reactions of the consultant. The rest of the medical team oriented not towards the registrar but to the consultant, monitoring his reaction rather than focusing on the charts. This confirms that the consultant, as the

senior member of the group, sets the focus of the formation. The effect of seniority was also evident in the group's differential reaction to the two registrars. When the more experienced registrar spoke, most of the medical team oriented towards him, even adjusting the formation to be able to see him. They did not do this when the more junior registrar spoke.

Medical Staff

The medical staff developed a number of communication possibilities suitable to their information needs, their place in the hierarchy, and the ward round situation. As noted above, they requested to speak by leaning inwards and catching the eye of the consultant. An alternative strategy taken by two of the bed nurses was to slide a chart in front of the consultant and allow him to take up the topic in conversation or not. In both cases the consultant oriented towards the nurse and a discussion ensued. More frequently, the medical staff needed to speak amongst themselves. Frequently, they would take a chart from the table indicating a desire to discuss it, at which point both parties would re-orient towards the chart. Other side conversations did occur but they were short and neither party re-oriented. Even with re-orientation, the medical staff turned only partially inward, not moving out of the formation. They continued to glance back to the main conversation regularly, indicating that they were monitoring it.

"What if medical staff repositioned themselves?"

Although they rarely changed places, some medical staff did leave the ward round -- the dietician being a prime example. As noted above, her original place in the formation was slightly outside. Her focus was different from that of the others, down rather than on the charts, and her attention often strayed to other happenings in the ward. At one point she turned and walked away, several minutes later taking up her previous position. This time however, her posture was one of engagement. She focused on the interaction, leaning forward slightly. When she decided to speak, she leaned fully into the circle before starting. Her behaviour in this situation indicates the porosity of the formation. While the focus of those in the formation never left the interior, there were a number of members who would come and go and lean into the formation when they needed, or wanted, to participate. Similar behaviour was seen with bay nurses who often had other duties simultaneous with the ward round.

Staff Engagement

Figure 8: Identified postures: (1) Engaged; (2) Neutral; (3) Personal

Posture and associated gaze are significant in suggesting an openness to engagement. We identified three types of posture. These are demonstrated in Figure 8: (1) engaged; (2) neutral; and (3) personal. An individual in the engaged posture is leaning forward slightly with gaze clearly focused on the speaker. Neutral can be identified by an upright posture and a gaze that encompasses the entire group. Individuals in this posture often stand with their arms crossed. The personal posture characterizes an individual who is leaning over, writing or reading notes, but still glancing up occasionally. The consultant asked questions or

opened a discussion with those in the engaged posture, suggesting that an engaged posture signals readiness to speak.

Disbanding

The session finished with the straightening up of the consultant at which point he asked, 'Anything else?' The consultant always left the conversation first. As he turned, the formation disintegrated and smaller conversation groups formed. For example, a bed nurse might walk over to the registrar and ask for something to be signed. The bay nurse might discuss food with the dietician; the pharmacist might point out an error on the drug chart to the registrar and ask it to be corrected.

Summary

This descriptive analysis demonstrates that there are opportunities to enter or advance the interaction. The consultant has multiple means to lead the group, regulating both the focus as well as the topic of conversation. The medical staff have several ways of joining the conversation and accessing information. The registrars have controlled access to both the conversation and information resources.

EVALUATIVE ANALYSIS OF ELECTRONIC RECORD

Electronic Patient Medical Record

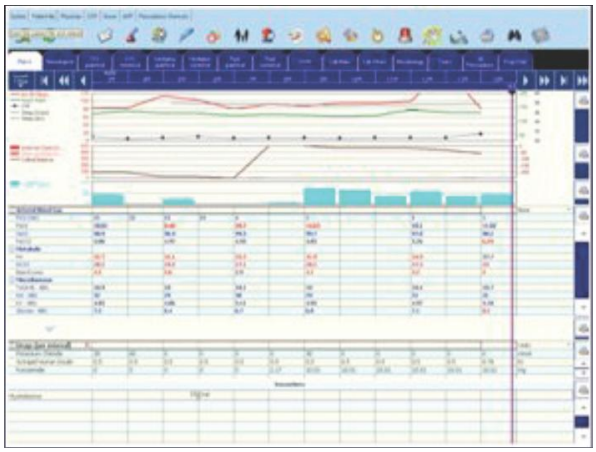


Figure 10: Electronic Patient Record summary screen screenshot

Figure 9: The ward round using the electronic patient record: 1. Bed Nurse 2. Pharmacist 3. Head Nurse 4. Consultant 5. Registrar

The EPR, MVICU, provided by (IMDsoft), had been customized by a medical team at the hospital to reflect local practice. The main screen presents trend information based on vital signs as well as the drugs and fluids given. The user can navigate the interface by clicking on tabs at the top of the display with a mouse to obtain all other information as displayed in Figure 10. To input data, such as a prescription, the user must log in. There are restrictions on who can enter what data and the user's identity is attached to all work. The computer is mounted on a semi-mobile, adjustable height cart – one per bed. The 19'' computer screen display, depicted in Figure 9, is considerably smaller than the nurse's table had been, and has a vertical rather than horizontal display.

The EPR was championed, customized and introduced by the head of the unit. Although the customization aimed to preserve local practice, the system was also expected to improve practice and enforce policy. The system improves data reliability by streaming in vital sign and test results

from various monitoring machines, thus avoiding copy and calculation errors on the part of the nurses. It calculates and displays graphical trend data, so doctors can more easily see the effects of a treatment (although some data extends over several screens, rather than being integrated on a single paper chart). The system also enforces attribution of clinical decisions to individuals, via time-stamped actions and user logins.

Formation (with electronic record)

The consultant arrives at the bed first, stands in front of the computer and logs in. The registrars stand slightly behind each shoulder of the consultant and look on, similar to their position around the paper record. As shown in Figure 9, the medical staff stand in a line off to one side about 1.5 meters away. They are unable to see the screen. The medical staff and registrars hold a print-out containing important information about the patients in their charge.

"What if the formation differed?"

This double ring formation, (the second ring can be both circular or a line), was settled upon after a number of other formations were tried. In the first week, the ward round team attempted to form a ring including the computer, but this was impractical as nobody could see the screen. Next a double ring was formed with the presenting registrar standing in front of the screen and the consultant to the right hand side holding the mouse.

The Consultant

The consultant's orientation towards the computer and forward leaning posture, along with control of the mouse, enabled him to guide the interaction in a way comparable to that of the paper charts. The mouse provided a means of pointing at the data and directing the conversation. The consultant's posture indicated the focus was on the data, and made it difficult for anyone to catch his eye and request discussion. However, the consultant was only able to direct the focus of those who could see the screen— in contrast to his pointing at the paper charts which was visible to the group as a whole. He consequently lost his ability to direct the attention of the whole group. The EPR then reduced communication possibilities in comparison with the paper system.

The Registrars

The registrars had similar communication possibilities with the electronic record as with the paper one. The registrars stood slightly behind the shoulders of the consultant. One of them presented the patient and the consultant pointed to the relevant data with the mouse. The second registrar occasionally added a comment or answered a question posed by the consultant. The registrars were free to say what they wanted, and to enter the conversation in the same way as with the paper record, but were guided by the mouse instead of the pointing finger. They have the advantage of sharing the same viewpoint as the consultant, but as with the paper record, they do not have face-to-face contact with the consultant and its usual benefits.

"What if the registrar changed position?"

When the registrar and consultant inverted positions – the registrar in front of the screen and the consultant to one side with the mouse – there was no change of leadership. Although the registrar gestured, he did not point at the screen as the consultant continued to keep control of the mouse and use it as a pointer. Further, the registrar oriented himself diagonally toward the consultant so that he could see both the screen and the consultant. In this position the consultant maintained the

requisite resources for guiding the conversation and communicating more satisfactorily with the registrars despite not maintaining the expected place.

The Medical Staff

The medical staff formed a ring, a line, or occasionally a cluster separate from the doctors. The only consistent feature across these formations seemed to be a disconnection with the group who could see the screen, usually the doctors. If we posed the question: 'What if the medical staff changed places?' -- the answer would be that no relationships would be disturbed. This answer and the frequent movement of people into, within, and out of the cluster, suggests a distinct decrease in focus compared with a single formation.

Side conversations have become a rare occurrence. There is no longer any device to indicate a desire to re-orient towards another person, a role the paper played previously. Moreover, side conversations disturb monitoring of the main conversation which can no longer be done visually, but only aurally. However, when side conversations do occur there is often significant re-orientation, with the participants turning to face each other, as opposed to just angling towards each other. This seems unproblematic because there is no formation, and thus no set of relationships, which might be upset.

While the above two paragraphs indicate that inclusion is a problem for the medical staff, participation is perhaps more so. The only means to gain access to the conversation is either direct verbal interruption, or, towards the end of the conversation, the consultant generally turned around and asked if there was anything else, making it possible to participate at this point. Only in the latter circumstance did we witness one of the medical staff speak. The respective situations created by paper versus the electronic record at the patient's beside do not provide equal opportunity for all members of the group to contribute to the conversation. In the former, the medical staff could respond and add to it. In the latter, they can only bring up problems that have not been discussed. One medical staff member mentioned that she tried to use the note feature in the software to solve this communication problem in the ward round, but found it problematic because the number of her colleagues using it was not high enough to make it practical.

Summary

The evaluative analysis indicates a dearth of possibilities to enter or advance the interaction surrounding the electronic patient record in comparison with the paper one. The consultant has lost his means to guide the interaction of the whole group and the medical staff can no longer access the information resources, nor participate in the conversation.

DISCUSSION

I have presented a study comparing the negotiation of the ward round interaction using both a paper, and an electronic, patient record in an intensive care unit. I do this with an analysis framework based on Kendon's F-formation system theory, focusing on how the physical technology setup affected the usage of the non-verbal behaviours specifically needed to negotiate entry into, and advancement of, the interaction. I demonstrated the ways in which non-verbal behaviours were used as an interaction mechanism around the paper patient record and concluded that the physical setup for EPR was not optimal in supporting such nuanced use of non-verbal behaviour. It minimized

the ability of the consultant to lead and the medical staff to participate. The following sections look at how these findings fit with other related research.

Multi-disciplinary Communication

These findings have ramifications both for the ISG, who were concerned about changes in multi-disciplinary communication, as well as for the research community that reports on multi-disciplinary communication in healthcare. The 'Related Research' section highlights the importance, but fragility, of multi-disciplinary communication -- particularly between nurses and doctors (Manias & Street, 2001). The choice of technology used (e.g. display device) affects the ability of multi-disciplinary teams to communicate by forcing formations that are not conducive to negotiating interaction, which should allow each party to contribute without wasting time on unnecessary discussion. As technology is being introduced into many care settings, this choice should not be taken with undue consideration.

These findings complement those of (Hill, 2003) who examines nurse participation in ward rounds and concludes that more experienced nurses use gaze and silence as a way to participate in the round, supporting or disagreeing with statements made by doctors without embarrassing or confronting them. She argues that nurses participate more than previously thought, e.g. (Busby & Gilchrist, 1992), but do so non-verbally. The research in this chapter affirms these results and broadens them to show more ways in which non-verbal behaviours beyond gaze are employed to communicate with doctors. This chapter also covers the non-verbal behaviour of doctors and how it might influence nurses, demonstrating how technology can enable, or restrict non-verbal communication.

The analysis in this chapter could also contribute to a number of the solutions posed to increase nurse participation in the ward round. (Coombs, 1999) for example, emphasises the need for nurses to 'break into the circle' of the ward round. The analysis in this chapter indicates why this is the case and suggests that care should be taken in the selection of technology to allow nurses to be part of the ward round circle. (Busby & Gilchrist, 1992) propose that nurses need to be trained to assert themselves during the ward round. The findings in this chapter could be taught as tactics that the nurses could use, and experiment with, to find ways to be better heard in the ward round. Doctors could also be sensitised to the signals nurses are making. A change in formation will not ultimately help a team that does not want to communicate across disciplines, but could support a team actively trying to achieve this difficult negotiation of interaction.

The Design and Deployment of EPRs

The results of this chapter can also contribute to discussions on the design and deployment of EPRs. As chapter 2 indicated, this is a particularly salient issue for the UK, where they are to be deployed in all hospitals. (Fitzpatrick, 2000) for example, argues that many discussions about the potential of EPRs conceive of the record as a passive information archive. She demonstrates that this is not the case, highlighting ways in which the making and keeping of the record is an integral part of carrying out healthcare. The analysis of this chapter supports this point, providing an example of how the paper record supports the careful negotiation of multi-disciplinary communication during the ward round and highlighting the need to consider this in the design of the physical set-up of EPRs to ensure that it does the same.

This chapter can also contribute to discussions about deployment. (Balka, Bjorn, & Wagner, 2008) discuss the deployment of EPRs across six units and two countries, identifying eight likely sources of variation that should be considered when designing or customising an EPR. One of those categories is 'allocation of space and spatial layout,' which refers to how the construction of space (in architectural terms) affects care. This category could also include the physical set-up of the technology. Although physical space did not change formations in a meaningful way in this case, considering how people are encouraged to use space by the physical set-up of the technology is relevant to this category.

Summary

There are many aspects that need to be considered when designing or deploying an EPR. This chapter deals with a very specific one, the non-verbal negotiation of multi-disciplinary communication during the ward round. It is also one that may be less readily noticeable or easily articulated by medical practitioners because of its non-verbal form. Nonetheless, as this section demonstrates, it impacts in a number of ways how EPRS are used, and therefore, how they are best designed.

4:Notating Bodies-in-Space

Head of a Man
Paul Klee 1922

RESEARCH INSPIRATION

The results of chapter 3 indicated that the physical technology setup of patient records in the ICU affected the formations of the ward round team and consequently the use of non-verbal behaviour in negotiating interaction. In order to investigate whether these results are generalisable beyond this specific unit, I observed a second ICU using the same EPR software. However, due to the general difficulties of obtaining ethical approval for studies in medical settings, the head of the unit asked me not to video. This chapter discusses the development and use of a notation system to record non-verbal behaviour in lieu of video and the results of the study carried out.

INTRODUCTION

Unable to use video in the second ICU studied, I explored the usage of notation as a means of recording non-verbal behaviours during ward round interactions which would capture enough data to make the results comparable to my previous work in chapter 3 with video analysis. I look first at existing notations of group interaction in HCI research articles. After discussing the advantages and disadvantages of relevant notations, I turn to the theory of dance notation, an established field of movement analysis and capture, for more explicit guidance. Specifying parameters for the notation to be developed from the lessons learned, I propose a notation system of non-verbal behaviour for the ICU context. I amend this version after use and comment on how the changes illustrate a number of challenges in notating bodies-in-space.

The later part of the chapter is devoted to the results of the study in which the notation was used. I cover background information of the ward, and then analyse the notated data. I close with a discussion that includes the research contribution of the notation system presented here and a comparison of the data from both hospitals.

NOTATING INTERACTION

Notation in HCI

A notation is a representation that encodes an information structure (Blackwell, 2008) and can take many forms. It could be a menu in Microsoft Word that expresses how to navigate Word's information structure. It could also be sets of symbols for writing down dance or music so that others can perform it. Or, it could be a cartoon that emphasizes chosen characteristics of a person or situation. A notation's design depends on its purpose. Notations for collecting data, for instance, are likely to differ from those that display data analysis. The concern of this chapter is a notation for collecting data on social interaction. However, as I did not find any such notation in the HCI literature, I will begin by discussing how analysis of social interaction has been visually portrayed, progressing from least to most abstract.

Photographic Depictions

When a new technology is presented in a research paper, it is often pictured in use in a photograph, as in figure 1 of (Morris, Morris, & Winograd, 2004), reproduced here in Figure 11. This photograph gives a background sense of the physical relationship of the body to the technology. Although not articulated, one implicitly gains information of group formation, body orientation, posture, and perhaps even gesture or object manipulation. Authors who use annotated photographs, that is, ones with circles, arrows or other marks drawn in, make such information explicit through the markings. The first figure of (Wang & Blevis, 2004), reproduced here in Figure 12, is one such example, pointing out gaze direction in an interaction. The use of photographs, particularly doctored ones, provides some information about the role bodies play in social interaction, but it does not abstract the most salient features as a notation would do.

Figure 11: Notational Type – Photograph (reproduced with permission).

Figure 12: Notational Type -- Doctored Photograph (reproduced with permission).

Workplace studies, which has a highly developed notation for transcriptions of speech, also uses photographs to portray non-verbal behaviours. In contrast with the examples above, workplace studies uses multiple photographs and links them to points in time in the transcription by adding captions to indicate what movement happened at a particular moment. Figure 13, based on fragment 2.1 of (Heath & Luff, 2000), is an example of this system. It is not clear why researchers in this field have not chosen to develop a notation complementary to their one for speech. It is notable that, unlike this community's treatment of speech, in which the same characteristics are usually marked throughout the transcription (e.g. words, vocables, time between phrases), descriptions of non-verbal behaviour are only highlighted when they impact the conversation.

This suggests that workplace studies are not treating non-verbal behaviour as a system in itself but as an addendum to speech. Consequently, photographs are adequate to convey the highlighted information without notating all body movement. Interestingly, researchers in this field do notate movement while analysing data. They do 'mapping' exercises, e.g. (Heath & Cleaver, 2004) to keep a rough, personal record of relevant spatial patterns and body movements to the analysis. Details of this notation system however, have not been published. (Prosser, 2007) proposes that reserving these maps for personal use emphasizes the "clear textual communication focus" of the research process of workplace studies (p. 21).

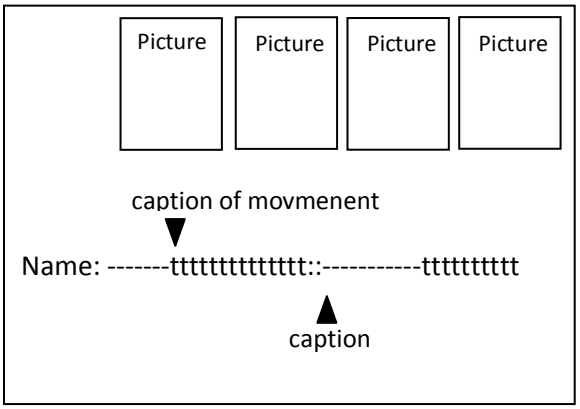
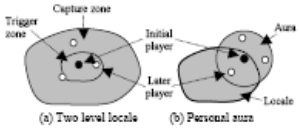
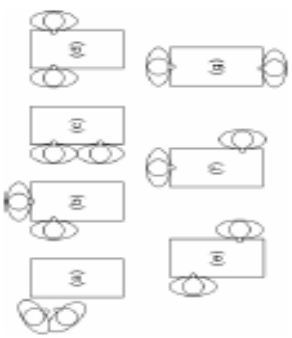


Figure 13: Notational Type -- Conversational Analysis with photographs





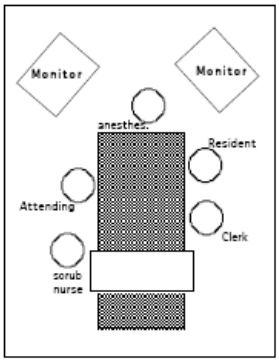


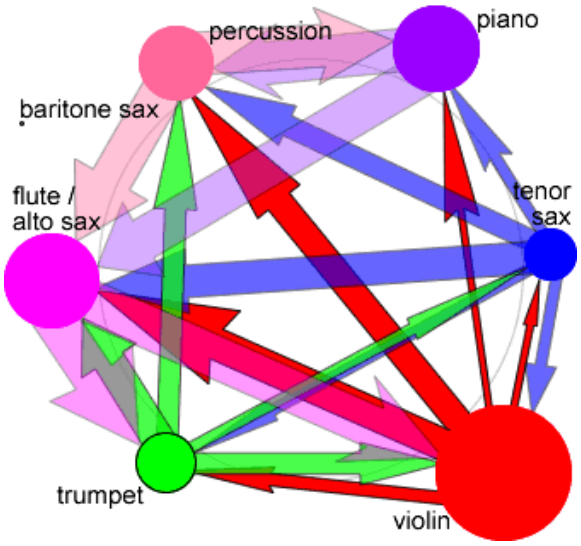
Figure 14: Notation Type - Spatial Relationships (left (a), center (b), right (c) (reproduced with permission).

Notational Depictions

Notations of social interaction, or those that include bodies-in-space in some way, exist in HCI it seems, only in diagrams. The majority of these diagrams portray spatial relationships. (Benford, et al., 2005), for example, reproduced in Figure 14a, shows how 'personal auras,' an area that the computer calculates around the person, can be overlapped to form groups in a game context as opposed to hard-coding areas of a space into which all participants must enter to make group moves. A diagram of spatial positions of people relative to objects and other people is also given in (Koschmann & LeBaron, 2003) and another which includes body orientation in (Tang, Tory, Po, Neumann, & Carpendale, 2006), reproduced here in Figure 14b & c.

(Rodden, Rogers, Halloran, & Taylor, 2003) in their fifth figure, reproduced here in Figure 15, expand the realm of spatial position and body orientation to include the perceptual pathways available for a given arrangement of people and technology. What is instructive about these four examples is the ease and effectiveness of portraying relationships, particularly spatial ones. Nonetheless, contrasting Figure 14b & c, draws attention to a possible weakness in notational design: the latter does not give orientation information and the former does, even though both papers use orientation information in their arguments. Although diagrams purposely strip out 'unnecessary' information that one might find in a photograph, one needs to carefully consider whether all necessary information has indeed been included to help the reader understand a particular concept.

Figure 15: Notational Type -- Perceptual Relationship (reproduced with permission).



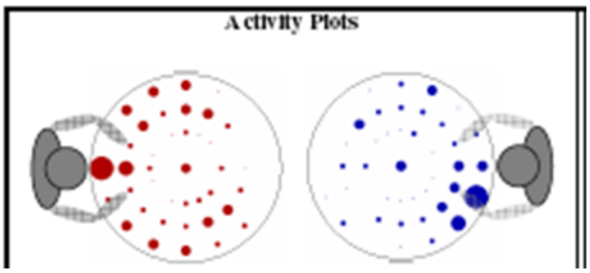


Figure 17: (right) Notational Type -- Interaction with Information over time (reproduced with permission).

Figure 16: (left) Interaction with various group members over time (reproduced with permission).

The following two diagrams, in contrast to the ones above, have multiple layers of information. Figure 17 drawn from figure 3 of (Scott, Carpendale, & Inkpen, 2004) depicts the spatial relationship of interaction with information to the body over time. The bigger the circle the more interaction occurred at that point on the table. Developed with similar visual techniques is figure 5 of (Healey, Leach, & Bryan-Kinns, 2005), reproduced in Figure 16. In this case, the pattern of acceptance to solo in a jazz improvisation circle, done non-verbally by re-orientating, is indicated. The thickness of the arrows demonstrates the number of times a solo was 'passed' to each person from another and the size of the bubbles represents the aggregate length of the improvised solos. The diagram is supported with discussion of formation and body orientation in catalysing such an interaction. Both of these examples are ways of illustrating quantitative occurrences of interaction over time, the former with information and the latter with a person.

As this short review shows, complex diagrams of social interaction, although not absent, are not frequently found in HCI and I was unable to locate any notation for collecting data on bodies-in-space. I have therefore chosen to create my own notation to record group interaction, undertaking the following research exercise as part of the larger project of this dissertation of understanding bodies-in-space. My strategy has been to attempt to articulate the most salient features of bodies-in-space during interaction around a particular technology and to test these assumptions through subsequent use of a notation based on them. I do not start entirely from scratch however, as I rely on the experience of the small field of dance notation. The section below is an exploration of dance notation research as it is applicable to this circumstance.

Notating Movement

Notating movement in a dance context is not a new phenomenon and there exist a variety of systems developed for this purpose. Although non-verbal behaviour in the medical environment is quite different from dance, common practice knowledge in dance notation can be utilized if the differences are appropriately considered. The notation to be developed is intended to capture the use of non-verbal behaviours during the interaction of a ward round team around an EPR for later analysis by the notator. In contrast with those situations in which dance is notated, the movement can only be seen once and therefore must be notated in 'real-time.' Fortunately, it is not necessary to notate all of the anatomical movements of each person, an impossible feat, but only movement

used to negotiate interaction in the group as determined in chapter 3. These constraints challenge and ease, respectively, the process of notation and are a core theme throughout this section.

Theory

Guest in *Dance Notation* (Guest, 1984) provides a comparison of the best known notations of movement. Although these notations are far too complex for notating non-verbal behaviour in 'real time,' the book provides a number of insights on which to build. Guest stresses that a significant part of notating is learning to see a certain style of movement in order to support decisions about what to write down and what to leave out. Much of her discussion revolves around how to capture the creative idea behind the movement in order that others will be able to re-create it later. Although this aspect of her argument is not important for the ICU environment, her advice can still be applied to the 'real-time' situation of this chapter. When notating in 'real-time,' one must decide rapidly what details to include. In order to facilitate capturing the data most useful for a comparison study, *the first requirement below will be to specify and prioritize what movements should be notated.*

Guest also recommends that a notation should support clarity of thought about the movement, that is, the system should support the analysis of the movement. In notation systems designed to produce scores, this will mean that the system should assist the notator in making decisions about the correct notational dialect for writing the movement and to find the notational style that most aptly expresses both movement quality and anatomical movement. In the case of this chapter, I have interpreted this to mean that the notation should prompt information needed, facilitating rapid decisions concerning what data to include. *The second requirement then is to determine what information is most relevant to understand and analyse the movement in the ICU and how it might be aptly expressed in visual terms.*

Speed is of particular importance when notating in 'real time,' something rarely, if ever done, when creating dance scores. Nonetheless, Guest comments a number of times on speed. She notes that known movement can be notated a third more quickly than unknown movement. However, she discourages short-hand recording of known or expected movements because it results in the loss of relevant context and requires the notator to watch the movement again. She also mentions a comparative study of the two major dance notation systems, Benesh and Laban, that concluded that Laban notation was faster because of the speed at which the symbols could be written. Benesh notation, seen in Figure 18 requires accurate drawing to differentiate between symbols. Laban notation, shown in Figure 19, although appearing more cumbersome with its many boxes, can be scribbled and the meaning remains discernable. *The third requirement then is to find ways to speed up the notation process.*

The amount (or complexity) of detail and its redundancy are important features when considering the development of a notation and Guest discusses them at length. However, as the notation proposed in this chapter is for 'real-time' notating, complexity and redundancy are less problematic issues. As the notation will be used as a memory aid, not a communication device, associated matters such as readability by someone unfamiliar with the movement, are of little consequence. Moreover, the speed at which notation decisions must be made does not allow time to think about these issues, as one might, if using the notation as a communicative tool. Complexity and redundancy have not been considered in the requirements section for these reasons.

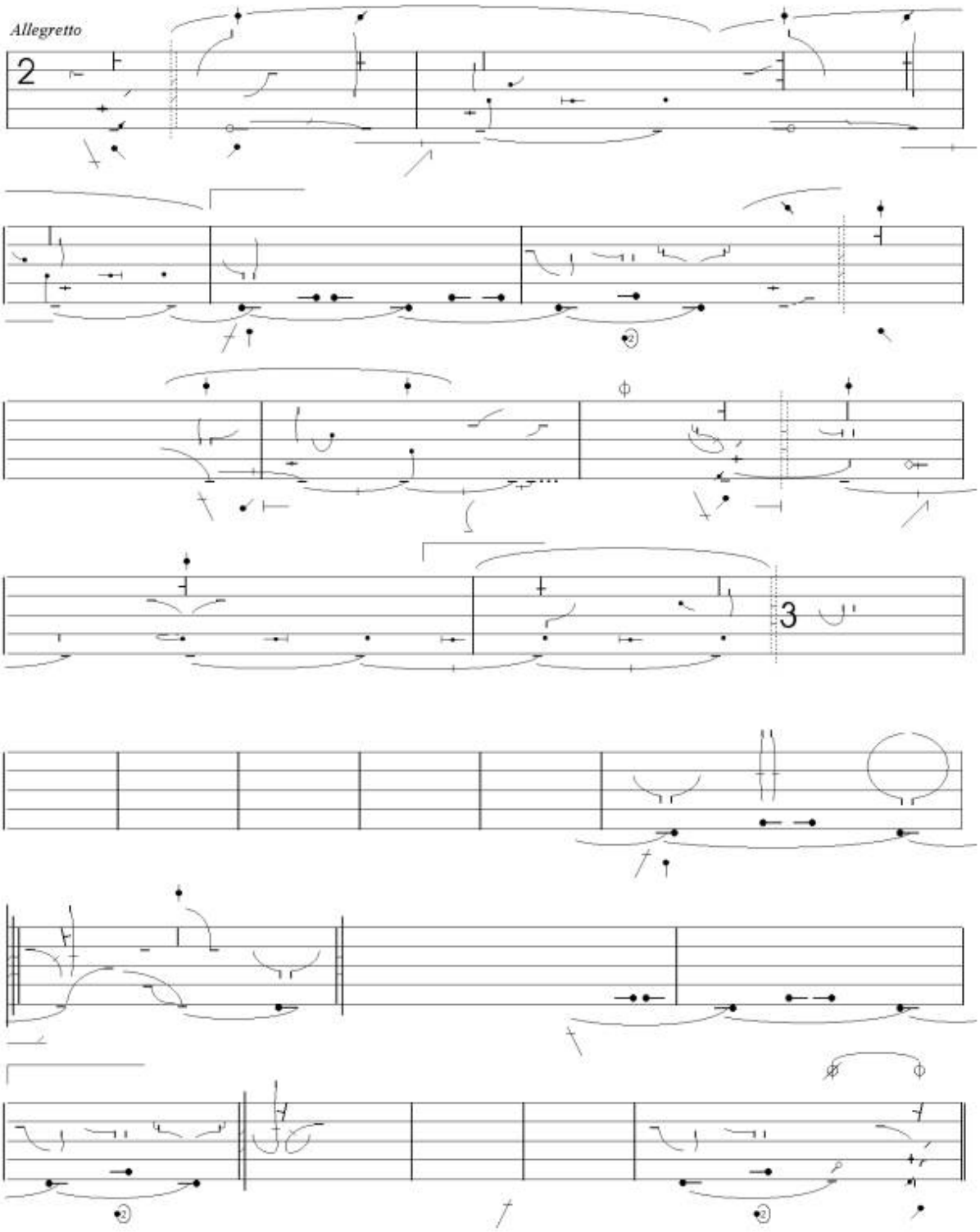


Figure 18: An example of Benesh Notation (Giselle Act 1, Peasant Pas de Deux, Male Variation, courtesy of Benesh.org)

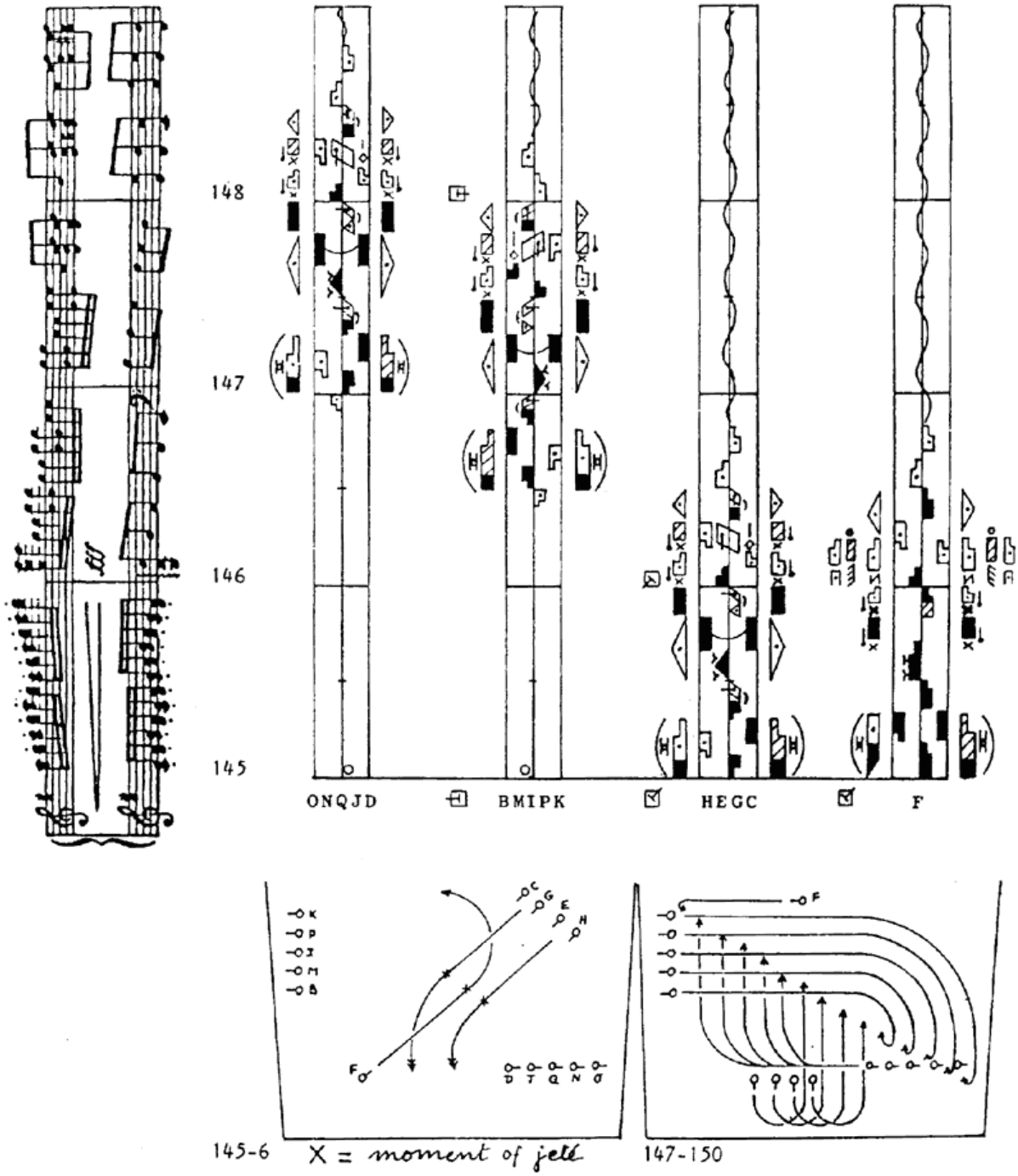


Figure 19: An example of Labanotation (A page from Rudolf Laban's Schrifttanz (1928), reproduced from the collection of Ann Hutchinson Guest)

Group Formation	• Spatial layout of the ward round team including role (e.g. nurse) and orientation • Place of patient and EPR • Spatial movement occurring throughout the interaction
Body-Orientation	• Amount of re-orientation towards someone • Impetus for re-orientation
Posture	• Identify posture when relevant to an interaction • 1 – Engaged, 2 – Neutral, 3 – Personal (explained in ch. 3)
Gesture	• Document gestures that catalyse the interaction in some way
Object Manipulation	• Document any usage of paper or EPR • Attempt to determine reason for usage • If it is a paper form, determine its purpose

Table 4.1: Requirements that the notation must meet.

Requirements

The above 'Theory' sub-section puts forward three points to be considered when developing a notation. The first, specifying and prioritizing the movement to be captured, is considered in the sub-section below, 'Context of Seeing.' The second sub-section, 'Notational Form,' and the third, 'Matters of Speed,' address what kind of visual information would support notating and how speed might be increased, respectively. In the fourth sub-section I depict more fully the notation's usage as a memory aid in this context as opposed to its role as a communication device in dance. The aim of this discussion is to give the rationale behind my choices in the notational system to be presented in the following section.

Context of Seeing

In chapter 3, I proposed that non-verbal behaviours are an important means of negotiating interaction – who speaks and how the topic of conversation is changed. I demonstrated that the physical setup of the technology affected formation of the ward round team and its members' consequent abilities to interact. There is a clear tension between the physical technology setup and possible interaction modes. The aim of the second study is to more clearly articulate this relationship of technology setup and modes of interaction. In the next paragraph I review the relevant data needed to make such a comparison and prioritize it for cases when speed constraints do not allow full capture of the desired data.

In order to make the above stipulated comparison, the most important data needed is the formation of the ward round team relative to the EPR and patient. Constituting the first layer, this provides information on both the effect of the physical technology setup and the interaction style in use. As formation affects the usage of other non-verbal behaviours, the next layer of relevant data is how upper-body orientation, posture, gesture and object manipulation are supported or hindered by the formation choice. Table 4.1 outlines more precisely what data needs to be captured for these two layers and is the reference point for the development of the notation used in this chapter.

Notational Form

In the 'Theory' section, I highlighted Guest's suggestion that a notation should facilitate the analytical process. I interpreted this to mean that the chosen notation should support analysis of the situation on the spot in order to assist judgements about what information should be included, or even sought out. Formation, as mentioned above, is the first indicator of a relationship between people. The shape of a formation and any disturbances to its boundaries are clues that would

Group Formation	Initiation of the formation Breaks in formation
Body-Orientation	Incidents of wandering attention
Posture	Postures that indicate control of information or space
Gesture	Pointing to information
Object Manipulation	Use of object to reorient Use of object to begin an interaction

Table 4.2: Indicators of unusual or problematic interaction.

prompt the analyst to look further for unusual relationships between people as indicated by other non-verbal behaviours. To visually highlight the shape and boundary of the formation, I have utilised a 'plan' view with precise indications of relative spatial positioning. Any deviations can be easily spotted as the curves will not be smooth.

Matters of Speed

Speed is essential to the use of notation in the ICU context and I have developed a number of means to facilitate it. First, the symbols of a notation need to be clearly discernable, so that when written quickly (and perhaps poorly), they are still distinguishable from each other -- a feature illustrated and discussed more fully below. Second, I propose in Table 4.2 a list of non-verbal behaviour events drawn from the first study which, in that context, were indicators of problematic or unusual interaction. This list, for reference of the notator, is to familiarize him or her with movements likely to be seen, which, according to Guest (Guest, 1984), speeds notation.

Third, I developed a coding sheet to help prioritize what movement is to be recorded, as seen in Figure 20. I split the non-verbal behaviours into two categories, drawn from difficulties faced by the team in the first study: (1) leadership -- the means used by the consultant to lead the discussion; (2) facilitation -- the means by which interaction between nurses and doctors is supported. These categories should ensure that data relevant to questions previously asked will be available.

Memory Aid

Dance notational has traditionally been used as a communication device. It is therefore very important that the notation system be able to communicate movement to someone with no prior experience of that movement style. Competent dance notators frequently watch a choreographer to decide on how to communicate the style generally and then watch each short phrase, usually about 16 – 32 bars of music, three or four times before notating. The notation is then checked in its entirety when finished. This process necessary to capture the detail of movement required to communicate it through notation would not suit the real-time coding constraint of capturing bodies-in-space in an ICU. However, a notation can also serve as a memory aid if designed appropriately.

The previous three sub-sections examined ways to speed the notating process. These propositions can also be useful techniques to serve memory. The list of priorities of movement to capture set out in the section 'Context of Seeing,' focuses one's attention on what is relevant and what is not and provides a structure within which to remember data. The 'Notational Form' and 'Matters of Speed' sections, likewise, offer a number of analytical concepts for differentiating important movements, such as a re-orientation to discuss a patient from a re-orientation to pull up one's stockings. It also offers a way to quickly analyse movements, such as a change in posture, so that only the analysis needs to be remember and not the movement in its entirety.

A notation oriented towards being a memory aid then, should distinguish between movement detail that is difficult to remember, such as positioning and formation, and that which can be easily cued for later description in field notes. The former should be captured accurately and a good cueing system provided to aid the researcher's memory in the latter case.

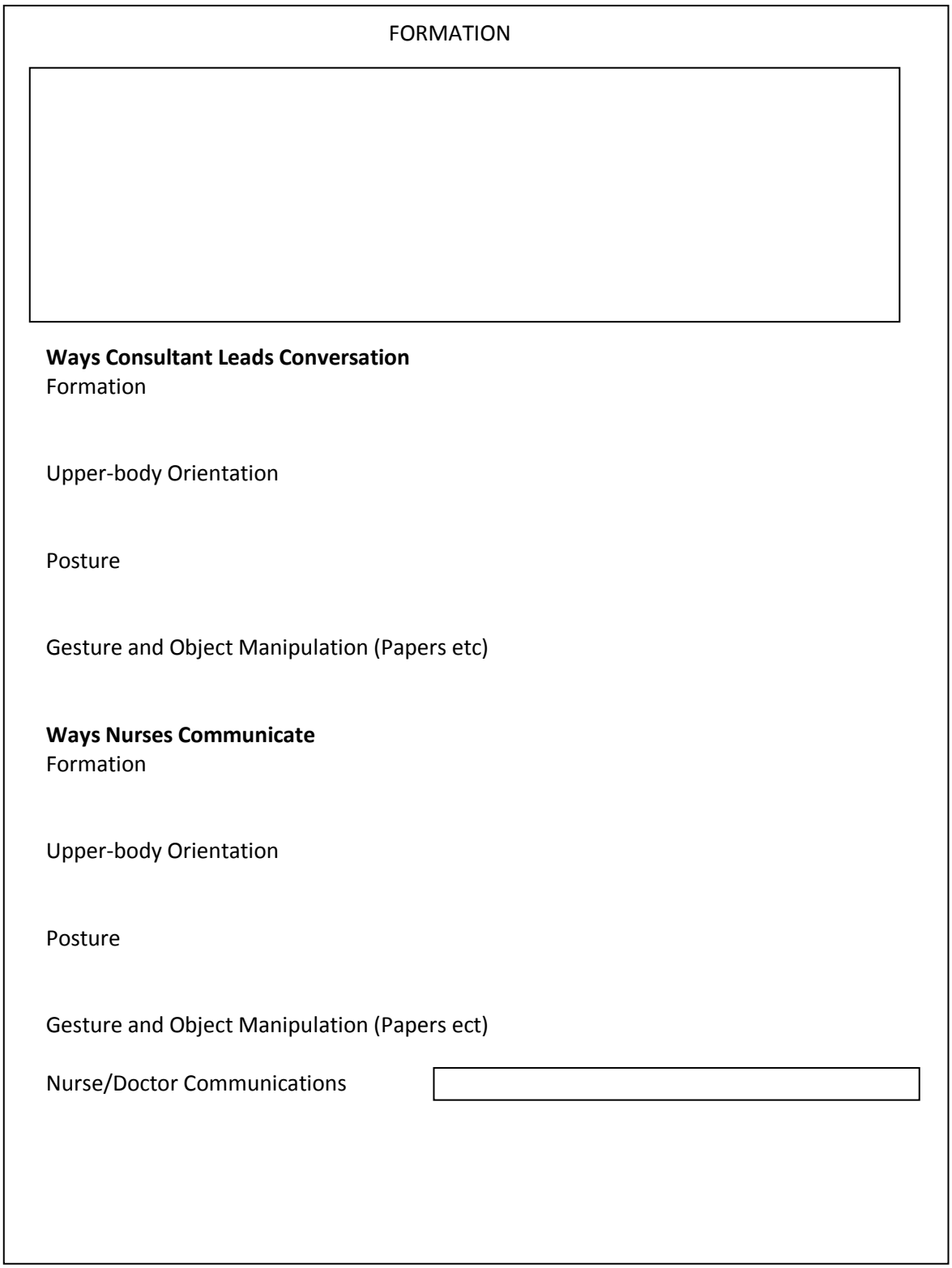


Figure 20: Coding Sheet

Developed Notation

The notation presented below is developed based on the criteria of the previous section for the specific task of notating bodies-in-space in an ICU for purposes of comparison with another unit. However, just as interesting as the notation itself, if not more so, is the development process. Iterative in nature, I first present the version based on the above analytical arguments and then the adapted version based on experience of use. The changes that occurred between the system in theory and the system in practice are helpful for understanding the notation of bodies-in-space beyond this specific context. Moreover, the elements of the theoretical version proved useful in creating diagrams to communicate the analysis.

Proposed Notation

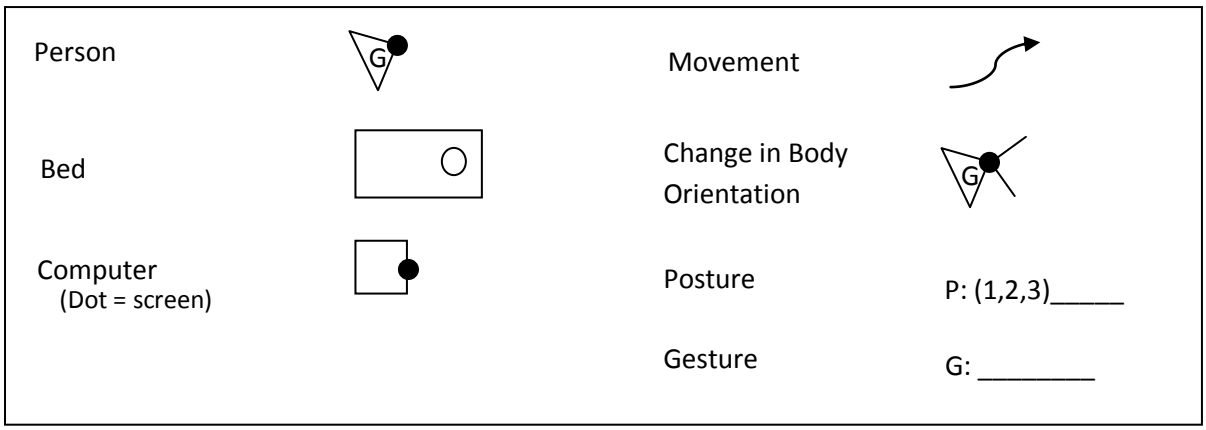


Figure 21: Notational Key

Explanation of Notation

A number of options were considered for notating the position and orientation of people. Movement notations from the 17th and 18th century (which tended to be much simpler than the ones used today) often utilised a pin figure as shown to the left. This is simple and quick to draw but has several drawbacks. There is no place to indicate the role of the person depicted which is important in interpreting the interaction, and pin figures do not communicate a clear view of the spatial relationships between people. Further, the pin figure does not prompt the notator to add other relevant information about the formation because it does not portray visually important characteristics of the formation, such as 'boundary.' A triangle with a dot was chosen instead because it is also quick to draw, but maintains the visual representation of the group more effectively. It also provides a place to write the role. The dot was used to indicate direction as a triangle drawn quickly may not robustly indicate orientation.

A change in body orientation is indicated by a line in the direction of the new orientation. This is done because re-orientations are expected towards other people or information during a complex interaction. The line acts visually, like an arrow, pointing to the person or object that has become the focus of orientation, facilitating the analysis process. A further line is extended in the original direction of orientation (perpendicular to the base of the triangle) to indicate visually the magnitude of the re-orientation. Although this is redundant information, it too supports the real-time analysis of the interaction, and consequently the quality of the data recorded.

The remaining symbols are relatively simple. The 'bed' and 'computer' are both easy to draw and clearly indicate orientation and relative size. Posture is drawn outside the diagram in order to record the information but not disturb the visual picture of the formation. For the sake of speed, posture has been characterized by three modes (as explained in chapter 3) where 1 stands for engaged, 2 for neutral and 3 for personal. A line is provided next to the symbol, for comments about the significance of the posture. Gesture and object manipulations also have distinct meanings and are therefore done in a similar way. It is expected that both of these types of body movement can be interpreted on the spot and a cue written to support a more detailed description when field notes are written. It is more likely that notating these phenomena on the diagram would detract rather than add to the clarity of the analysis. It would also take more time.

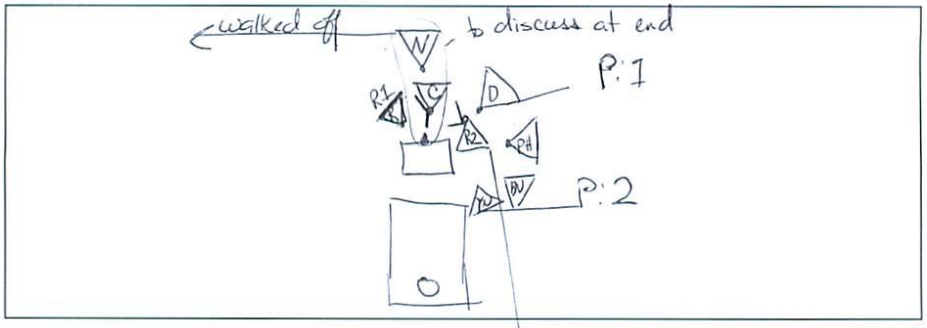
How to notate the element of time has caused considerable debate in the dance notation community. A number of dance notation systems use rhythm to mark time, but even when the notation is not done in real-time, unless only one other spatial dimension is captured, only moments on specific points in time can be captured. One is expected to interpolate between these moments. Fortunately, in this case movement is interesting as a choice to change the formation. The particular movements over time are in themselves, not important. The movement's catalyst (e.g. somebody opens the book of charts) is interesting, but it can be written down, rather than depicted. Consequently, movement (in my system) is drawn with an arrow in order to indicate the path taken and the direction chosen in the new orientation. A new 'person' is not drawn in order to keep the drawing from becoming cluttered.

The notation developed is summarized in Figure 21.

Testing the Notation

In order to do a preliminary test of the notation, I coded several interactions from videos of the first study. I did not encounter any problems and the coding worked as anticipated. An example of this test is shown in Figure 22.

FORMATION



Ways Consultant Leads Conversation

Formation

Upper-body Orientation

Posture Hand on mouse, leaning over screen and talking

Gesture and Object Manipulation (Papers ect)

Ways Nurses Communicate

Formation

Upper-body Orientation

Posture Nurse looks at other bed several times - also looks at floor.

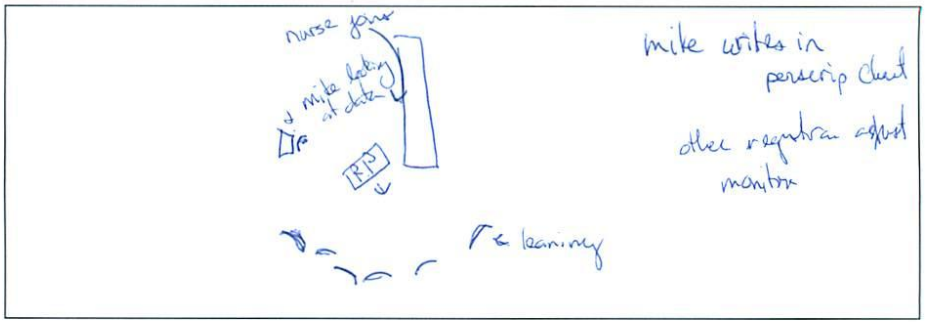
Gesture and Object Manipulation (Papers ect)

Nurse/Doctor Communications

Figure 22: Preliminary Coding Test

7

FORMATION



Ways Consultant Leads Conversation

Formation — mike turns in + out
Richard comes over + joins

Upper-body Orientation — looking at patient, or notes, or at speaker

Posture

Gesture and Object Manipulation (Papers ect)

Ways Nurses Communicate

Formation

Upper-body Orientation

Posture

Gesture and Object Manipulation (Papers ect)

Nurse/Doctor Communications — Registrar explains to nurse

Figure 23: Example of Actual Coding Sheet

Amended Notation

Speed turned out to be more of an issue when actually in the ICU, where I needed to make some changes on the fly as shown in Figure 23. Although the data I recorded was adequate for comparison, I propose a revised notation (pictured below) and discuss the changes made. The amended notation is shown in Figure 24.

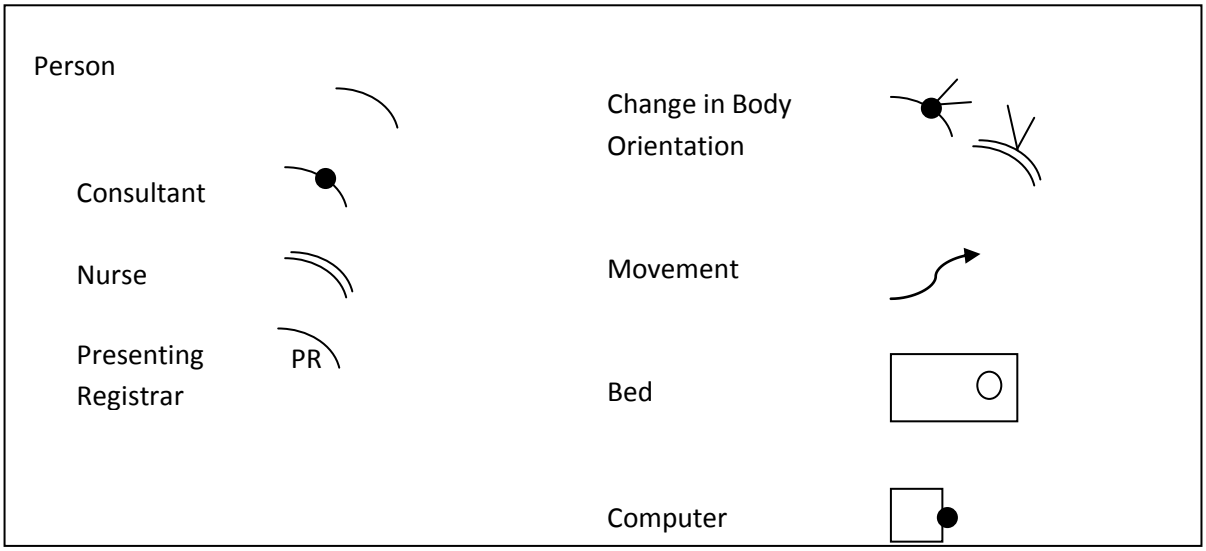


Figure 24: Amended Notation

Discussion of Amendments

Towards the end of the coding, I made a number of changes to the notation that better suited the speed of the task. I depicted participants by a curved line with the apex being the orientation. This was faster to draw, accurate at high speed and provided a simpler visual image. Nurses were depicted with a double line, the consultant with a curved line and dot and the presenting registrar labelled with initials. In contrast with the first study, the ward round was not as diverse. Nurses rarely participated, and the rest of the team, except the consultant, were registrar doctors. Consequently a simpler notation was possible as the dynamics between the various roles were not as pronounced.

Depicting changes in orientation on the diagram was problematic because as time is not illustrated, the context around the re-orientation was unclear. Nonetheless, a visual depiction is still useful to indicate how much re-orientation took place and by whom. In order to depict orientation, I suggest circling the participants involved and then re-notating the changes to one side with a written indication of the catalyst. Just as arrows are often used to suggest changes in movement, this strategy depicts a change in the formation while keeping intact the visual representation of the formation.

Notating posture, gesture and object manipulation in the diagram was not helpful at all. Such data can only be interpreted in the framework of events around it. More useful was noting down when one of these changes involved a catalyst of, or response to, an interaction. In retrospect, posture, gesture and object manipulation are important in their roles rather than in actual movement, in contrast with formations where the position of bodies is important. My analysis suggests that portraying the physicality of posture, gesture and object manipulation may not be helpful. Two

alternatives to gather this data would be writing events with words, e.g. ‘used paper to initiate side-conversation,’ or using a tick-box system to notate known phenomena based on Table 4.2.

Amendments to Coding Sheet

I also amended coding sheet, which can be seen in Figure 25. The original or initial area for coding the interaction was too small and too constrained. A revised coding sheet has an area for drawing that is larger and square. The bed is also drawn in to encourage notating at a size that can be easily analysed without the need to be re-drawn and that would not suffer from mistakes of hand-writing. The categories proved unnecessary and I spent time searching for the correct place to write a given comment so they have been replaced by free space. This agrees with Guest’s report of the surprising result that Laban notators worked more quickly without a pre-drawn score.

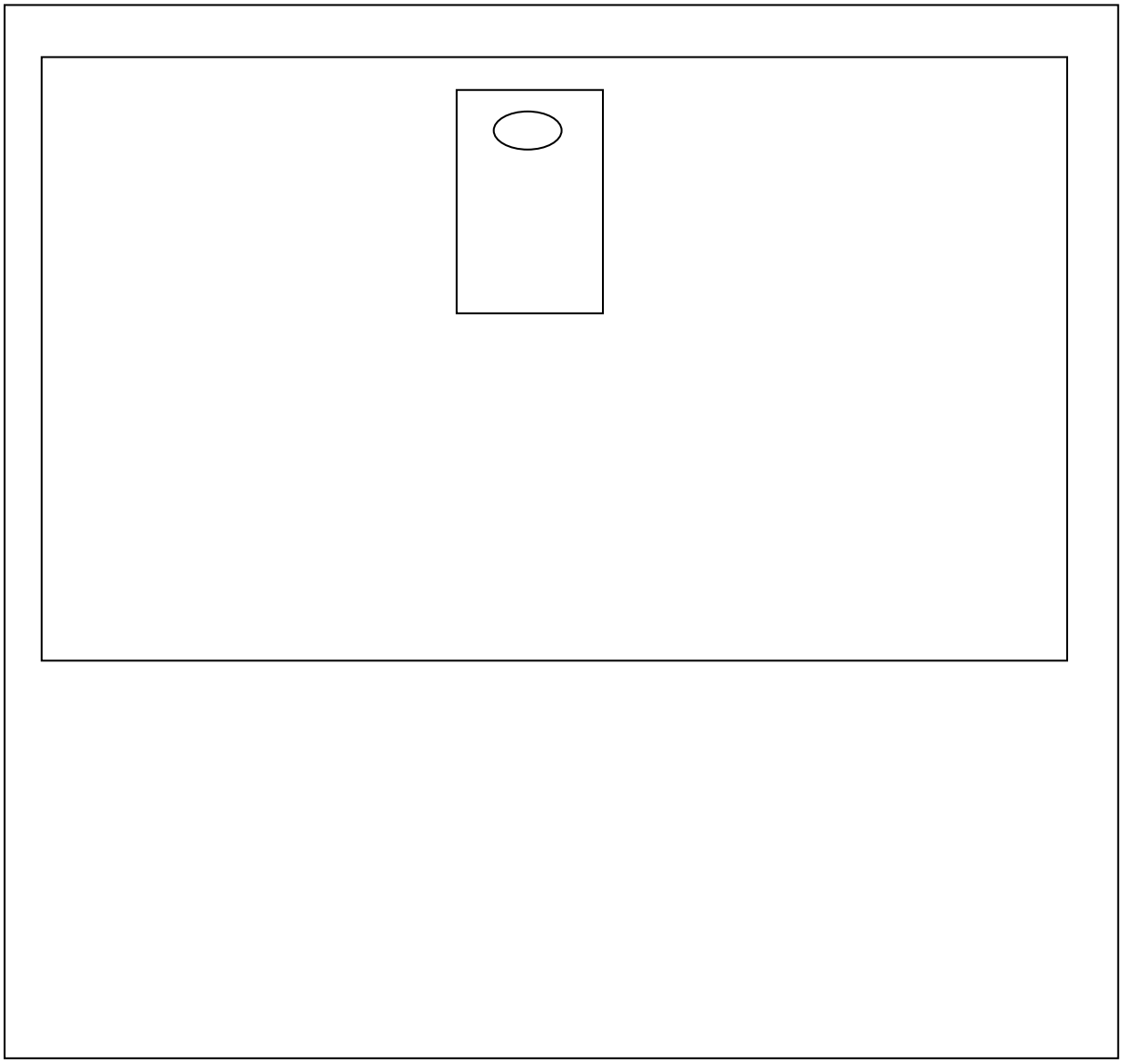


Figure 25: Amended Coding Sheet

RESULTS

Background

The Unit

The second study took place in a newly built ICU of a large general hospital that was designed with the understanding that EPRs would be used. Although the original intention was to have the EPR in place from day one, lack of time for required training resulted in a number of tasks being carried out on paper when I made my initial visit, six weeks after deployment. These included keeping the ward record book where notes of tasks to be done by the registrars were kept in order to facilitate coordination of duties. The balance between the EPR and the supporting paper was a source of tension communicated to me by a number of different parties during my observation, including the lead consultant. It is also one that is significant to the analysis of the interaction.

The Ward Round Team

There were between seven and ten members participating in the round during observation, two consultants, the charge (or head) nurse, a number of registrars (junior doctors) and some medical students. One of the consultants was clearly, yet subtly, in charge, leading the post-presentation discussion and prescribing medication. The other provided a second opinion and made specialist contributions in the areas of neurology and anaesthesia. The charge nurse raised issues that nurses had flagged to him and wrote down tasks needing to be done by the nursing staff. There was little to no participation by the bed nurses looking after the patients. The older, and presumably more experienced, nurses, however, frequently listened in and occasionally spoke directly to the consultant. However, it was clear that they were not officially part of the round. In contrast with the first study, there did not seem to be a concerted effort to include the nursing staff.

The ward round seemed to take place mainly for the benefit of the four registrars. They rotated between presenting the patient, taking notes in the ward book, and contributing to the discussion. Although the consultant contributed to and facilitated the discussion, most of the talking was done by the registrars. This is not surprising given the teaching status of the hospital, visible by the constant presence of students, both medical students, who listened but did not participate in the round, and nursing students at the beds who ignored the round. Despite the emphasis on discussion, there was tension about the amount of time it took and several reminders were given to the consultant concerning the new 'five minute rule.' This rule articulated a goal of not spending more than five minutes at each bed. There was a gradual disappearance of the registrars towards the end of the round as they left to carry out other duties. Discussion and learning are central to this unit, but time is also extremely important.

The EPR

Although a number of systems were researched, IMDsoft's Metavision was chosen by the hospital because of its flexibility with regard to customization, just as in the hospital that was the locus for the first study. It was also the system used in the ICU of a sister hospital. Consequently, the expertise of the sister hospital was utilised in the customization effort. This effort was lead by a team of five who started seven weeks before deployment and included the two consultants observed. As part of the deployment plan, consultants now spend time in both hospitals each week in order to become familiar with different practices. The ward round practice in the sister hospital ICU is extremely

different, because it features nurse-led ward rounds, rather than those led by consultants. This contrast was pointed out to me by the lead member of the team customizing the software, who, a nurse herself, was particularly focused on supporting the nursing staff. Because the customizing team was not particularly large, individual personalities had an important effect on the development of the system.

Data Collection

I observed one entire ward round six weeks after deployment. I watched twelve interactions – eight in a large ward room and four in side rooms. I was only able to notate the first nine because the small size of the side rooms made it difficult for me to remain unnoticed, and I chose to minimize distraction by not using the notation system. However, I did take notes in words, and discussion of these rooms will be included. Extensive field notes were written after this visit elaborating on events that occurred and contextualising the formations seen and why. These are similar to the fields notes described in chapter 3 and an exemplary page can be seen in appendix C. I was also able to interview the head customizer and correspond by email with the lead consultant. Information from these discussions is included as appropriate.

Data Analysis

In the first study, the analysis first described the initial formation followed by how it facilitated or hindered the use of other non-verbal behaviours of the participants grouped by role (e.g. nurse). This structure was helpful in illuminating how the two record types affected a known issue – specifically, communication across hierarchy. In the second unit, however, the ward rounds were not particularly multi-disciplinary; nor was doctor-nurse interaction encouraged. Thus, 'role' was not a helpful means of organizing the data. In this study, tension was manifest in the paper versus electronic resources used in the ward round. Consequently, the data analysis will be structured around the possibilities that these two resources offer, given the initial formation of the group and subsequent changes to it.

Formation

The most common formation is shown in Figure 26. It is a semi-circle facing the presenting registrar and the patient. The presenting registrar usually does not have his/her back entirely to the patient, but stands to one side of the bed, angled so that s/he could see both the ward round team and point to the patient or monitors. The computer is off to one side and generally not a significant part of the discussion. That said, the lead consultant always immediately logs in and scans through the EPR while the registrar presents. He frequently has his back to the ward round team, turning only when he wants to prompt the conversation in a particular direction or to close the conversation.

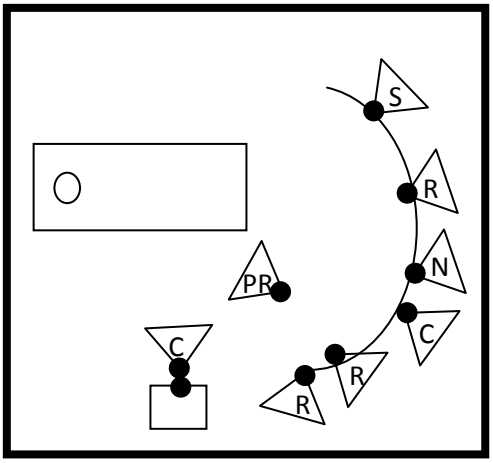


Figure 26: Typical Formation -- C = consultant, PR = Presenting Registrar, R = Registrar, N = Nurse (charge), S = medical student

On a number of occasions the formation was not a semi-circle as depicted here. Frequently the medical student would stand behind the formation rather than being part of it. Even when part of it, he frequently separated himself spatially. Others taking marginal positions in the formation were registrars who joined the group late for

different reasons or doctors with particular specialties who wanted to listen in on the discussion of a particular patient or contribute to the conversation without partaking in the round. Nurses also occasionally joined the outskirts of the formation, a position allowing them to withdraw when they wanted to or found it necessary.

Significant rearrangement of the formation was unusual and happened only for three reasons. (1) One of the registrars would go and speak to the patient. S/he would back out of the formation, turn and go around everyone to the bed. This was clearly meant not to disturb the discussion. (2) Somebody in a 'watching' position peripheral to the formation might step into the formation in order to discuss, rather than just comment on, a particular topic. (3) A registrar might cross the space in the middle of the formation in order to check some information on the computer but continue talking to the presenting registrar. These three examples suggest that formation in this situation is functioning much as Kendon originally proposed. The space that the formation encloses is considered the interaction space and is not entered unless it is part of the interaction as in the third example.

Information Resources

Interestingly, the EPR is not part of the formation nor does it play a significant part in the ward round. A set of charts that augments the EPR does not play a central role in the interaction either, although there are personal papers scattered between members of the round. The only official papers (charts) are the ward book, held by one of the registrars, and the prescription chart, which is kept on the EPR stand. The ward book is primarily used for notating tasks to be done, but occasionally the holder uses it as invitation for another to re-orient. The prescription chart is primarily looked at by the consultant who make any necessary changes. If information is needed, it is read aloud by the closest person. Many of the ward round members also have personal notes. These seemed to be used primarily when presenting. It is the presenting registrar who is the main source of information for any particular discussion. It is not surprising, then, that we see the formation of the ward centred around the presenting registrar.

The EPR is used almost exclusively by the consultant. He makes a clear statement of his priorities by keeping his back to the registrar when s/he is presenting and checking the information for himself on the EPR. During one interaction, the consultant corrected the information presented by the registrar from the EPR. He clearly did not trust the accuracy of the registrars' presentations, yet he showed no desire to hinder or direct the discussion between the registrars. There seemed be a tension here between the consultant's desire for information found in the EPR and a desire to help the registrars learn through discussion.

Other Non-verbal Behaviours

There was no prevailing use of non-verbal behaviours to gain access to information resources. There was nothing but the EPR and therefore no shifting to point at, pick-up, or re-orient. The most common non-verbal behaviour was (re-)orientation to indicate a sub-conversation. In fact, unanimous attention was not paid to the presenting registrars. As Figure 26 illustrates, there was a tendency for people to orient slightly to the person they stood next to and with whom they often shared a few words. These groupings did not appear to be random, suggesting that people chose to stand next to individuals as a function of communication interests. I did not notate these non-verbal behaviours because they did not deviate substantially from what one would expect given Kendon's

theory (Kendon, 1990); nor did they involve information. The lack of distinct negotiation of the interaction may well have resulted from the homogeneity of the participants.

DISCUSSION

This chapter has put forward two issues for discussion: (1) a notational system for capturing and expressing bodies-in-space; and (2) the comparison of the data from a second unit to the first. Although both topics arise from the same research project, the results have rather different implications and will be discussed separately in the following two sub-sections.

Notating Non-Verbal Behaviour

The development of the notation system detailed in the earlier part of this chapter served to demonstrate that notation is particular to its purpose. A notation for 'real-time' recording of non-verbal behaviour for example, is not necessarily the most appropriate notation for visually depicting analysis of non-verbal behaviour. As already noted above, the use of a curved lined to depict a person allows for fast capture of position and orientation within a formation, but a triangle with a dot more explicitly highlights, for analytical purposes, group formation and its changes. Similarly, a notation to capture social interaction of groups using technology will differ significantly from a notation for describing people's spatial movement in an interactive gallery, as in (Loke, Robertson, & Mansfield, 2005).

Designing a notation then requires careful consideration and tailoring to capture or express the data salient to the information of interest. It is therefore likely that notations will not be easily reusable in different research situations that require 'real-time' notating. Nonetheless, developing this notation offers a number of useful lessons. First, picking up on a point of Guest's (Guest, 1984), trying to express movement, or any phenomenon, in an abstract notation, prompts one to think more deeply about the nature of that movement or phenomenon. The first sub-section is a reflection on bodies-in-space prompted by the development of the notation. Second, it provides an example of a notation. The second sub-section looks at some lessons that can be learned from this and other notations.

Reflections on Bodies-in-Space

The notation developed in this chapter provides greater clarity in 'seeing' bodies-in-space, first done in chapter 3, by characterising them more explicitly. Creating the notation made it clear that formation is distinct in my analysis from the other non-verbal behaviours noted. I have used formation as a primary indicator of relationships between people in a group and other non-verbal behaviours as a way to view people's intentions. Extending (Kendon, 1990), I would go beyond his premise that relationships are engendered by formation, to say that formations allows (or disallows) intentional use of the other non-verbal behaviours to negotiation interaction. This statement provides the rationale for the observation in chapter 3, that lack of continuity in a formation around technology can demonstrate a communication problem.

Lessons Learned

A first concern when designing a notation is whether it is an appropriate tool. Chapter 3 and 4 present similar data collected with different tools, video and notation respectively, allowing a comparison. Video presents an opportunity for greater reflection when the goals of the study are

still broad or little is known about the movement context. However, there are situations when video cannot be used or the time frame of the study is to short, a common problem in industry. Notation can fill both of these gaps if the aims of the study have been articulated. It is particularly useful for collecting large data sets or verifying hypotheses. Designing a notation may also be a helpful analytical exercise to better articulate the movement concept, even if video would be a more appropriate way of collecting data.

If a notation is to be used, the next decision is whether to use an existing one or to create a situation-specific one. Laban notation is the most famous, as well as the most versatile, movement notation, and has been used several times in the HCI literature, e.g., (Loke, Larssen, Robertson, & Edwards, 2007), (Schiphorst, et al., 2007). The former paper utilises the notation primarily to enforce rigour of observation by necessitating careful viewing in order to notate. The latter paper focuses more on the concepts supplied by Laban notation system (e.g. effort) rather than the actual notation itself. This is a helpful strategy for those unfamiliar with movement. Laban notation, however, would be too slow to use in 'real-time' coding situations. It would also not support the analytic process during observation, as the notation is too complex to highlight phenomena of interest at a glance.

Developing a notation for a specific situation has many advantages. As (Loke, Larssen, Robertson, & Edwards, 2007) point out in their comparison of four frameworks for assessing movement, each one helps focus the analysis in a different way. Designing a notation is useful in that it can be tailored to support observation and can be re-worked to provide more than one view on the data. Multiple views are relevant to the study of movement in a social context, as movement is less about the physical placement of the body, and more about the consequent relationships between people that develop because of the placement of the body, which may be context dependent. As the number of movements for a particular context is small, designing a notation to support the analysis of specified movement concepts is useful without being onerous.

Developing a notation necessitates choices about what should be notated. The development of the notation in this chapter suggests that formation and its analysis are best served by visual representation, while other non-verbal behaviours are best expressed with words. This seems to be the unarticulated conclusion of others using diagrams to characterise social interaction. All of the examples in the review only depicted relationships, either spatial or perceptual. One might say that visual depictions are most useful in representing relationships, and words are better for expressing intention. Whether designing a notation for 'real-time' use or for the presentation of social interaction data, it is best to capture relationships with a notation and use cues or verbal explanations for descriptions of intentions.

EPRs and Non-verbal Behaviour

Comparing the analysis of non-verbal behaviour in both ICU units confirms statements made in chapter 3 about the role of non-verbal behaviours in negotiating interaction. Formation remained a good indicator of the possibilities of interaction; participants formed sub-discussions by re-orienting towards one another and so forth. What was different, however, was the physical place of paper and the EPR in these interactions. In the first unit, both patient records were at the centre of the group, while in the second unit, a person speaking was the central focus and information was kept off to the side for checking. Below I explore these two attitudes towards information usage during an

interaction and consider how the balance between interaction and information affects technology design.

Interaction versus Information

One might describe the ward round in the second hospital as interaction-centric rather than information-centric, as interaction is privileged over information. It is not clear whether this is a conscious choice, or due to lack of familiarity with the EPR. There are related situations which suggest that either could be likely. The lead consultant, who has worked with an EPR for the previous five years, developing much of it himself as an amateur programmer, found the information on the EPR very useful – perhaps more so than the interaction. The second unit's sister hospital however, which has had an EPR for five years, remains interaction focused in the ward round. Relevant information from the EPR is transferred to a paper form by hand before the round and the computer used only to check discrepancies in data or for data not recorded. These examples indicate that people make clear choices about whether to privilege information or interaction.

This conflict between interaction and information was also an issue for the hospital in the first study. The analysis of their EPR usage soon after deployment highlighted that the doctors put too much emphasis on information in the EPR, which coupled with the physical setup of the EPR limited interaction between the disciplines in the group. The analysis of the ward round's usage of the EPR one year after deployment showed adjustments to the formation and interaction style used that allowed for a more even balance of information use and interaction. Discussion with the lead consultant indicates that this balance can be particularly difficult to achieve with certain personalities. It is clear that there is a conflict between information that the EPR can provide and the benefits that multi-disciplinary interaction gives to the ward round. It seems that this can be further exacerbated by technology, including its physical setup.

Design Insight

In the ICU there seems to be a conflict between information gathering and interaction. It is helpful to think of these respective goals as different ends of a spectrum. If individuals spend all of their time interacting, it is difficult for them to gather information from a patient record. Conversely, if they spend all their time scanning information, they do not have the non-verbal resources to interact. In the first ICU context, this problem was solved when the paper record was in use by designing it to be visually scannable. This was accomplished by limiting the amount of information and putting it in a format that supported reading. One might argue that the large amount of information available in an EPR is not presented for scanning and there lies the design problem. I would suggest that the problem lies elsewhere. People are still finding ways to utilize large amounts of information to benefit medical practice and are still experimenting with different possibilities that an EPR can provide in medical care.

How the amount of information and the means of accessing it affect multi-disciplinary interaction is indeed an interesting question and one that is relevant to the discussion in this dissertation of formation and the physical setup of technology. Returning to the idea that group formation is affected by the physical technology setup and formation determines which non-verbal behaviours can be used in negotiating interaction, because of the need to balance between information and interaction, there is likely to be a conflict between the two. How do people divide their attention between the information needed to participate in an interaction and the non-verbal behaviours

needed to negotiate the interaction? For example, if a person is attending to information on a personal PDA, can that person be attending to the conversation as well? This conflict is the motivating question for the next two chapters. In chapter 5, I recount my endeavour to have the doctors solve this problem and in chapter 6, I address the problem in a laboratory setting.

5:Choreographing Bodies-in-Space

The Anatomy Lesson
Rembrandt, 1632

RESEARCH INSPIRATION

As part of the agreement with the implementation steering group (ISG), the research team was asked to provide regular feedback based on its observations. The first part of this chapter reports changes observed in the ward round after we discussed the implications of the physical setup of the technology on the formation and interaction of the team, as reported in chapter 3. The second part of this chapter details a proposed method to help teams either fully utilize an existing technology setup without disturbing interaction, or explore alternative technology setups and the impact they might have on the team's interactions. When I suggested the method to the ISG, they were satisfied with the adjustments that the ward round team had already made and therefore I did not have an occasion to try it with the medical practitioners. I did, however, have an opportunity to evaluate it in a more general environment with a large participatory audience at a CHI conference Design Theatre event, the results of which are reported here.

DISCUSSING THE PROBLEM

The Discussion

I compared the interaction in ward rounds centred around paper patient records and EPRs in chapter 3. I noted that with the paper record, the medical team relied heavily on non-verbal behaviours to negotiate interaction, but with the EPR the medical team struggled to do this with the same ease. I suggest that the physical setup of the technology discouraged the established non-verbal interactions by influencing the formations of the team. Six months after the deployment of the EPR, I discussed these observations with the ISG, showing them the two contrasting pictures seen below in Figure 27.

Figure 27: The ward round team using the patient records with the formation emphasized. (left) the paper record; (right) the electronic record.

Members of the ISG, particularly those pictured in the photographs, were very surprised by the clear difference in formation. Although less dynamism in the ward round had been noted, the group had not realized that the physical setup of the technology had been a contributing factor. The ward round team lead by the head consultant, despite its changing configuration of members, did adapt. Observing a ward round team (with the same clinician) 1 year after deployment, I found that once again the team formed a horseshoe – this time around the patient as shown in Figure 28. They reported better communication, and observation revealed less wandering of individuals' attention.

The team eventually adjusted their interaction style after discussing (and discarding) alternative technologies. The ISG, for example, had wanted larger screens to reflect the A3 paper charts, but the cost was prohibitive. Projecting the chart onto a wall in a side room was also considered, but rejected for the morning round (although used in the afternoon round) because the practitioners felt that it was important to be at the bedside and include the bed nurse in the discussion. Projecting onto the wall behind the patient's bed, as found useful in (Kietz J. Hayes G. Abowd G. Grinter, 2006) would have been impossible given the machinery already hanging on the wall and would have compromised patient privacy. Tilted screens, given their poor visibility, would also not have been appropriate. Since there was no immediate technological solution, the ward round team had no alternative but to adapt.

Figure 28: The ward round team using the EPR 1 year after deployment.

The Adaptations

The Consultant

One significant problem noted in the use of the EPR in chapter 3 was the inability of the consultant to lead the interaction because the medical staff could not see the information he was reviewing or his reactions to it. The consultant's adjusted position, although still in front of, and oriented towards, the screen, is upright and several steps back. The registrars and medical staff rearranged themselves to form a horseshoe around the patient's bed. From this position, the ward round team can easily monitor the consultant's gaze and reactions toward the conversation. They frequently followed his gaze to the patient and attached machines used to monitor him or her (e.g. heart rate) or kept their attention on the faces of those speaking. The consultant, able to see everyone, leads the conversation, not by focusing the team's attention on the data as with the paper record, but on the conversation itself.

Medical Staff

This new formation supports a number of ways for the medical staff to enter the interaction, one of the chief concerns highlighted in chapter 3. As when using the paper record, the medical staff could catch the eye of the consultant and request the floor by leaning into the formation. The use of non-verbal behaviours more generally is facilitated by this arrangement. Further encouraging the interaction, the consultant logged out of the EPR and stepped back before the interaction ended, focusing attention on the interaction itself rather than the information in the EPR. He also posed general questions to the team to give medical staff an opportunity to speak up, with staff often leaning into the formation to answer the question or point to something. It is not surprising, then, that interaction between the doctors and the medical staff increased once this adjustment was made.

As was the case with EPR usage during the first round of observations, the main conversation remained dominant. Side conversations were rare and limited to a sentence or two, with the parties occasionally shifting closer to one another, but not re-orienting themselves. Following the completion of the ward round, however, there were numerous small conversations. As the intensive care pharmacist commented, before the introduction of the EPR she would have reviewed and made changes to drug charts during the ward round. Now she focuses on the team discussion during the

round and makes her interventions afterwards. On the one hand, there is a greater concentration on the main discussion, but on the other, less work can be achieved in parallel.

Paper

Another significant change was a much more visible use of personal papers or charts by the ward round team. Practitioners had always been provided paper print-outs with the names and vital information of their patients. In this observation period, 1 year after deployment, most of the ward round team had the paper records at hand and regularly checked them. This differed from personal paper usage during previous observation periods. When the paper patient record was in use, personal papers were mainly for keeping notes. During the first observation of the EPR, 4 months after deployment, personal papers were usually tucked away in a pocket and taken out only for the occasional reference, if at all. Queries to several practitioners revealed two possible reasons for these changes. First, many practitioners now do greater preparation before the ward round, making a note of questions or information that will help them follow the round on their print-outs. Second, although paper use was initially discouraged after the introduction of the EPR, its usage was accepted as beneficial.

Summary

The net result of these changes is an increase in communication between the doctors and the medical practitioners. The almost circular formation and a less constant orientation towards the data seemed to change the dynamic of the interaction. Medical staff responded to discussions more frequently without necessarily requesting the focus of the group. Their confidence to speak out may also have been bolstered by greater preparation before the ward round. However, on the negative side, what might have happened concurrently before, such as side conversation or drug review by the pharmacist, has to happen sequentially and therefore at another time. This is a finding consistent with other environments in which there is a switch from paper to electronic documents (Sellen & Harper, 2001).

END-USER SOCIO-TECHNICAL DESIGN

Introduction

The above section demonstrates that the ward round team adapted to the change in technology in a number of ways. They reconfigured around the patient instead of the computer display and carried with them more printed information about patients. Their willingness to adopt these strategies is in line with their efforts to customize their EPR software. A multi-disciplinary team designed the interface to suit the needs of the unit. Feedback was encouraged and even after two years, there remains an employee to continue to imagine new ways of interacting with, and utilizing, the data. The group's demonstrated effort to adjust both the technology and the interaction style suggests an opportunity for end-user 'customization,' or design, of group interaction as well. In other words, the end-users customize their group interaction by exploring and choosing an appropriate combination of technology and interaction techniques.

In my discussion with ISG reported above, the emphasis was first placed on adjusting the technology and then on the ability of the team to adapt. The process proposed in this chapter, in contrast, is a combination of assisting users in finding the best technology setup for their own communication

process and tweaking that process to make the technology useful. It is unusual perhaps for technologists to focus on designing the whole interaction rather than just improving the technology, or more precisely, to help the end-users do this. It is not without precedent to engage directly with users however. Participatory Design and End-User Development are two sub-fields of HCI that do. End-User Socio-Technical Design (EUSTD) utilizes ideas from both of these fields, but engages them simultaneously. The following sub-section details more exactly what ideas and inspiration are drawn from each of these sub-fields.

Background

End-User Development

End-User Development (EUD), as a field, has mainly focused on supporting a single user, sitting at a machine, trying to accomplish a programming task – similar to the basic HCI scenario mentioned in the first chapter, e.g. (Lierberman, Paterno, & Wulf, 2006). Little has been said about how an end-user developed system affects interaction between users, as in the ICU scenario presented in this dissertation. EUSTD focuses on such interaction. I highlight that the word interaction in this case refers to the group interaction with the machine which includes both interaction with other people as well as with the machine. It is not a referent used to denote interface design.

The most relevant studies to this goal in the area of EUD are those that do some ethnographic work when defining application requirements, e.g. (Stevens, Quaisser, & Klann, 2005). In such studies, the interaction between users is considered before the application is put in place, but not during the evaluation of the application when it is being used. Because I will focus on evaluation in this chapter, there are few specific ideas I can draw upon. Nonetheless, the goal of empowering end-users to shape their experience of technology is one of the guiding ideas behind EUSTD (Fischer, 1998).

Participatory Design

Participatory Design has developed a tradition of using creative exercises to prompt users to think about technology usage. Paper or clay prototyping or other art class exercises are common, e.g. (Schuler & Namioka, 1993). Researchers concerned with contexts of technology use extended the concept, using physical exercises such as body-storming (Burns, Dishman, Verplank, & Lassiter, 1994), in which people act out scenarios pretending that the everyday things in the environment can be used as an imagined technology. Svanaes & Seland have evolved these ideas still further, adopting exercises from art and theatre classes to encourage young people to imagine technologies that do not exist yet and how they might be used (Svanaes & Seland, 2004). EUSTD follows this pattern, drawing on contemporary dance rather than theatre exercises and applying them to situations of technology use and re-design, rather than initial design.

Choreographic Techniques

My focus on bodies-in-space and particularly my finding that non-verbal behaviour plays a significant role in supporting interaction in semi-mobile settings such as the ICU ward round made using choreographic techniques, which are meant to explore bodies-in-space, a natural choice as the basis for EUSTD. Choreographic techniques are used with dancers to inspire them to generate novel movement. In this case, I use the exercises to explore formations within teams, directing the experience to probe both conscious and unconscious movement. In pursuit of conscious movement, I use the exercises to provoke teams to try out and evaluate various formations while interacting. To

investigate unconscious movement, I utilize the choreographic exercises to help make visceral the often unconscious role of non-verbal behaviour in interaction.

Put in a technological context, these exercises can assist the exploration of the possible formations around various technology setups (conscious movement) and the needed group interaction techniques, e.g. non-verbal behaviours, for each (unconscious movement). As an example of the first, one could look at how the number, placement or mobility of displays, and the input capabilities, or software support for communication, affects formations during interaction. As an example of the second, a team might investigate how a given formation, such as standing in a straight line, affects interaction in order to realize and articulate each member's non-verbal interactional needs. Below I convey how choreographic exercises might be adapted to achieve such a purpose.

I begin by describing and giving examples of the choreographic process as used by dancers. Then I propose an analytical model that can provide the structure necessary to create exercises for EUSTD. Using this, I present example exercises appropriate for the ward round context based on arguments from the analytical model. I finish with an evaluation of the experience of these exercises in use at the CHI Design Theatre event.

The Choreographic Process

Choreographic tasks are designed to develop novel movement material by asking participants to be creative within a set of rules or restrictions. The first step is usually to generate movement material by providing a structure or set of rules and asking the artist to create within those. The resulting idea then becomes the seed for creative manipulation in a different task. Often the second task is to deform the movement material by applying a sequence of rules. Done recursively, the desired result is to generate material that would never have been imagined otherwise. The process finishes by reflecting on the material generated and choosing the most effective parts. The following is a concrete example of structures, rules, and the recursive process in a choreographic setting.

Step 1: Structure – Imagine that you are standing in a stack of three cubes. Each corner and segment mid-point are assigned to a letter spiralling upwards and clockwise. Spell your name by indicating each letter with any part of the body you choose. You may transition between letters and body parts as you like. (Brown)

Step 2: Rule Manipulation – Using the created solo, create a duet. Rules: (1) you must stay in contact with the other dancer at all times; (2) your head must never be on the same level as that of the other dancer.

Step 3: Recursion – Take your movement created in the duet and perform it as a solo.

Step 4: Review – You, or the choreographer, now must review the movement created and assemble it in such a way as to create a visually provocative piece.

Step 1 illustrates a structure to generate movement material. It is important to note that the structure provides some constraints, in this case the performer must not move off the spot, while it allows for variability in type of movement and length. Step 2 takes the movement material, and by applying rules, encourages the dancers to try out movements that they would not normally do. Step 3 is an example of the recursion process. Step 4 is the point when the dance piece is created. The

choice of structures and rules are important in determining the end result and should not be arbitrary. Below I build an analytical model from three theories of group interaction which will assist in inventing rules for EUSTD exercises, based on the above 4 steps.

The Analytical Model

In the choreographic process, rule choice is guided by the vision of the choreographer. To adapt this process to suit EUSTD, rules can be developed utilizing existing analytical perspectives of group interaction. I draw upon three: F-formation system theory, reflexive accountability, and socially distributed cognition. I briefly present the rationale for these choices in the paragraph below, and then summarize each of these analytical perspectives and their ramifications for creating EUSTD exercises in the following sub-sections.

One aim for EUSTD exercises is to explore possible formations around a given technology. Kendon's F-formation system (Kendon, 1990), introduced in chapter 2 & 3, can provide a foundation for such exercises. The second goal for EUSTD exercises is to make visible the often unnoticed use of non-verbal behaviours. As Garfinkel's theory of reflexive accountability (Heritage, 1984) offers a method for conceptualizing the role of non-verbal behaviours in establishing intersubjectivity, it can be a starting point for this kind of exercise. A distinct part of both of these goals is to examine how non-verbal behaviours are linked to information. As neither of the above two methods are concerned with information artefacts, I draw upon Hutchins's idea of socially distributed cognition (Hutchins, 1995).

F-formation System

The theory of F-formation systems articulates the systematic organization of groups who adjust their spatial and orientational arrangements to maintain an interaction. The empirical work that supports this theory indicates that different types of non-verbal behaviour are used to adjust certain types of relationships within an interaction. There are three types of relationships that could be interesting to explore in an EUSTD exercises: (1) inside versus outside of the group, shown with group formation; (2) alliances between members of the group, demonstrated by upper-body orientation; and (3) hierarchy between members, illustrated with posture/stance. Although an exercise might explore all three simultaneously, I will expand each individually for purposes of clarity.

In order to gain a sense of how different formations change an interaction, groups can do the same activity (e.g. a ward round) with different pieces of technology and compare the formations naturally used with each. Conversely, a group can carry out an activity without technology to find a comfortable formation for interacting, and then decide what kind of technology would support that style of interaction. To address issues of upper-body orientation or alliances between members, groups can experiment with different combinations of people sharing devices. What is the difference, for example, of two nurses sharing a device as opposed to a doctor and a nurse? Lastly, posture can be considered by asking the team to carry out an interaction while staring at a piece of paper or device with the direction only to look up once during the interaction.

The proposed exercises in the above paragraph are just a few examples. Employing some creativity, a researcher can generate numerous exercises by thinking of ways to manipulate the three relationships delineated above.

Reflexive Accountability

During a group interaction, one is always negotiating one's relationship to the others in the group by changing one's spatial position and posture, as illustrated in chapter 3. Indeed, this happens whether one would like it to or not. It would not be possible to stand entirely still for example, without affecting the interaction. The positions in space of members in a group then are reflexively accountable – a concept borrowed from ethnomethodology (Heritage, 1984).

Reflexive accountability posits that any action towards another is intelligible and accountable. In other words, no matter what action one takes, it will be interpreted, and accounted for, in terms of norms. For example, if one is greeted, one is drawn into an interaction in which any choice of return action (whether returning or not returning the greeting) will be consequential. If one chooses to uphold the norm and return the greeting, the interaction will be completed without thought. If one chooses to break the norm instead, and not return the greeting, the greeter will seek a reason and the negotiation of further interaction will reflect this. There are also an infinite number of in-between situations, such as a person returning the greeting but only turning the head rather than the upper-body, thereby signalling a desire not to break into conversation.

Most people are more or less aware of the reflexive nature of speech, even if they cannot describe it. People seem to be less sensitive to the effects of their non-verbal behaviours though, adjusting less easily to disturbances as a consequence. The beginning of this chapter demonstrates this point. The purpose of this kind of exercise then is to make visceral the sensation of the reflexive accountability of non-verbal behaviour. Kendon points out that a person's place in the formation affects her ability to signal others of her intentions as well as other people's ability to receive those cues. 'Unnatural' formations then should hinder the reflexive use of non-verbal behaviours. A starting point for exploration would be to carry out an interaction in unexpected formations, such as standing in a straight line or standing 35 cm apart. These are not unlike breaching experiments (Garfinkel, 1966).

This same idea can be extended to other non-verbal behaviours as well. Body-orientation, for example, could be highlighted by insisting that everyone stand at right angles; or gesture, by insisting that no gestures are used. The difficulty, or frustration, of completing these extreme exercises can bring awareness to non-verbal behaviour in more subtle contexts. The most important part of these exercises is reflecting upon the results that these rules have on the interaction. With some teams, a general discussion might suffice. In situations in which there is an embedded hierarchy or the participants are not well acquainted with each other, more structured reflection will be necessary.

One way to structure a discussion in a hierarchical situation, such as a hospital, would be to ask those at the top of the hierarchy what difficulties they perceive others face in this exercise. Likewise, those people at the bottom of the hierarchy can verbalize the difficulties they feel the people at the top might face. This type of reflection extends the consideration of reflexive accountability from one's own needs to that of others in the group. In a situation in which participants are less familiar with one another, one might use a technique similar to (Carroll & Kerridge, 2008) in which video clips of medical interaction were shown to doctors and specific questions were raised for discussion. As much thought must be put into designing the reflection period as into designing the exercise itself.

Distributed Cognition

The above discussion of F-formation systems and reflexive accountability is intended for exploring the physical setup of the technology, but not of its design as an information system per se. Hutchins' theory of distributed cognition (Hutchins, 1995) can support the creation of exercises that bridge the two – the physical setup and the design of the information system. He defines *distributed cognition* as the "propagation of representational states across a series of representational media" (p. 49). Drawing from his lengthy discussion of how distributed cognition is manifest in a particular environment, I see two ramifications for group interaction scenarios like the ICU. First, representations of data can serve as norms for thinking about data. Second, the physical appearance of the device no longer represents the informational state.

The creation and use of paper forms in an ICU is an example of representations serving as norms for structuring thought. Forms are designed so that the process of filling them in supports carrying out the steps of clinical work. They are also meant to highlight problems, so that they can be seen at a glance. Serving both these purposes, forms become the standard way of expressing a body of information. In a ward round for example, the order of discussion often follows that of the form. However, as only problem areas are usually discussed, if one does not have access to the form it can be difficult to follow and contribute to the conversation. Exercises should encourage team members to think about what information they need in order to contribute to interaction. One example would be to vary who has what information sources (e.g. a paper form or mobile EPR), and compare the interactions.

Hutchinson also points out that an important part of distributed cognition is making visible the information access of others by the visual appearance of a device. Well designed paper forms, often of different colour and shape, make it easy for group members to know what information everybody has at a glance. This is not the case with information technology with which the device does not represent its current information state. Group members cannot verify their expectations of others information knowledge and adjust the interaction accordingly. Exercises could explore the differences in interaction in a situation in which everyone is looking at the same information as opposed to everyone's having access to a large number of browseable forms. Mechanisms for indicating the 'state' of the information device, or what form is being looked at, might also be explored in terms of how the interaction is coordinated.

Example Exercise

When describing the analytical model, I pointed out a number of physical and informational aspects to be queried. The following example demonstrates how various choices can be combined into a single exercise for a particular environment. The specific scenario for this exercise is the ICU described in chapter 3. There are three problems highlighted in that chapter that I address in this example. First, the physical setup of the technology fractured the formation and was clearly one of the causes for decreased interaction between doctors and nurses. Second, decreased interaction was not quickly noticed and rectified because, in all probability, the importance and accountability of non-verbal behaviour to the interaction was not understood. Third, there was a discrepancy in information resources held by different members of the group, pointed out a number of times by the nurses.

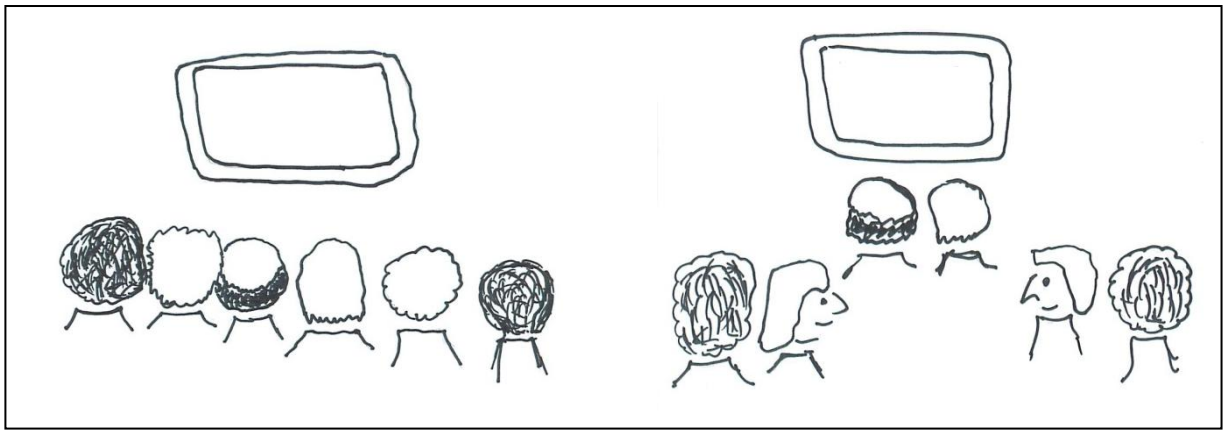


Figure 29: The straight line rule (Drawing by Nikiforos Karamanis)

The following example exercise is designed to help a team facing these problems find a better combination of technology and interaction style. It takes place in three parts and would be expected to take three hours. The reasons for the chosen constraints follow the presentation of the exercise.

The Exercise – Part I

Structure – A Ward Round Interaction

The ward round interaction provides the basic material.

Rules – The Straight Line

The team should carry out the interaction standing shoulder-to-shoulder in a straight line as in the left side of Figure 29. If members would like to turn, they can do so only at a 90 degree angle and all members must maintain a shoulder-to-shoulder connection as in the right side of Figure 29.

Iteration – Changing Places

The team should repeat the interaction generated in the 'Rules' section, but the consultant and bed nurse should change places.

Reflection – Structured Discussion

Ask each team member to state what options the nurse had to enter or advance the conversation in each location and then ask the same question about the consultant. Answers should first be written on a piece of paper and then put forward in turn, as might be done in a focus group.

The Exercise – Part II

Structure – A Ward Round Interaction

The ward round interaction provides the basic material.

Rules – Paper

Randomly give paper versions of the overview page of the EPR to half of the team members. Allow the team to create any formation that they want and have the interaction. (Be sure to note the formation down.)

Iteration – Looking Down

The team should repeat the same interaction done in the 'Rules' section, but each person is only allowed to look up from the paper once.

Reflection – Form Design

Showing a diagram of the formation created in the 'Rules' section, ask each person to say which other place they would have taken happily and why. Then ask them to say at what point they looked up , in the 'Iteration' round, and why. Then ask groups of two to create a form that provided all the necessary information for carrying out the task. To finish the reflection period ask each person to explain his or her form and discuss.

The Exercise – Part III

Structure – A Ward Round Interaction

The ward round interaction provides the basic material.

Rules – Adding Mobile Devices

Give half of the team members mobile devices which allow them to interact with the EPR. Ask them to find a formation that is comfortable and begin the interaction. Halfway through the interaction ask them to find a new spot.

Iteration – 50 Centimeters Apart

The team should do the same interaction as in the 'Rules' section, but each person should be 50 centimetres from every other person and with their back to at least one person.

Reflection – Reflexive Video Ethnography

Video the interactions and show snippets from each video. Discuss the choices people made to change position and how that affected the interaction.

Explanation of Choices

The first part of the exercise is designed to help the team understand the impact on the interaction of its ability to use, or not use, non-verbal behaviours during the interaction. The straight line should make it difficult to use 'normal' non-verbal behaviours. The iteration of changing places should emphasize to the most, and least, powerful members of the team respectively, the range of group interaction possibilities that exist. This should help the consultant adjust his interaction to increase the interaction abilities of the nurse and should help the nurse understand what kinds of changes she might make to have more interaction possibilities. The reflective discussion is designed in such a way that the difficulties of cross-hierarchy discussion are minimized.

The second part of the exercise focuses on how the physical setup of technology affects formation, and by consequence, the interaction. The exercise aims to capture all three issues that Kendon proposed – formation/group status, upper-body orientation/alliances, and posture/group-person relationship. Formation is explored by asking people to change positions during the interaction and then discussing these changes. Giving paper to only half of the team is likely to create alliances and be a means for discussing upper-body orientation and the effect of devices upon that. Investigation of posture is done through allowing people with papers only to look up once. This is likely to be very irritating during the exercise, but revealing during the discussion.

The final part of the exercise concentrates on the changes that information introduces to an interaction by giving each person access to all of the information on the EPR. The first rule allows the team to explore formation possibilities while the second iteration forces bizarre formations upon them in order to help the team understand the role of formation in interaction. This part of the exercise will either push the team to find new ways of interaction through the EPR or build in them a desire to find a formation that works – either way it is likely to be very educative. It is hoped that

watching the videos at the end of all of the exercise will strengthen the points brought up in the discussion along the way.

TESTING END-USER SOCIO-TECHNICAL DESIGN

Evaluating EUSTD is not straightforward. I have chosen a visual case-study approach, in order to weave a story of how EUSTD worked and illustrate the role of bodies through pictures. I will judge the exercise by whether it inspired creativity and reflection about the relationship of formation to non-verbal behaviour as that is its goal. I also include several questions that were asked by the audience at the Design Theatre event as they help clarify the more subtle aspects of the method. I begin by providing some background about how the exercise was carried out, including the situation and the specification of the exercise. I then present the visual case-study and responses to the questions.

Background

Context

I did not have the opportunity to try the EUSTD exercises with the ward round teams in the hospital where I did my observational study. As mentioned in the research inspiration section, the ISG were satisfied by the changes that occurred after my first discussion with them and did not feel the need to make further changes at that time. I did however, have the chance to test people's usage of an exercise on two occasions: first during a seminar in my research group in February 2008 with 25 people and then with an audience of about 200 at a CHI Design Theatre event in which the basic ideas of EUSTD were presented as a play in April 2008 (Morrison & Blackwell, 2008). The latter will be described here, with comments on changes from the first version.

CHI Design Theatre was a track dedicated to research presented in an unconventional, performative style. The exercise took place after a theatrical skit about the method of EUSTD. As a much larger number of people turned up than expected, I randomly assigned ten people to each of eight groups. Some people chose not to participate and they, along with the others for whom there was no space, sat and watched from their seats or wandered around to get a closer view. Each group was sent to a space where the exercise was setup along the walls and was given an instruction pack. With helpers, I went around to make sure that the exercise was understood and that the rules were being maintained. The groups had fifteen minutes to complete the exercise. It was not the ideal space or circumstances for the exercise but the participants were very enthusiastic. Figure 30 gives an idea of the overall space.

Figure 30: CHI Design Theatre Event (photograph by Luke Church)

Exercise

The exercise was an abbreviated version of part I of the exercise detailed above. In contrast with the one above, the structure needed to be provided since the participants were not doctors. I maintained the medical theme and asked people to diagnose a patient. An 'EPR' was mimicked through a chart of vital signs posted on the wall. A patient statement and family statement were distributed on paper to random team members and a description of illnesses was projected onto the screen on the wall opposite or perpendicular to the direction faced by each group, as shown in Figure 31. The distribution of information was intended to evoke the multi-disciplinary nature of the medical ward rounds and stimulate a need to share information. That said, all vital sign names and illnesses were imaginary in order to avoid a problem noted in the trial run in which participants got too involved in 'playing doctor' based on their previous hospital experiences as opposed to paying attention to the aim of the exercise.

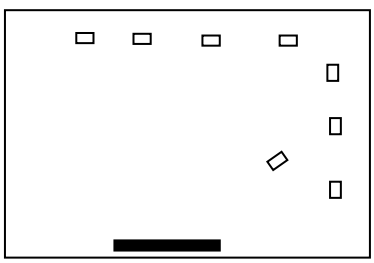


Figure 31: Diagram of the setup of the exercise. White boxes portray where the 'EPR' was attached to the wall and the black box depicts the screen onto which the illnesses were projected.

Figure 32: Participants carrying out the straight line rules during the exercise (Photograph by Luke Church).

Participants were given seven minutes to find the illness and they had to maintain the straight line rule described above: participants had to begin in a straight line standing shoulder-to-shoulder; participants could re-orient at 90 degree angles but everyone in the line had to remain shoulder to shoulder. Unfortunately, the short time slot did not allow for iteration. Discussion was then encouraged through a structured set of questions asking about abilities to interact in various positions. All of these documents can be found in Appendix A and an illustration of the exercise in action can be seen in Figure 32.

Visual Case-Study

The goal of this short exercise was to make the team members understand the importance of formation in supporting the use of non-verbal behaviours to negotiate a normal interaction. Judging whether this was achieved is not straightforward, but I will focus on two questions that provide indirect evidence of this. First, did the groups experiment creatively with, and engage in, the task? If this did not happen, it would be unlikely for the exercise to have had any impact on their understanding. Second, is there any indication of team members being more aware of their non-verbal interactions in the aftermath of the exercise, such as changes to, or comments about, non-verbal behaviour? Finally, I discuss a few changes that I would make if doing it again.

Figure 33: (a) Demonstrates usage of non-verbal behaviours – gesture, body-orientation, and posture; (b) engagement with the exercise

Figure 34: Creative solution to not being able to see the illnesses. The whole line moved away from the EPR.

Creative Engagement

There was an overall engagement with the exercise. Although one group appeared confused, most of the groups went ahead with gusto. The non-verbal behaviours seen in the left picture Figure 33a, and the concentrated facial expressions in the right picture of Figure 34Figure 33b, suggest both the effort and suspension of disbelief of the participants when performing the exercise. I also noticed several unusual interpretations of the rules, which indicates that the teams must have thought carefully about the exercise. The team pictured in Figure 34, for example, moved their entire line away from the wall and the EPR so that they might have better access to the screen on which the illnesses were projected. This was a creative response to their particularly bad location in the room.

Demonstrating Awareness

The goal of this short exercise was to make the team members understand the importance of formation in supporting the use of non-verbal behaviours to negotiate interaction as it normally occurs within groups. Three happenings suggest that the exercise was successful in accomplishing this goal: (1) the observable frustration felt by the members on the end of the line that resulted in their difficulty in abiding by the restrictions; (2) the structured discussion after the exercise; and (3) individual comments of participants. I discuss each of these in turn, drawing out evidence that indicates that participants began to realize the importance of non-verbal behaviour during interaction.

People had difficulty in maintaining the imposed formation of a straight line. In Figure 35a, one participant moved forward to point at something. When I told him that he could not do this, he became agitated and frustrated. This suggests that he was not aware of any other means of communicating his point. The participants in Figure 35b are in a circular formation discussing the exercise. They did not want to give up this formation until they had to at the start of the exercise itself. They thought it would be difficult to explain and understand the exercise while standing in a line. The team pictured in Figure 35c did manage to maintain a line but the end person is leaning inwards in order to get the attention of one of the other members. This is much more of a challenge in a line than in a circle. These three examples clearly show that the exercise was successful in making people realize their desire to enable: certain non-verbal interactions (Figure 35a), formations (Figure 35b), and the difficulty that a particular formation can impose on interaction (Figure 35c).

The discussion part of the exercise is the most likely place for the relevance of formation to be verbalized. Fortunately, most groups took the discussion quite seriously, as illustrated in Figure 35d. Although I was only able to listen to the discussion of one group, members made a number of comments that indicated new insight into the importance of formation for ‘smooth’ negotiation of the interaction. One person pointed out that the people in the middle had to make no effort to be aware of what was happening unlike the people at the end. However, people on the ends were in the best place to lead because they could see everyone’s reaction by looking in only one direction. Another pointed out that the people with the papers were given more visual focus and therefore tended to gain the leadership roles, while the others were asked to manoeuvre to maintain the rules.

A third means by which I gathered evidence of understanding was from people’s comments. One individual, a Google engineer, made his new insight clear by saying, “Oh now I see what you’re on about. No wonder my wife is annoyed when I play with my mobile phone when talking to her.”

More frequent comments were about how doing an exercise makes a concept more clear, particularly a concept related to one's physicality. Although it is unlikely that negative comments were passed on, I can surmise from this that at least for some participants there was more benefit to doing an exercise than discussing the topic.

Figure 35: clockwise from top left corner -- (a) one group member stepped out of line because of his frustration to communicate; (b) wanted to keep a circular formation while discussing the exercise; (c) engaged in the discussion; (d) end of the line person leaning in to interact.

Proposed Changes

Although the exercise went quite smoothly, there are three alterations that I would consider. Some, although not all, of the groups had great difficulty in maintaining the constraints. The urge for the end people to curve inwards was significant. We spent much of our time asking people to go back into a straight line. This was probably exacerbated by participants not knowing each other, a situation that makes interaction more difficult, and by the general rush and chaos associated with understanding and completing the exercise. However, in another execution of the exercise, I would make an effort to create more visible constraints, putting a piece of tape on the floor to mark the place on which each participant needs to stand, for example, or creating a low barrier, even using chairs, that people could stand behind.

The other two areas that I would revise, since they were not as successful in engendering results as expected, were the scenario and the discussion. An artificial scenario based on reality proved not to be a good idea, although it did work better with "false" illnesses. A more abstract scenario would have made it easier for these particular groups to focus on the aim of the exercise and not get distracted by notions of healthcare in various countries. The structured discussion was not as successful as I would have liked because often the groups did not carry out the discussion as asked. Moderation of the discussion is likely needed in some contexts. In summary, the scenario should not distract the group from the research questions and the discussion should provide a forum where all voices are heard, not only the loudest voices, or those of the most powerful team members.

Questions

The two questions below were posed by audience members of the CHI Design Theatre event. The answers are useful in clarifying the concept of EUSTD as well as drawing out points to reflect upon in the discussion section.

I am working with NHS staff to gather requirements to build a system that gives nurses the information needed for a particular patient at point-of-contact. They just won't do role plays. They freak out. The session always turns into a focus group. Do you have any advice?

Although EUSTD is similar to role plays, there are some subtle differences. First, the purpose of EUSTD, unlike role-playing, is not to gather requirements, but to adapt to a system that they already use. The medical practitioners are already experienced in improving their medical practice through adjusting processes and forms. In the ICUs discussed in this dissertation, they have established ways of contributing appropriately to the customization of the EPR considering the social and hierarchical circumstances of the ward. Drawing parallels for the participants from their current practices of improvement to what they would achieve in EUSTD, can help them link into the established routines of contributing to the development of the medical practice on the ward. In my experience, emphasizing the relevance of any activity to each person's own practice encourages them to partake in it.

There will undoubtedly be people who resist change. They may not want to explore new possibilities if they are satisfied in their current ways. They may not want their practices scrutinized for fear that the results may reflect negatively upon them (Sellen & Harper, 2001). They may not feel that the work required is relevant to their particular role in the organization (Martin, Rouncefield, O'Neill, Hartswood, & Randall, 2005). These are problems associated with the introduction of new

technology and are not particular to this method. One always needs to account for the organization context during the deployment of a technology and adjust accordingly.

Why is taking part in End-User Socio-Technical Design different from the medical staff creating scenarios verbally? Are they able to give you details that they would not be able to do otherwise?

As stated above, EUSTD is not about requirements gathering. The aim of the exercise is not requirements gathering for the designer/technologist, but a chance for the users to explore various technology setups and interaction possibilities for themselves. In particular, the exercises help them explore and make conscious the role of their physical bodies when interacting around technology. In my experience working with dancers and non-dancers, this is not something that can be easily imagined, but something the body must experience. If it could be easily imagined, people would be able to pinpoint group interaction problems in their minds and adjust accordingly, but the beginning of the chapter demonstrated that this is not the case.

Summary

The visual case study shows that EUSTD was successful in the CHI Design Theatre Event in creatively engaging the participants and helping them understand the role of their non-verbal behaviours in facilitating interaction. Although I cannot argue that this would work for all teams, the results of this trial suggest it could certainly work for some. Moreover, it might help the reader to continue to develop her sensitivities towards the importance of attending to the body when designing technology.

DISCUSSION

This chapter has looked at the ways an ICU adapted, and adapted to, an EPR. This is an important step in deploying EPRs and one of the main reasons for their high failure rate, e.g. (Scott, Rundall, Vogt, & Hsu, 2005). The first sub-section reflects upon the techniques used in the ICU and the second section looks at how the lessons learned here might be applied more broadly in HCI.

Benefits to the ISG

The ISG, particularly the consultant, claimed that the observed changes in formation in our final observation period were a direct result of our discussion. They pointed to the confidence that it gave to the medical practitioners, specifically the senior nurses and pharmacist, to be more insistent about their interactional needs. It also caused the consultant to consider how his leadership affected formation and the amount of interaction between doctors and nurses. Observing the leadership and consequent formation of ward round teams led by other consultants (in the same time period) suggested that not all consultants managed the round as effectively as the one whom we worked with. Another measure of utility of these results is their publication in a medical journal (Morrison, Jones, Blackwell, & Vuylsteke, 2008).

It is impossible to state with certainty however, whether the ward round team would have adapted, or adapted more slowly, without our discussion with the implementation steering group (ISG). I propose that most groups eventually adapt based on the many documented cases of work-arounds, e.g. (Sellen & Harper, 2001). However, there are a number of reasons to suggest that adaptation without intervention would be slower and perhaps even less effective.

People are very familiar with adapting group interaction when using paper. Sharing a textbook is part of most people's education, and using whiteboards, charts and other paper devices are common in the general work environment. Most people in the working generation have considerably less experience interacting around technology. Moreover, paper is a medium, unlike digital technology, in which people have the tools to experiment with and make changes, e.g. creating a new form or putting a whiteboard on the wall. It would not be surprising if the lack of technology-centred group interactional experience slows the adaptation process and the dearth of technical skill makes it less effective.

In particular to the medical setting, few people are accustomed to working with such large data sets and even less so, in a social context – an issue noted in chapter 4. Solving the conflict between group interactional needs and informational needs is likely to take some time, as the field of medicine gradually discovers the best way to treat patients using the large amounts of data that the EPR provides. Furthermore, this particular conflict is difficult to solve within the hierarchical context of the ward round. A break in the formation for example, most affects the nurses and associated medical practitioners, but requires that the doctors change their behaviour. Although it would be a tricky negotiation in any context, it is especially difficult if the doctors feel that they need intensive access to the information in the EPR to make good clinical decisions.

About a year and a half after our discussion with the ISG, at the time that I was working in conjunction with the consultant to publish the results of the ethnographic work, the consultant told me that he had started to re-position his ward round team members. He experimented with how the interaction between the doctors and the nurses changed when he asked people to stand in different places. He reported that the results of his experimentation aligned with what I had reported. He noted that moving his team members around was an especially useful technique when there was a registrar in the group who, by personality, dominated the interaction. Whether or not our conversation with the ISG catalysed the first adaptations, the consultant's intimate understanding of my ethnographic results gave him a tool to lead the interaction more effectively.

The above paragraphs suggest that the ISG gained from an understanding of bodies-in-space. Nonetheless, at the time of this research, they did not feel the need to explore this issue further using the EUSTD method proposed. (Hornecker, et al., 2006) discuss a similar problem with encouraging participation in a participatory design setting when there is no technological problem to solve. In that case there was an opportunity space, a better design for museum tours. In this chapter there is a problem, but one that is not easily recognisable as it is not linked to a piece of technology. As (Shapiro, 2005) urges, participatory design would benefit from a higher profile in non-HCI environments. This is particularly true in medicine where the design and configurability is crucial to the success of the software.

Benefits to the HCI Community

Reflecting upon the next era of computing, configurability, (Balka, Wagner, & Jensen, 2005) point out that it is important that "end users themselves have the capacity to appropriate the technology, struggle with its constraints, and find their own interpretation and set-up" (p. 87). EUD is working towards this goal for software design and EUSTD complements this effort by providing one tool to consider the set-up of technology for co-present groups utilising technology. Although this proposed method has the disadvantage of not being tested in the domain for which it was made, it still can

provide inspiration. Its theoretical construction can offer researchers and practitioners a starting point to develop context-specific exercises to support end users in finding an appropriate physical set-up for their technology and a complementary group interaction mode.

The work presented in this chapter, both the results of the discussion with the ISG and the proposition embodied in EUSTD, can also further the understanding of bodies-in-space. The CHI Design Theatre event demonstrated how powerfully formation affects the use of information and the negotiation of interaction by artificially constraining the possibilities of the body during group interaction. It highlights the need to find ways to help people consider how technology is likely to change their interactions with others and how they might adapt. Building upon the tradition of Participatory Design and End-User Development, this is feasible.

End-User Socio-Technical Design, like EUD, aims to empowering the user to define her own environment with the tools provided by the technologist in a participatory fashion, as in Participatory Design. As technology becomes part of every activity in life, there is greater involvement of people in creating the environments in which they live and work. Involvement ranges from creating content on web 2.0, to imagining new ways of interacting with Facebook, to manipulating interfaces or large sets of data through End-User Development. If technologists create the tools to help people add technology to their activities, why would they not create the tools to help them understand the impact of that technology and how to assimilate it – EUSTD is such a tool.

6:Bodies-in-Space in the Laboratory

Images produced with the bodyPaint application
March 2008

RESEARCH INSPIRATION

In the hospital context described in chapter 3, the physical setup of the EPR, a 19" display at the end of each patient's bed, restricted the formation of the team and consequently the participants' ability to feel part of the team and to utilize non-verbal behaviours in negotiating the interaction. The solution to this problem, caused in part by static display devices, might be to use mobile devices that allow people to configure themselves as necessary. It is also possible that using mobile devices would create new and equally problematic difficulties. For practical reasons, most importantly safety, it was not possible to explore the use of mobile devices as part of the EPR in the hospital setting. Neither would a typical laboratory experiment have been appropriate for such a socially complex situation. This chapter explores the use of a 'new media' arts application in an adjusted research cycle as the basis for exploring group interaction in the laboratory.

INTRODUCTION

The comparison of interaction when the ward round team used a paper patient record as opposed to an electronic one (described in chapter 3) demonstrated that these different technologies could support or hinder the negotiation of interaction by the team. With the EPR, there is tension between formation changes that occur as a means of interaction negotiation and ones that occur because of the physical setup of the technology, as team members balance between information and social interaction needs (described in chapter 4). I questioned whether mobile devices would defuse the formation conflict imposed by the static display, or make group interaction more problematic. Posture, for example, affects people's ability to interact, as does access to information – two things likely to change with mobile devices. To investigate this, I chose to look at what people do at the two extremes of display types, posing the following research question:

> **How does a team negotiate interaction differently when using a large shared display as opposed to individual small displays?**

Hospitals, particularly intensive care units, however, are difficult environments in which to do interventional (as opposed to observational) research, such as a technology probe or prototype. This is especially true if the proposed technology is very different from the status quo, as any upset can be life-threatening to a patient. In the unit that I studied, the implementation steering group (ISG) was not prepared to introduce mobile technology at the time of this study because they thought further change would be too stressful for the medical practitioners. I consequently aimed to do a laboratory study that would support the ISG as they continued to develop the EPR in their unit. However, as (Robson, 2002) notes, results from studies done in a laboratory do not translate easily to socially complex settings, because most of the social context is lost.

The central aim of this chapter consequently is to develop and test a research model that supports investigating group usage of technology for critical environments. I begin by reviewing how related studies have balanced the advantages of the laboratory with the need to maintain social context, providing initial guidance for the design of the study completed for this chapter (later referred to as the bodyPaint study). Highlighting the purpose of laboratory studies as they are most often used in HCI, to compare one situation to another, I suggest that the laboratory can also be a place to generate ideas and not just evaluate them. I propose a new media arts application as an element in an adjusted design cycle to achieve this, demonstrating this idea with a study of how two displays affect the negotiation of interaction that utilizes the application *bodyPaint*.

STUDY METHODOLOGY

Discussion of Literature

Studies in HCI frequently draw upon experimental methods to evaluate interface design decisions (Barkhuus & Rode, 2007). Experimental approaches have worked well for applications in which a single person uses a desktop machine. More recently, experimental methods have been applied to technologies used by groups (Hawkey, CSCW Workshop 2004). In the former case, there are many studies in which social context that is relevant to the application use does not differ dramatically between in-situ and laboratory environments. This is not true for the latter case in which the social context may dramatically alter the way that groups interact and therefore use technology during

interaction. The following sub-section highlights problems that arise when choosing participants, task, and measurements for studies of co-present groups using technology.

Corpus Study

As a starting point for this discussion, I have reviewed the design of studies of the corpus introduced in chapter 2 that includes studies of co-present group usage of technology. My aim is to highlight some of the difficulties that come to the fore when designing laboratory studies for groups. I looked at 52 studies that either referred to the technology as collaborative or portrayed multi-person, co-present interaction. Of the 52 studies, 32 described a novel piece of technology as opposed to requirements capture or design method. 13 of these studies presented technology with either no evaluation study or one so limited that the majority of details were not given. Of the remaining 19 studies, 1 presented a qualitative evaluation of technology in-situ, (vom Lehn, Hindmarsh, Luff, & Heath, 2007)'s discussion of technology that augmented a museum exhibition.

I will focus on the 18 studies that had an explicit evaluation period as that is the type of evaluation most similar to the proposed study. This narrowed corpus contains studies that can be split into two groups: (1) those that describe technology designed for a specific environment or activity, such as to assist travel agents (Rodden, Rogers, Halloran, & Taylor, 2003); and (2) those that focus on general properties of specific pieces of technology, such as tabletops, e.g. (Morris, Paepcke, Winograd, & Stamberger, 2006). The most significant difference between the two categories is the place of evaluation. The 7 studies in the former group are all evaluated in the environment for which the technology was intended, while the 11 in the latter group are evaluated in the laboratory. I will refer to these two groups throughout the analysis below as field group and laboratory group respectively.

Participants

In the narrowed corpus there are studies in which the unit of analysis is the individual in a group context and others in which the group itself is the focus. (Piper, O'Brien, Morris, & Winograd, 2006), a study that investigates the ability of autistic children to learn to work together using a tabletop interface, focuses on whether individual skills to participate in a group, such as sharing, increase with the use of the designed tabletop game application. It is an example of investigating individual behaviour in a group context. In contrast, most studies in the narrowed corpus aim to improve group interaction, usually the ability to collaborate. (Morris, Morris, & Winograd, 2004), for example, look at how private audio channels affect work strategy, communication, productivity and usability of the system.

The distinction between analysing the group as opposed to the individual in a group context is not made clear in most of the studies in the laboratory group. Of the 9 studies that employed statistics, all included an age range or mean and 7 identified the gender of their participants. None of these studies indicated the gender or age composition of the groups. The two studies that do qualitative analysis in the laboratory group were more careful in defining group composition. (Rogers, Hazlewood, Blevis, & Lim, 2004), for example, specifically look at the gender breakdown of their groups. Unlike in the field group, in which the nature of the group is established by the context: a group of musicians (Coughlan & Johnson, 2006) or a school class (Benford, et al., 2005), it is important to attend to the composition of the group in laboratory studies rather than the spread of individuals.

Perhaps the most important characteristic of group composition to group interaction is whether the group has previously done similar types of interaction. 4 of 11 studies in the laboratory group indicated that the participants knew each other well, mentioning that this is a factor likely to affect collaboration. These studies do not distinguish between types of knowing. I would argue that previous experience in doing the kind of task in the study together is more likely to influence the study then familiarity gained from knowing someone. Working as a team for example, suggests different relationships with people than being friends. *An important study design choice in the bodyPaint study is that the participants must have an established way of negotiating interaction as a group.*

Task

Task is another choice that influences how groups interact. In studies in the field group, the task is to use an application and related technologies to partake in a designed experience. In (Benford, et al., 2005), students collaborate to learn about the ecological system of the African Savannah. Studies in the laboratory, which usually use generic tasks that are thought to be representative of typical kinds of activities associated with a piece of technology, have more of a challenge to create social context in the experience. (Morris, Paepcke, Winograd, & Stamberger, 2006), for example, when investigating whether there should be multiple copies of menus on a tabletop, have a task of labelling photos. The lack of purpose in such tasks however, often does not motivate participants to engage with each other and the task.

Social interaction depends on previous social interaction, developing an emotional reaction to certain situations and people. For example, people are more likely to be willing to overcome difficulties in interaction when someone's life is at stake, as in a hospital, than when the outcome is unimportant. In laboratory studies, researchers often give monetary rewards to increase motivation, such as (Birnholtz, Grossman, Mak, & Balakrishnan, 2007). Whether this is appropriate motivation depends on the person and his or her culture. Anticipated financial rewards might help maintain motivation over repetitive tasks, but does not account for motivation being an emotional response (e.g. anger or strong sense of equality) which is likely to be a factor in collaborative interaction in a real-world setting.

There are two successful ways to motivate collaboration, particularly the emotional side of interaction, reported in the corpus: (1) games, and (2) creative experiences. Games tend to have motivation built into them with a surrounding culture of play and expectation. They have the further advantage of having been refined over time and are thus more likely to have rules that encourage interaction. (Winberg & Bowers, 2004) translated the Towers of Hanoi puzzle into a game for two people, for example, to study collaboration between the sighted and the blind. Established games, however, may not be available to study all types of interaction. An alternative is a creative activity, such as designing a calendar in (Rogers, Hazlewood, Blevis, & Lim, 2004). In creative interaction motivation comes from a sense of ownership and desire to achieve ones artistic goals (Gauntlett, 2007). *In the bodyPaint study, I chose to use a creative game as a way to increase motivation to negotiate interaction in such a way that would be reasonably comparable to the real-world situation.*

Measures

Measures, unlike participants and task, do not influence the social context in which the group interacts, but do affect how the interaction is understood. Of the 32 papers that discussed a novel

technology, only 19 evaluated group interaction in some way (usually referring to collaboration). Another 13 claimed their technology to be collaborative but did not provide evidence of this. These authors' decisions that it was unnecessary to evaluate this claim reveals a common implicit assumption that certain characteristics of technology, shared display the most frequently noted, lead without question to collaborative social interaction. This phenomenon was also noted and explored by (Rogers & Lindley, 2004). Uncritical claims about group interaction are not helpful, but assessing group interaction is not straightforward either (Hawkey, CSCW Workshop 2004). The researcher must determine what group interaction is in order to measure it.

Collaboration, the most common type of group interaction investigated in the narrowed corpus, is a word well understood, but difficult to define. Studies done in a context, such as those in the field group, skirt this issue by defining collaboration in terms of the context. For example, one of the design goals of (Rodden, Rogers, Halloran, & Taylor, 2003) was to relieve the socially awkward moments between travel agent and customer. The authors specified the difficulties in the ethnographic work and described how the new technology addressed these in the evaluation. (Benford, et al., 2005), taking a different approach, had a model of collaborative group interaction built into the technology and tested its suitability by deploying the technology and assessing its usage. In both cases, what was meant by collaboration was defined before the evaluation, either through the needs of the participants or through the technology itself.

It is more difficult to assess collaboration in the laboratory, in which the measures rather than the context define what collaborative group interaction means. In some cases group interaction is quantifiable, such as the number of conflicts resolved in a study of conflict negotiation. In many HCI settings, the researcher is interested in the *quality* of the interaction and whether the technology improves it. When investigating quality, it is often necessary to count some behaviour that is considered indicative of better quality but is not directly correlated. Equal participation or speech is an example of such a measure that is common to a number of the studies in the narrowed corpus. Unfortunately, the interpretation of such measures is often ambiguous.

Conflicting interpretations of several studies of tabletop displays illustrates this point. (DiMicco, Pandolfo, & Bender, 2004) measure the amount of speech during collaboration and assert that a more even distribution of speech across participants is an indicator of better collaboration. In contrast, (Rogers, Hazlewood, Blevis, & Lim, 2004) point out that some group members might choose to present alternatives on a display device without saying much, making them strong participators but 'under-speakers.' The contradiction between these two studies suggests that speech alone is not adequate as an indicator of equal participation. This is one example of many, in which construct validity -- that the chosen measures capture the desired phenomenon, is difficult to attain and demonstrate, when quality of interaction is being measured.

To reduce the problem of ambiguity (Rogers, Hazlewood, Blevis, & Lim, 2004), focus their study by defining clearly what is meant by collaborative interaction. They create a tabletop application that decreases asymmetrical access to, and the creation of, information. By reframing the enquiry from the general goal of looking at collaboration to the specific goal of decreasing asymmetric access, the authors can more easily specify appropriate measures that have narrow interpretations, increasing the likelihood of attaining construct validity. I take a similar approach in the bodyPaint study, by stipulating that *the study will look at the negotiation of interaction non-verbally.*

Summary

The design of all laboratory studies must balance between what is easily measured in the laboratory and what needs to be measured to provide results useful for developing technology for a real-world situation. The previous three sub-sections explored some of the study design decisions necessary in a laboratory study. I draw from these three criteria that I would like the bodyPaint study to meet:

(1) *Participants should have previous experience of negotiating interaction as a group.*
(2) *The task should be a creative game that suggests the limits of negotiating interaction.*
(3) *The measures should concentrate on assessing the negotiation of interaction non-verbally.*

This list is intended to optimize study design for laboratory assessments of group interaction around technology and provides a starting point for the bodyPaint study.

The discussion of study design so far has covered routine decisions but has not considered closely the purpose and type of knowledge usually gained from laboratory studies. One way of characterising laboratory studies is as a means to compare two entities. This might mean comparing one design decision against another; or, a technology solution against the replaced non-technology scenario. A laboratory study is not usually used, like a technology probe would be, to explore new modes of interacting, whether within a group using technology or with the technology itself. In the case of this chapter, the goal is to investigate the many ways group members can interact amongst themselves while using two different display types. I wish to find the boundary between possible interactions and not possible ones, rather than compare one way with another. I turn to new media arts for inspiration in how to set up such a study.

A 'New Media' Arts Approach

Suchman (2007) argues in *Human-Machine Reconfigurations* that new media arts is fertile ground for exploring such complex human-computer interaction issues as the one central to this dissertation. Her discussions lead the reader away from the prevalent computer science occupation with determining and debating the agency of the 'smart' machine towards a depiction of agency as a construction made by humans using machines. She suggests that while artificial intelligence as a field is occupied with the former debate, many new media artists, those who work with digital technologies as creative tools, are on the forefront of exploring how humans give machines agency. As artists, their approach is not one of reasoned possibility, but one meant to provoke an experience in viewers so that they explore the boundaries for themselves.

The design of the bodyPaint application follows a similar approach by motivating people to explore an 'interaction problem' by using a new media arts application. In pursuit of their own personal artistic goals, people generate a large number of possible ways of interacting. The result is a solution space of possible interactions for the researcher to analyse, fulfilling the study design goal of generating new ways of interaction. Embedding this new media arts application in a larger research process supports its generative nature. Once the researcher has analysed the data to determine the boundaries of interaction, in this study whether a group can or cannot negotiate interaction with a given technology setup, the researcher can then advise those in the real-world situation of starting points for developing their own interaction and the technology that supports it. This process is pictured in Figure 36.

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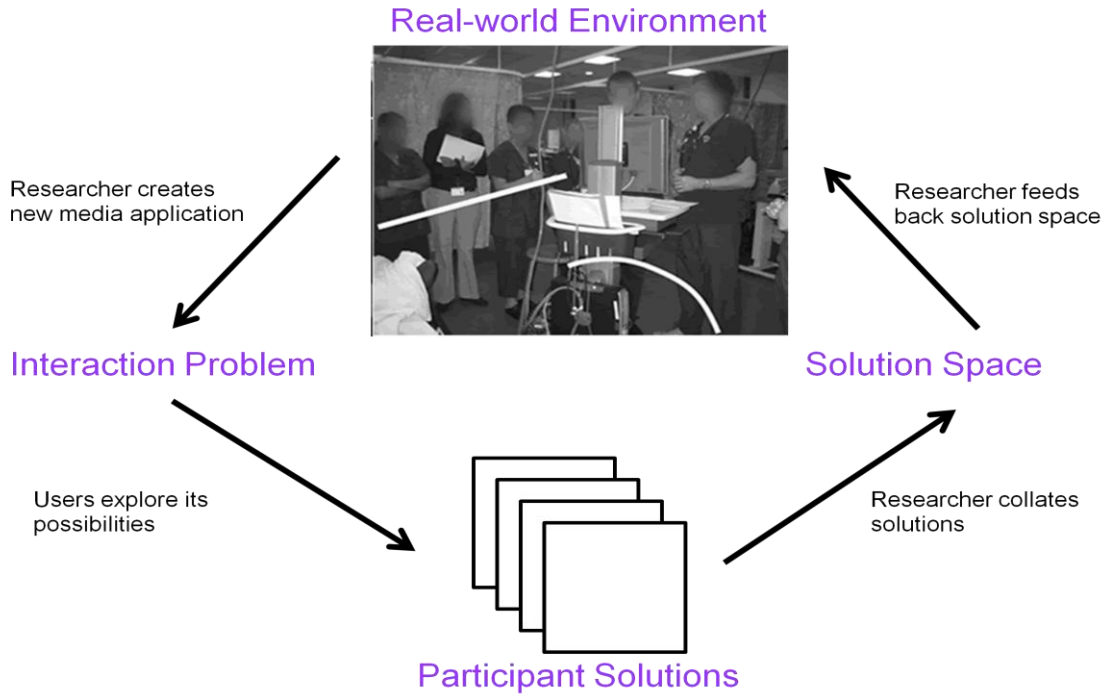

Figure 36: Using 'new media' arts to get from an interaction problem to a solution space

STUDY DESIGN

The study described below was carried out based on the research model described above which utilizes a new media arts application in a laboratory environment to explore interaction. The selection of task, participants, and measures reflects the conclusions of the discussion of the literature: (1) group not the individual is the basis for the study; (2) the task needs to motivate the interaction desired; (3) the type of interaction to be studied is the negotiation of interaction – how members participate in and advance the interaction.

The Artistic Experience (The Task)

bodyPaint Application

bodyPaint is an interactive multi-person paint program which I built in which three users control a single on-screen brush with their movements. It utilizes a Vicon motion capture system to track the position of participants' torsos and hands in three-dimensional space (Vicon Motion Capture System). Horizontal hand motion of the three participants controls the direction vector: the x-coordinate, the y-coordinate and the speed respectively. Moving around in the 2 x 3 meter grid controls the colour, line width, and drawing mode as indicated more precisely in Figure 37. The novel control mechanism, split between three people, used to manipulate the system in order to achieve the group goal, is intended to encourage group negotiation of interaction.

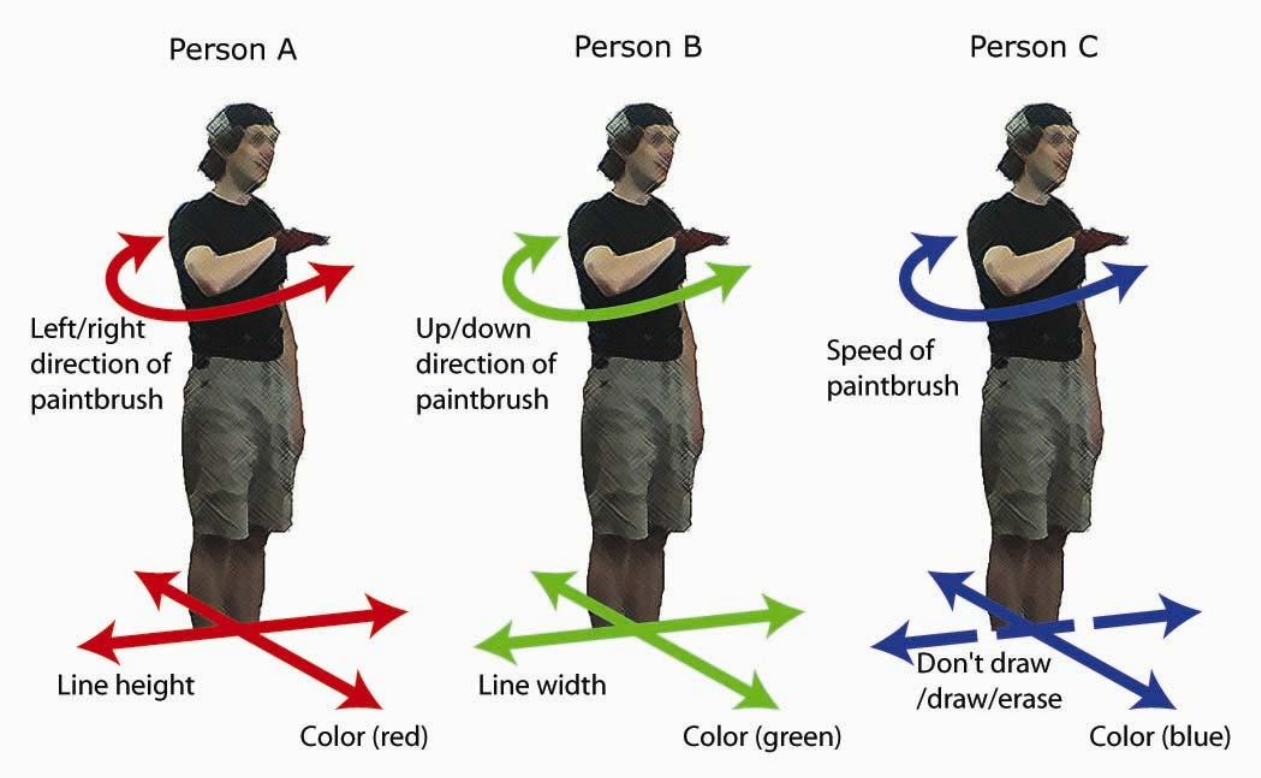

Figure 37:bodyPaint Application Controls showing the roles of the three different participants (Made by Alan Blackwell)

Figure 38: Drawings with the bodyPaint application

The Challenge

Teams are introduced to the application with written and verbal directions. Afterwards, they are asked to draw a square with sides of differing widths and a multi-coloured, unattached circle. They are free to ask questions while figuring out how the application works. The teams are then given the creative challenge of drawing their 'dream pet,' depicting a creature that includes recognizable features from at least three animals. Example creations are shown in Figure 38. This challenge is designed with the dual purpose of giving the participants some structure to get them started and of accentuating the negotiation of interaction.

Teams first need to negotiate which aspects of each animal to include, where to draw them, and how to shape them. For example, if they decide to draw the head of a giraffe, the body of a fish and the tail of a rooster, the team needs to negotiate a shared understanding of what that combined creature looks like -- size, position, and shape. It also must adapt that understanding as the picture develops and team members opportunistically take advantage of the unintended, depending on their positions and the state of the drawing. The constant need for negotiation gives researchers the opportunity to watch the negotiation process develop over time, the crux of the interaction problem.

The Teams (The Participants)

Group Selection

I invited four teams of three people each to use the system by asking one individual to bring two people that s/he had known for over a year and had collaborated with in some way (e.g. organized an event, worked closely on a publication or project). Fitting with the research model proposed, I wanted a diverse set of teams in order to increase as much as possible the number of solutions to the 'interaction problem.' As shown in Figure 39, the teams ranged from a design team to a family. I limited the number of teams to four in order to carry-out detailed video-analysis of their respective solutions.

Group 1	Postgraduate Research Team
Group 2	Family
Group 3	Design Team for Education Software
Group 4	Trio of Musicians

Figure 39: Team Composition

Figure 40: large, wall-projected display (left); individual, small display (right)

The Data Capture and Analysis (The Measurements)

Method and Theory

The goal of the data analysis, as put forward in the research model, is to describe the solution space of the interaction problem that I posed to the teams. I use video-based interaction analysis to generate a rich description of each solution. To structure the analysis, I drew upon the theory of F-formation systems (Kendon, 1990), a means of describing how people negotiate interaction by adjusting their formation, described in chapter 3.

Modes

In line with the research question posed above, "How does a team negotiate interaction differently when using a large display as opposed to individual, small displays?" -- I asked the teams to solve the 'interaction problem' in two modes. The first mode was a wall projected display 1.5 meters in front of the grid (Figure 40a), the second -- required the use of individual small screens strapped to the left arm (Figure 40b). I focused on the two extremes of display type in order to gather solutions that contrasted as much as possible, without significantly disrupting the creative experience. I did this by switching displays after twenty minutes, giving each team up to forty minutes to create its drawing. The teams did not find this switch disturbing, but used the break to discuss what they had done and what they would like to do. This format was chosen because initial use of the application suggested that a minimum of thirty minutes was needed to complete a drawing but that more than twenty minutes was too long for individuals to hold the small display units without tiring.

Data Analysis

I collated and organized these individual solutions into a description of the solution space by focusing on three areas of analysis: formation, learning, and preference.

Formation -- My original query asked whether there is a conflict between using formation to negotiate interaction and the formation possibilities of the physical setup of a given piece of technology. I investigate this by comparing how Kendon expects groups to act and how I observed them when using the bodyPaint application with two types of displays.

Learning -- With two different 'interaction problems' to solve, it is likely that a team's second solution will incorporate elements of the first. I minimize the effects of learning by making it one of

the main themes of analysis. For this reason, both the learning period and the main task were videoed and analysed.

Preferences -- A third area of interest is whether preference for one display type over another reflects differences in team members' abilities to negotiate the interaction. I gained data on preferences through a fifteen minute discussion following the use of the application.

ANALYSIS

Formation

This study was developed to investigate the conflict between the use of formation to negotiate interaction and the formation possibilities imposed by the physical setup of the technology in use. The aim of the analysis then is to tease out when adapting to the technology has a detrimental effect on the negotiation of interaction. I will begin by detailing the possibilities of interaction that a formation allows according to Kendon. I will then see if the formations of the groups differ from that which Kendon describes, and if so, whether the interaction possibilities have been lost or shifted to another medium.

Kendon

Kendon suggests that formation is a way of depicting relationships between people. One relationship is between those inside versus those outside of the group. For this reason, formations are generally circular and inward facing as depicted in Figure 41a. One capability that derives from an inward facing formation is the creation of a shared interaction space. The shape of the formation also demonstrates relationships between the people in the formation. In a horseshoe shaped formation, as in Figure 41b, some people, depending on their position, have more access to the interaction space. This person then has the opportunity to lead as others have more access to his/her non-verbal cues.

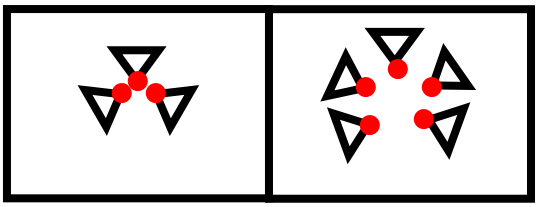

Figure 41: People in Kendon Formations: Circular (left), Horseshoe (right)

Examples of both of these concepts were demonstrated in chapter 3. The break in formation when the EPR was introduced, showed how a formation change caused by the technology did not define clearly who was in the group and who was not. It neither provided an alternative shared interaction space with the result of lack of interaction and wandering attention. The consultant's position at the head of the horseshoe shape in front of the paper patient record is an example of access to the interaction space and ability to lead.

Teams

The formations developed by the four teams did not differ dramatically. The teams oriented themselves towards the wall where the large display was located, as shown in Figure 42, regardless of the display type in use. Their spatial relationship, although partly determined by the teams' drawing needs, tended to be circular in nature. When teams needed to be in a more linear configuration to draw, one often bent down or turned

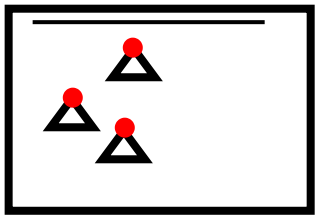

Figure 42: Typical Team Formation

slightly, maintaining a sense of circular dimension, rather than linearity. I would characterize the formation as circular, but not inward facing. However, the teams did re-orient inwards and move closer together when chatting during the technical break or at the end of the exercise.

The predominant team formation differed from Kendon's examples. Consequently, I looked for alternative ways used by the team to satisfy interactional needs that an inward-facing circular formation would have provided, notably (1) creating a shared focus; (2) using non-verbal behaviours other than formation to negotiate the interaction; and (3) establishing leadership or facilitating coordination.

Discussion

Shared Focus -- The formations of the teams made it impossible for the shared focus to be the enclosed interaction space as in the Kendon description. One possibility is that the happenings in the entire room made up the shared interaction space, something that might be tested if multiple groups were in the space simultaneously. Observation indicates that the focal point of the interaction space was the display(s). All teams spent the majority of their time with their members' eyes 'glued' to the display. A number of teams explicitly stated that the large display was a means for having a shared focus.

Interaction negotiation -- The forward-facing orientation necessary when using the large display would make it difficult for team members to see each other's non-verbal behaviours, which Kendon suggests groups use to negotiate interaction. Although a circular formation might have been difficult to achieve in relation to the large display, the small displays allowed people to orient towards each other. Nonetheless, the teams chose not to orient towards each other, stating a preference for the large display. They reasoned that the position of their heads, straight ahead rather than looking down towards the small display, made it easier to monitor their team-mates and their team-mates' movements.

Although non-verbal behaviours seemed unnecessary in coordinating activity when the teams were drawing, they reverted to using them and the associated formations when discussing their drawings during the technical break or at the end of the session. Non-verbal behaviours were also employed if there was a breakdown in communication. The most common strategy was first to instruct each other verbally if the drawing was not going according to plan and then strengthen the verbal communication with a turn of the head, followed by a re-orientation of the body, and as a last resort, use a gesture indicating what to do. This suggests that non-verbal behaviours (in this context) are most important when there is a misunderstanding or conflict but are not necessary all of the time. The amount of non-verbal behaviour also seemed to depend on the personality and expressive habits of each person.

Coordination -- Physical coordination, so that team members did not bump into each other, was not a problem. As soon as someone entered the space of another, the stationary person compensated, as one would expect. An additional means of coordination was the mental model of the grid, the 2 x 3 meter space in which the team members moved to control the paint brush. Even when the teams used individual displays, they oriented towards the large display, also the top of the grid, in contrast to the expectation that they would face inward. A number of people commented that this facing helped them know in which direction they should move and to predict where others might be. This could be one reason that teams did not orient inwards.

Coordination of the activity was another matter. Across teams there was a general consensus that the large display was preferred because it made monitoring the actions of others easier. Teams used different strategies for coordinating the task: two teams utilized a previous shared experience and two had to create rules as they went along. The design team for example, used very little verbal communication, relying heavily on pre-established interaction roles: the idea generator, the approver, and the helper. The idea generator proposed what was to happen, the approver said 'yes' or 'no,' and then they carried out the action. The team of research colleagues exploited their shared knowledge of Greek mythology and how creatures are made from different animals in order to describe what needed to happen.

The other two teams had more difficulty coordinating and took longer to settle on a strategy. One team, (the musicians), took nearly five minutes to draw the first line of their pet as they could not communicate what part of it they were drawing or what it looked like. Eventually team members relinquished individual control and allowed a leader to emerge who barked out orders to the group. Sarcastic comments about the leader in the discussion suggest this was not an optimal solution. The second team, (the family), also had a leader who directed everyone's action. However, this team agreed upon what they were drawing through a series of short consultations during which they formed a Kendon-style formation around the screen (both large and small) and used gestures to define the shape of the image.

Conclusions

An inward-facing circular formation provides a transaction space and a means to non-verbally negotiate the interaction. The teams in this study did not employ such a formation, but demonstrated a number of other ways of achieving the same level of interaction. Shared-focus was provided by the display; the real-time update encouraged constant monitoring. Shared experience or concepts were also employed to maintain a shared virtual 'sketch pad' for considering and coordinating ideas before they were drawn. Despite these substitutes, nobody was comfortable when s/he could not monitor, at least peripherally, the other people on the team. This was seen both in the desire for the large screen and the careful rearranging of heights when a linear formation was needed in order to draw.

Although the inward-facing formation that facilitates non-verbal behaviours to negotiate the interaction was done away with, non-verbal behaviours remained essential to the interaction, if at unusual times. The most common usage was to resolve conflicts or crisis, but they were also important at other times. For example, the family created an inward-facing formation to facilitate non-verbal behaviour when planning, or re-planning, their drawing. The music trio, unable to solve the interaction problem because their practiced non-verbal behaviours did not serve them in this context, had to resort to an autocratic leader. *These results suggest that there are alternatives other than an inward-facing circle for productive interaction around technology, but that the alternatives should be closely scrutinized because not all of them are optimal.*

Learning

Watching the learning process was another goal of this study. Both the 'learning period' with the technology as well as the creative task itself were videoed and subject to analysis. The learning period demonstrated a number of formations tried and discarded, indicating the relative importance

of various formation factors. The main task period also revealed whether the physical setup of technology was prominent enough to change established ways of interacting.

Two groups learned the application with the large display and two with the small one. The two that learned it with the large display faced toward it in both modes, not even considering an alternative formation with the small display. Those teams that learned the application with the small display began drawing in an inward-facing formation. This dissolved within the first five minutes as team members began to move along the grid. The inward-facing formation was again tried when the small display was used after the large display, but disappeared even more quickly. This immediately suggested that the inward-facing formation was not necessary for coordination. *It also indicated that the physical setup of the technology does not seem to dictate, only guide, the choices of how participants organize themselves.*

Preferences

Another important issue was how preference changed observable behaviour, which I explored in a short focus group following the activity. I asked team members to sit around a one meter square table covered with paper. They were asked three questions and encouraged to write or draw before answering in turn; they were told that they could freely react to what others said. The questions were:

1. Did you prefer the large screen or the small one? Why?
2. How did your group make decisions about what to do next?
3. If you could have displays of any size, anywhere in the room, where would you put them?

In each of the four groups, two team members preferred the large display and one the small display. In all four cases, the person who preferred the small display used a lot of non-verbal actions -- gesticulation, engaged posture, and turning to face the person spoken to. The small displays facilitated the use of these non-verbal behaviours. Nonetheless, the display type did not change either the teams' coordination strategies or the formations. This implies that preferences are particular to an individual's personality and do not affect his or her ability to participate in the team.

The last two questions did not lead to any helpful information. The teams had difficulty describing their decision-making process, and their thoughts as to how things might have been different were not particularly imaginative or revealing. At this point the participants were very tired, though, and they did not seem to feel like answering questions.

Application to Hospital Environment

Several of the insights acquired as a result of this study are applicable to further exploration in the hospital environment. First, fostering a shared perspective could be useful in circumventing some possible issues introduced by new technology and should be considered as part of the development of a system. This would not have to relate to the application specifically, but could be linked to an information structure for providing care or a social protocol. It should be noted that when the physical setup of the technology makes the negotiation of interaction with non-verbal behaviours impractical, and there is no shared perspective, there is the danger that some team members will be unable to participate.

Second, the deployment of individual small displays for each team member is probably not a useful direction for further exploration. Their incorporation into other technology setups might be a more productive avenue, such as one or two members of the team having a handheld device to supplement the existing display. Third, individual preference for a display type does not affect how a team coordinates. It seems that teams can adapt to a variety of physical technology setups if given the opportunity. Although their ability to do this should not be the default, it should be taken into account when considering tradeoffs.

DISCUSSION

Summary

In this chapter I have described a laboratory study intended to generate ideas about how a group can negotiate interaction while using technology. I first reviewed relevant literature to produce criteria of study design that would optimize the results for groups rather than for the individual. These criteria were easily incorporated into the study and therefore do not need to be discussed further. I then suggested that a different way of thinking about the study was needed to change it from an evaluation of an idea to a means of generating new ideas. I proposed the use of a new media arts application in an adjusted research cycle to achieve this. It is this proposition and its usefulness that I discuss in this section.

In the first sub-section I consider how this different perspective on laboratory studies influences study design. I discuss the resultant, if unusual, choices of task, participants and measures. In the second sub-section I look more closely at the success of this idea in achieving the end goal. The third sub-section examines the benefits of such a study to the HCI research community.

Discussion of Study Design

Task

The task does not look like any activity that takes place in a ward round. Instead, the bodyPaint application maximises the amount, and quality, of negotiation of interaction in the laboratory setting. This choice follows the example of much of psychology by isolating the phenomenon of study in the laboratory. Although there is much debate of the external validity of such an approach (Robson, 2002), as the purpose of this study differs from those in psychology, I would argue that it does not fall prey to the same criticisms. Isolating a phenomenon in the laboratory often ignores the influence of social context on the results. In the study proposed in this chapter, the balancing force of social context is not gained through the laboratory study, but rather by its place in a larger research cycle.

The ethnographic work done in the hospital prior to this study pointed out a clear area of difficulty – the negotiation of interaction while using displays. Although it was not the only problematic area, chapter 3 argued that it was a significant one and that improvements in this area would have palpable benefits for multi-disciplinary communication. The task was therefore focused to explore this phenomenon specifically and not ward rounds more generally. The results were then fed back to the medical team for further experimentation in situ. Unlike experimental studies in psychology which produce a final result, the study proposed in this chapter generates ideas for investigation in a scenario that maximizes social context.

This approach stands in contrast to a more usual approach of simulating an activity in the laboratory. Simulations might be partial, as often done in HCI, with the task reflecting an activity common to the real-world situation, the ward round in this case. Or, simulations might be entire, re-creating the situation and its environment precisely. In medicine, such simulations are not uncommon and often use patient actors and real medical cases. It is easy to assume that since the simulation 'looks' like a ward round, then the results are automatically 'correct' and applicable to the original environment. However, this may not be the case. Partial simulations are unlikely to capture the complexity of the ward round and full simulations are likely to lack the motivation of the original environment.

Medical practitioners do not have strong motivation to resolve conflicts that arise while negotiating interaction during simulations as the patient actor is not in danger. For example, if it is difficult for a nurse to participate, she may not make an effort to do so if not absolutely necessary. It is for this reason that I have chosen to focus the task on increasing the motivation to negotiate interaction, the phenomenon of study, using the new media arts application which encourages participants to provide interaction solutions for their own creative purposes, and not a simulated task.

Participants

The choice of participants for the study in this chapter is also unusual. Similar to the reasons for using simulation described above, it is not uncommon to use participants from the real-world environment if one cannot carry out the study in that environment directly. I chose not to do this because the aim of the research model is to produce as many and as varied solutions as possible. Asking a ward round team to be participants and do what they usually do is unlikely to be generative. Most teams have established ways of working and may not be keen to experiment. Using other participants provides a fresh perspective on how one might go about solving this particular interaction problem. It is for this reason that I chose diverse sets of teams (within the criteria that they had worked together before) to maximize possible variation in solutions, rather than follow the norm of laboratory studies to minimize variation between participants.

Measures

The measures used in the study presented in this chapter derive from theory-structured qualitative analysis. This differs from the norm of using quantitative measures in laboratory studies. Quantitative measures are used to compare one situation which another. There use therefore requires a base line against which to measure change. In many areas of HCI research the goal is to make the interaction with the machine the same as that with a human – human interaction being the base line. For example, the studies of remote collaboration tools aim to make them as effective as face-to face interaction. The aim of the study in this chapter is to improve upon this standard base line, to make face-to-face interaction more effective by using technology.

The measures consequently need to be generative as well as evaluative. It is for this reason that the analysis describes a solution space rather than a single solution. I try to determine the boundary between possible interaction modes and impossible ones. Theory of group interaction supports this endeavour by providing a source for comparison, and evaluation, of solutions without minimizing their number. I take example from (Rogers, Hazlewood, Blevis, & Lim, 2004) and (Winberg & Bowers, 2004).

Discussion of Research Model

There is evidence to suggest that this research model and the bodyPaint application provided useful insight into how the ICU might continue to develop its EPR. The ISG have taken up all three propositions of the conclusions of this study: (1) They have facilitated a shared perspective by making an effort to design a paper print out that supports the ward round. (2) They are in the process of supplying their pharmacists with a mobile version of the EPR but decided against giving mobile devices to everyone. (3) They have actively adapted to the technology setup they have by adjusting the social process of the ward round. Although it is not possible to say, as discussed in chapter 5, whether my suggestions came before or after their ideas to carry out these changes, these changes validate that the study produced fruitful results.

As in any laboratory study, there are aspects of the results which could be considered in finer detail through further related studies. Several of these points were mentioned in the analysis section. The one that is most likely to give additional insight is to explore how participants react to changing the grid that they use to control the bodyPaint application. The simplest way to do this would be to introduce the bodyPaint controls in a different way, emphasising that the current 'side' is the 'front' and see if the participants orient themselves differently. It would also be interesting to make bodyPaint responsive to a person's direction relative to their previous position rather than to absolute space. This, however, is a whole new design problem. These further explorations would help nuance the description of the solution space.

Benefits to the HCI Community

This chapter, like the previous one, presents a study that 'improves' technology not by changing the technology itself, but its usage. It supports end-users in making decisions about what technology they should use and in what kind of social interaction. It generates new kinds of interaction between a group and a piece of technology. It is not unlike the use of design games in Participatory Design to provide a common ground to end-users, designers and researchers (Brandt, 2006). This study acts much like a probe in a design context; however, the probe is not a piece of technology, but a study, and the designers are not professionals, but end-users.

7:Bodies-in-Space

Space Walk
Yinka Shonibare, 2002

INTRODUCTION

This dissertation attempts to move from bodies in space to bodies-in-space. Yinka Shonibare's, *Space Walk,* succinctly depicts bodies in space – the presence of bodies without clear relationships, physical or social. I present the idea of bodies-in-space, that is, how bodies relate spatially and posturally to each other during group interaction. Chapters 3 through 6 demonstrate four methods I used for exploring bodies-in-space to inspire others who wish to take such a focus when designing or evaluating technology for co-present groups. After summarising the contributions of each chapter individually, I consider the lessons that can be drawn from the empirical work about bodies-in-space. I then reflect on how this research fits with discussions of embodiment in the HCI community. I conclude by discussing future work.

Chapter Contributions

Chapter 3

Chapter 3 derives from the question of how to observe bodies-in-space. It builds upon Kendon's theory of F-formation system to provide a framework to observe bodies-in-space when doing video analysis. It can be used to describe interaction around technology or to evaluate a new technology. Above this analytical contribution, the analysis indicated a useful result – formation, and breaks in it, is a simple, rough indicator that the technology is causing a social interaction problem to which the group is not adjusting. The chapter captures a perception of movement in a way that provides a coherent method to perceive bodies-in-space, a first step before design or evaluation can be considered.

Chapter 4

Chapter 4 presents a notation system to capture bodies-in-space during social interaction in real-time without the support of video. I discuss notations used in HCI to express social interaction (often around technology) as well as summarise insights from the field of dance notation. From these, I derive a notation suitable to capture observations of bodies-in-space. Although the proposed notation is specific to the context of use for which it was developed, it serves as an example of how one might come up with a similar notation system for other studies. It also helps make explicit the relationship between formation and the other non-verbal behaviours encapsulated implicitly in chapter 3.

Chapter 5

Chapter 5 examines how groups might adjust, and adjust to, technology. It begins with a discussion of how one team adapted in the ICU and then presents the idea of End-User Socio-Technical Design as a way to support groups in the adjustment process. Drawing on choreographic techniques and analytical perspectives of social interaction, I propose a framework for designing exercises that would help a team in a specific context explore: (1) the impact of formation on their ability to communication; and (2) alternative technology setups.

Chapter 6

Chapter 6 investigates how bodies-in-space can be explored in the laboratory. Inspired by the desire to explore the possibilities of using handheld devices in conjunction with the EPR and being unable to do so in the ICU unit for safety reasons, I probe what a laboratory study might offer to understanding bodies-in-space. After reviewing relevant literature, I present criteria for optimizing

laboratory studies for group interaction around technology in contrast to an individual using technology. I then propose that laboratory studies could be used to generate ideas, and not just evaluate them. I present arguments to support the use of a new media arts application in an adjusted research cycle to achieve this. The bodyPaint application is a demonstration and evaluation of this research model in practice.

Summary

These methods approach the body-in-space from a number of different angles. In chapters 3 and 4, the methods support researchers doing observational research, playing the outside eye. In chapter 5, the method is meant to inspire researchers or practitioners to create exercises that will help end-users engage with the concept of bodies-in-space and the issues that arise subsequently. Finally, in chapter 6, the method provides researchers with a starting point to investigate bodies-in-space in the laboratory. The diversity of these methods is useful in that they can be chosen to suit the study of technology in different contexts. They also provide different kinds of empirical data, which can be brought together to generalise properties of bodies-in-space, as is done in the next section.

Lessons Learned

1. Group formation frames the interaction space.

Group formation frames the interaction space. It helps to determine what is, and what is not, part of the interaction. The mechanism of this framing is the shape and sanctity of the formation. Chapter 5 illustrated the difficulties of interacting when teams stood in a line and no interaction space was demarcated. Chapter 3 adds a further example of how shape frames the interaction, illustrating a preference for inward facing formations that differentiate between the group, the ward round team, and not the group, the other activities in the ICU. The sanctity of the interaction space created by the formation is illustrated in chapter 4, in which people only cross through the centre of the formation when their action is the focus of the interaction (e.g. being asked to check patient data).

Group formation as the demarcation of an interaction space has a number of ramifications for the design and evaluation of technology. Technology used by co-present groups can easily affect the formation and therefore the interaction space. Designers can think about whether the possible formations that users can make will exclude anyone from the interaction space or will create an interaction space that includes activities or people who should not be part of the interaction. One 17" monitor would be an example of the former, and an 8 foot projected image in a room with 30 chairs, an example of the latter, for a ward round of 9 people. *For most types of small and medium group interactions, the group should be able to surround and enclose the interaction space as much as possible.*

How groups input into a system is also an issue for groups interacting with a piece of technology. This has been extensively examined in the area of Single Display Groupware, a term first coined by (Stewart, Bederson, & Druin, 1999). Researchers have looked at issues such as whether multiple inputs devices should be used, e.g. (Birnholtz, Grossman, Mak, & Balakrishnan, 2007); or whether collaboration can be encouraged by distributing the input devices (Hornecker & Buur, 2006). Another dimension to add to this area of research is whether using input devices disturbs group interaction by forcing someone to inappropriately cross the interaction space. *Designers should*

minimise entry into the interaction space to use an input device, unless that movement in specifically designed to modify the human-human interaction.

2. Group Formation determines access to the interaction.

This dissertation looked at five types of non-verbal behaviours that affect how groups negotiate interaction: group formation, upper-body orientation, gesture, posture, and object manipulation. Chapters 3, 4, and 5 provide examples that demonstrated that group formation affects all other non-verbal behaviours, allowing or restricting them. The consequence of this is that group formation determines: (1) the access of each group member to the other group members' non verbal behaviours; and (2) who has access to what kinds of data. The following paragraphs will detail several examples from this dissertation and consider the ramifications for the design and evaluation of technology for co-present groups.

In order to negotiate interaction, which is done largely non-verbally, group members need to have access to others' non-verbal behaviours. This access is determined largely by formation. A circular formation gives each member the same access, while other formations privilege certain people. The horse-shoe formation used around the paper patient record in chapter 3, for example, allows everyone to easily see the consultant at the head of the horseshoe and for the consultant to easily see everyone else. This would be less true for people on the sides of the horseshoe. Nevertheless, the minimum requirement for a formation that allows everyone to participate is that it be continuous. *When the physical set-up of technology for co-present group interaction is being determined, choices that would lead to breaks in a formation should be avoided.*

Group members' needs for accessing data are also likely to be an issue that affects formation. It is difficult to create a rule for all groups as needs will be affected by the activity taking place and the relationships of people in the group (e.g. the hierarchy). However, the following questions are useful to ask. Does everyone have access to the data that they need to participate in the interaction? This may include access to data directly or access to what information others are viewing. Chapters 3 and 5 together, for example, show that nurses need a sub-set of data that the doctor uses, but it is important for them to know what data the doctor is viewing. This may also include access to data that others are not viewing. *When considering the display and input devices that will be used, it is important to test (analytically or in-situ) whether the combination of physical set-up and software gives appropriate access to data.*

The above lessons learned are meant to avoid problems that a technology set-up might cause co-present groups using them. Designers who are not constrained by what physical set-ups they can use may like to think of how their design encourages formation. Just as certain shapes afford certain manual interaction, as described to the HCI community in (Norman, 1988), certain physical set-ups afford different formations. These can be considered with the rules above, but may also be extended to think about design of the interaction on a more fundamental level. For example, how does a physical technology set-up balance between data access and interaction possibilities? – a tension seen in chapter 4. *There is a large design space in considering how technology supports groups that will augment designs if explored.*

3. Build the physical intuition of designers and practitioners.

The above lessons for examining bodies-in-space are aimed to support researchers and designers exploring embodiment when designing technology for use by co-present groups. They offer analytic

insight into bodies-in-space; however, they do not support the development of a designer's physical intuition. As many designers depend heavily on their repertoire of examples when partaking in creative design exercises (Herring, Change, Krantzler, & Bailey, 2009), it is important to also develop a designer's physical intuition. Chapter 5 provides starting exercises for designers to internalise bodies-in-space concepts. *Designers should partake in such exercises, developing their own as appropriate, in order to physically internalise embodied concepts*.

4. Be prepared for adaption.

Much of the technology that we use today is, from an embodied perspective, not particularly different from non-digital technologies such as paper or slide projectors. Consequently, many of the rules about formation articulated with those technologies also apply to digital technology. As digital technologies develop, and people have different means of accessing information, like the continuous updating property of the bodyPaint application in chapter 6, rules about formation are likely to be altered in some situations. Nonetheless, if one continues to ask the questions about how people have access to others' non-verbal behaviours and to data, answers will remain a useful design guide. *It is important then, to be aware of how and why we use our bodies to non-verbally negotiate interaction, so that the embodied perspective continues to evolve with technology.*

EMBODIMENT

The previous section summarised the four methods demonstrated in this dissertation for exploring bodies-in-space in different contexts and some useful lessons learned from the empirical data gathered. This section looks at how this research fits within the broader HCI literature, returning to the starting point of this dissertation discussed in chapter 2, embodiment.

Seeing the body

Chapter 2 began with a discussion of embodiment as characterised by (Dourish, 2001) for the HCI audience. My review proposed that his work provided a strong theoretical foundation for studying embodiment in HCI, but did not offer tangible methods for considering the body in social situations and how to account for this in the design process. The methods presented here aim to fill in this gap, offering ways to do observational research, participatory design and laboratory work. These methods can be added to the toolkits of designers and researchers to be used when creating or evaluating new technologies to support the interaction of co-present groups. As (Hummels, Overbeeke, & Klooster, 2007) point out, it can be difficult to explore, visualise or reflect upon physical interaction, without appropriate tools.

Using techniques that help visualise and reflect upon bodies-in-space can address a number of the problems raised in the corpus review. These tools provide ways to critically reflect upon the knowledge people have about the use of their own bodies when interacting socially. This will give greater subtly to design rationales based in the body, avoiding ones that may not always be true, such as, if the digital world mimics the real world, it will be easier to use (see p 17). These tools may also inspire designs that move beyond the display, providing a structure to encourage designers to think about tangible and ubiquitous solutions as well. Lastly, some of the methods can offer alternative means for evaluating technology used by co-present groups.

The angle on embodiment taken in this dissertation, however, is just one of many. Other characterisations of the philosophical field of embodiment exist, such as (Robertson, 1997) and the study of the body is done in varying ways in many sub-fields of HCI. The area of whole body interaction, e.g. (England, Hornecker, Roast, Romero, Fergus, & Marshall, 2009) and movement-based interaction, e.g. (Mueller, Stevens, Thorogood, O'Brien, & Wulf, 2007) for example, investigate how physiology and movements of the body can be used as inputs to systems. Tangible computing looks at optimising the physical interaction between an object and a human. Examples include examining physical manipulation, e.g. (Manches, O'Malley, & Benford, 2009) and creating tools for sketching movement (Parkes & Ishii, 2009). Ubiquitous computing often considers movement of bodies through space, such as in exhibits, e.g. (Cosley, et al., 2009).

Each of these areas contributes to different ways of seeing the body. Most of the above examples focus on the physicality of the body to which this dissertation contributes the added angle of the body as a social tool. As the body becomes a more regular focus, these different perspectives overlap. For example, when (Morrison, et al., 2009) discuss findings of a study that compares an augmented map with a virtual map display, they consider the tangibility of the augmented paper map as well as highlight its role in encouraging a formation that stimulated group interaction. As technologies move off the desk, their designs will continue to benefit from a rich and varied empirical literature in HCI that stimulates understanding of how the physical nature of the body influences technology design. It also provides inspiration for methods of exploring it.

Approaching the body

These varied perspectives on embodiment discussed above come not only from looking at different types of technology, and therefore focusing on specific aspects of the body, but also from drawing on a range of fields outside of HCI. Some of those are other academic fields, such as the philosophy of embodiment (Dourish, 2001) or sociology (Heath, 1986) and provide strong theoretical and methodological grounding. Others come from artistic disciplines that offer a very different kind of knowledge which is less easily captured in words. (Candy, 2007), for example, draws on fashion design to reflect upon how technology influences a person's movement style. (Jacucci, Jacucci, & Psik, 2005), on the other hand, proposes the art of directing theatre as a useful way to encourage designers to think about movement.

This dissertation attempts to combine the strengths of academic and artistic knowledge by drawing on social science and dance. Social science gave the theoretical start for exploring bodies-in-space, which came from the F-formation system (Kendon, 2009). Dance provided practical wisdom in assisting my exploration of bodies-in-space as well as contributed directly to the methods. Chapters 4 and 5 draw explicitly on dance practice. (Jacucci, Jacucci, & Psik, 2005) points out that the value of artistic methods comes in driving the creative process of others, encouraging people to explore embodiment rather than learn about it from a written statement. Bodies-in-space is strengthened by its combination of academic and practical knowledge of embodiment.

This combination of approaches contributes to the variety of frameworks that currently exist to think about bodies, or embodiment, in some way. The focus of frameworks and methods span the gamut from technology-centric to body-centric. (Bongers & van der Veer, 2007), for example, looks at the body's abilities in terms of inputs and outputs in order to make specific inferences about the design of multimodal spaces. (Benford, et al., 2005) also takes a technology-centric approach, investigating,

movement and mobility from the perspective of designing sensor-based technologies. In contrast to Bongers & van der Veer, they do not use language that portrays the body as an extension of the machine, but similarly, they limit the investigation to aspects of the body that can contribute directly to the design of a specified technology.

(Loke, Larssen, Robertson, & Edwards, 2007) take a more body-centric approach. They compare four different frameworks for investigating movement in interaction design, several of which are focused mainly on the body, such as the use of Laban notation to describe movements when interacting with technology. Bodies-in-space sits more on this side. This gives it the advantage that it can be applied to many types of technology, as opposed to the more techno-centric frameworks which are oriented towards a specific kind of technology (e.g. sensing technology). However, it has the disadvantage of needing to be applied. This may require a researcher with ethnographic skills and knowledge of embodiment and therefore bodies-in-space concepts may not be fully available for everyone's use. Nonetheless, the range of methods proposed should be able to offer some insight to any given person, whether researcher, designer, or medical practitioner.

FUTURE WORK

This dissertation was written with a focus on embodiment, rather than health informatics, in CSCW, even though the practical application of this work is in health. Situating the idea of bodies-in-space in CSCW health informatics however, can lead to a number of interesting extensions of this work. I have chosen four papers against which to frame ways in which the research in this dissertation complements, or could be extended in future to augment, areas of research reported in the CSCW health informatics community.

An Embodied-Perspective

Workplace studies has provided one way to consider the body in CSCW studies of health technology. (Svensson, Heath, & Luff, 2007) is an example of this technique used in healthcare, looking at the use of instruments in an operating room and how they form the basis for collaboration. This approach, drawing on a branch of sociology -- ethnomethodology, aims to articulate the accomplishment of interaction through very close scrutiny of particular short incidents as described in chapter 2. Although this includes body movement, the narrative structure of the interaction is one of the primary vehicles of analysis. This technique is particularly useful for considering certain aspects of interaction (e.g. the nature of collaboration) or detailing work practices, but only covers some aspects of embodiment.

The concept of bodies-in-space offers an alternative approach to the body and consequently different insights into embodiment. Bodies-in-space is not wedded to the conversational structure and therefore reveals systems of non-verbal behaviour more readily because they are compared in relationship to each other rather than as addendums to speech. This is a useful perspective within which to evaluate new healthcare technologies which might disturb non-verbal interaction systems. It also provides some useful lesson learned for designers and practitioners without experience in embodiment to utilise and introduces to those with a greater interest in embodiment some social science literature and theory not widely used in CSCW.

To understand bodies-in-space, I chose not to formally include speech and information artefacts in the analysis, although they are present in my field notes and therefore impact the analysis. This

extreme was useful in finding a way to consider the body and non-verbal behaviour as part of a system of its own. However, it would be interesting in future work to consider both the verbal transcripts and relevant screen recordings in relation to the video to see what other insight might be gained from considering the non-verbal system in relationship to other interaction systems.

New EPR Designs

This dissertation did not address directly the design of EPR software. However, it is interesting to consider how bodies-in-space might affect software design, particularly EPRs. Most EPRs look like standard database record systems that could be used in any domain, and have been criticised for this property of being a passive record, e.g. (Fitzpatrick, 2000). (Cabitza, Simone, & Zorzato, 2009) have taken on the challenge to reconceptualise EPRs and present a novel idea of what an EPR might alternatively look like based on their studies of paper and electronic patient records in use. After summarising their design, I will discuss how the empirical work in this dissertation complements their design.

ProDoc, the EPR design written about in (Cabitza, Simone, & Zorzato, 2009), is based on three basic tenants: (1) 'Let me keep my folders,' which suggests that folders rather than a dashboard style of information grouping is more useful; (2) 'Let me do what I do on paper,' which indicates that annotation is important and the continual design of forms is also helpful to the constant improvement of healthcare; (3) and 'Integrate data and processes but don't mix' em up,' which states that maps, rather than scripts that insist on certain logic, support doctors in keeping with clinical pathways without the need for designing a record around them. These tenants are elaborated and linked to design decisions in the paper.

The rationale for many of these decisions is based on how a single clinician interacts with the EPR. However, my findings suggest that these tenants of design may be useful to support group interactions as well. Folders are one way to provide visibility to the categories of information being currently viewed. Likewise, the flow-chart set-up of ProDoc that requires clinicians to choose a branch to follow, affords another mechanism of visibility of choice and allows verbal negotiation of the conversation as clinicians decide which path to follow. These are two of many examples of how ProDoc software may help transfer some of the non-verbal negotiation of interaction to the verbal realm. On its own, this may or may not be useful, depending on the dynamic of the round.

The choice of technology set-up and viewing rights (e.g. can people view different things) however, can be aligned with the design choices of this software such that people's actions are more visible and therefore allow ease of non-verbal negotiation. The short description of ProDoc in (Cabitza, Simone, & Zorzato, 2009) suggests to me that there might be a number of ways that the design of software supports the physical set-up, which in turn, supports multi-disciplinary interaction. This is an area that would be interesting to explore with further description of the system and ultimately, field studies with the system.

Deploying EPRs

CSCW literature has detailed, in studies of EPR usage, many of the social reasons why it is difficult to deploy them successfully, even when well designed. (Pinelle & Gutwin, 2006) offers some of this evidence and a compelling frame to think about deployment issues, loose coupling. They argue that loose coupling is a phenomenon common to healthcare settings, characterised by autonomy of, and boundaries between, entities. Loosely coupled organisational structures can make deployment of

EPRs across organisations difficult. While loose coupling is often identified between organisations or departments, it can also be between individuals (Pinelle & Gutwin, 2005). As my research looked at multi-disciplinary teams rather than health organisations, I will consider what bodies-in-space has to offer situations of loosely coupled multi-disciplinary teams.

(Pinelle & Gutwin, 2006) document four problems in deploying EPRs in loosely coupled organisations: (1) difficulties centralising deployments; (2) perceptions of inequity; (3) role conflicts; and (4) problems with achieving critical mass. While these authors provide a number of examples at the organisational level, my work can provide examples of these four elements within the ward round team. For example, chapter 3 illustrates how perceptions of inequity may be felt by the formation that the EPR affords. In chapter 4, I discuss role conflicts between information seeking and teaching and how that plays out non-verbally. Not only does my work provide a possible extension of the theory proposed by (Pinelle & Gutwin, 2006), but it also suggests that an embodied perspective might offer new insights or interpretations of their categories.

These authors also proposed several strategies to support deployment, many of which support acceptance and more importantly, adaptation. These include using focus groups and bottom up deployment, identifying local champions, aligning roles and responsibilities and addressing inequity early in the deployment process. The research in this dissertation agrees with these and can offer additional insights and methods for adapting to situations in which bodies and embodiment are concerned (e.g. chapter 5). Interestingly, the ICU studied and many of the hospitals in the associated user-group, state that EPR offers many benefits to the medical team but many are note seen until one to two years after deployment. This suggests that adaptation after deployment, particularly for issues of embodiment, would be complementary further work.

Other Healthcare Technologies

The research in this dissertation provides an embodied perspective for evaluating the impact of a technology on the non-verbal negotiation of interaction in ward round. Currently, I have only considered static monitors and co-present teams. However, the lessons learned can be applied to other technologies, such mobile devices (as partially done in chapter 6), large screens and possibly remote group situations such as telehealth. The results of (Kane & Luz, 2006) in particular, describe a situation in which bodies-in-space might be adapted to. These authors, when comparing multi-disciplinary communication in co-located and remote meetings, note that stated preferences and the actual use of the technology change, as do patterns of non-verbal behaviours across these two scenarios. It is possible that these two observations are linked.

The study says that the survey data of doctors indicates that they prefer looking at projections of medical artefacts (e.g. radiology reports). In the co-located situation this is all that they use, but when discussing with remote parties, 60% of the time is spent looking at the video link of the other party and not at artefacts on the screen. The authors suggest that video supports the communication and by the end of the study 70% of the doctors agree. Video is thought to support communication because of the access it gives to facial expressions and other non-verbal behaviours. Consequently, careful consideration of the camera angle is important in relaying non-verbal behaviour accurately (Nguyen & Canny, 2009). Bodies-in-space could be adapted in future work to look at non-verbal systems in remote situations using video links.

CONCLUSION

I have presented four methods in this dissertation for researching bodies-in-space. These include seeing, notating, and choreographing bodies-in-space, as well as studying them in the laboratory. I then look at the lessons learned from the empirical data collected in this dissertation that might be applied more widely. Considering the start of this dissertation with discussions of embodiment, I examine what bodies-in-space offers the field of embodiment in HCI, both in how bodies are seen and how they are approach. Although the dissertation must be focused in scope, I conclude with a discussion of four areas of CSCW health informatics that I might expand this research into in the future. The most compelling area within these based on my three years of observing the customisation, deployment and use of an EPR in an ICU, is adaptation.

Adaptation may be a simple issue of changing a piece of technology, or slightly more complicated of changing interaction style, or perhaps, changing the way medical practice is done. The head clinician of the ISG recounted a story that suggests how much adaptation needs to take place. During an unusual power outage, the nurses followed the emergency plan and took out the back-up paper charts and started to fill them in. Even nurses with more than twenty years experience with paper charts found it very difficult to remember how to use them. The EPR had changed the way that the nurses thought about data and their role as nurses, and they were not able to quickly shift back to the paper record. Although anecdotal, this story indicates that the period of adjustment is often about substantial changes in the way people view their work.

Adaptation is an area of HCI that has been considered in sub-fields, such as Participatory Design and End-User Development, but it does not seem pervasive in HCI thinking and the design of technologies. Indeed, some argue (and are correct for certain technologies) that required adaptation is a signal of bad design (Krug, 2006). However, when technology alters the way in which people carrying out their work, such as EPRs, adaptation is essential. I would argue that it is important to continue to remember that the boundaries of HCI do not stop at designing technology. As technology continues to change the way that our society is structured, it is important that HCI researchers support this process of adaption and resulting social change.

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APPENDIX A

The material used to carry out the End-User Socio-Technical Design activity at CHI Design Theatre.

1. Directions and Discussion Questions
2. Electronic Patient Record
3. Virus Definitions
4. Patient Statement
5. Family Statement
6. Reference Sheet

Directions and Discussion Questions

Directions:

Task: Using the information that you have please decide what ailment the patient has.

Rules:

1. The group should stand in a straight line, shoulder to shoulder.
2. Any member of the group can change position to stand at a right angle to another person, but the group must adjust so that everyone remains shoulder to shoulder.

Getting Started:

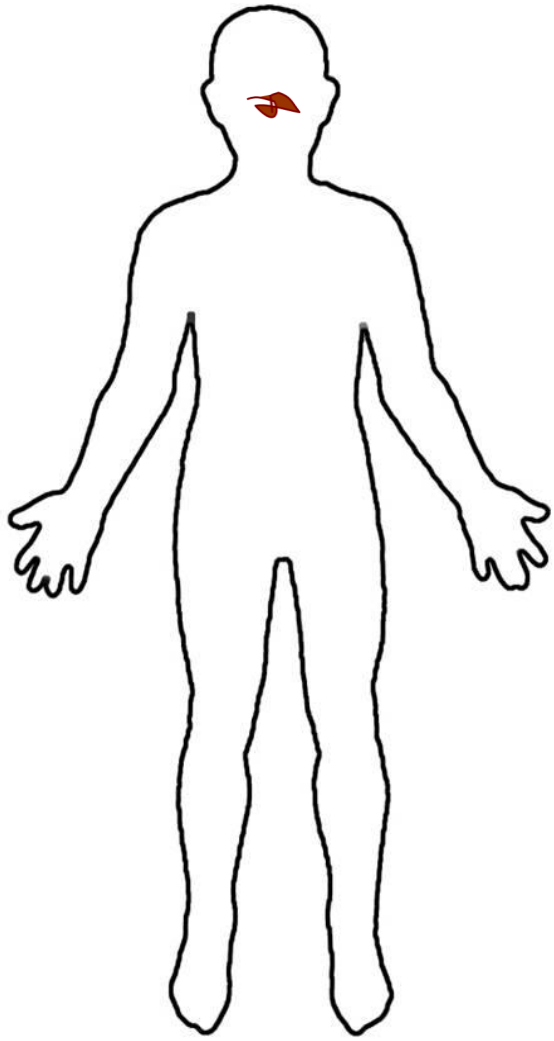
1. Pass out the sheets of paper randomly to members of the group.
2. Work on the task for 7 minutes until the moderator tells you to stop.
3. Gather together as a group to discuss the activity using the following questions.

Discussion Questions (5 min):

Ask each person in turn:

1. Who was in the easiest place to communicating and who, the most difficult?
2. Which place would you like to have stood most?
3. What kind of technology or tool could have made the group interaction easier?

Electronic Patient Record



Red: Liaisons on Tongue
Green: Swelling

Temperature (every hour)	Heart rate (every hour)
38.2	110
38	115
37.9	105
38	103
37.6	100
37.3	90
37	92
37.1	89
37	95
36.9	85
36.8	90
37	83
37	82
37.2	81
36.9	75
37	74
36.9	79
36.8	75
36.8	72
36.6	70
36.5	69
36.6	72
36.5	73

Medications	Other
Parafo Tristo	Bellin Pragma: 130/80 Woll Bee Count: 105 Crettlin Level: 3.5 Prostatic: 8

Virus Definitions

Astroid Virus

Common Symptoms:
Diarrhea,
high crettlin levels, liaisons on tongue, swelling in chest, headache, watery eyes, constant high temperature

Possible Symptoms:
thirsty, may have high prostatic

Notes:
More likely to occur in patients with high bellin pragma; only known to exist in Africa

Banchee Virus

Common Symptoms:
fever, swollen or watery eyes, cough with lots of mucous, high cretin levels, low white blood cell count, rapid pulse

Possible Symptoms:
diarrhea, blood in urine, swelling in the body

Notes:
Usually comes on suddenly

Carrfo Virus

Common Symptoms:
liaisons, cold sweat, headache, cough, blood in urine, high prostatic levels

Possible Symptoms:
very thirsty, blurred vision or red eyes, high woll bee count, gas

Notes:
Patients often lose consciousness before symptoms are noticed

Patient Statement

I felt strong allergies yesterday. My eyes and nose were running and I had a strong headache.

Family Statement

We were so glad to have our son home from Africa and celebrate his return but now we are very worried. He seemed alright yesterday though.

Reference Sheet

Results

Bellin Pragma	Low: 110/60	High: 140/90
Woll Bee Count	Low: 60	High: 100
Crettlin		High: > 4.5
Prostatic		High: > 6
Thelma	Low: 35	High: 37.5

Medication

Parafo reduces fever
Tristo slows the heart rate
Galgan reduces swelling
Rerefen reduces cretin levels

Appendix B

Papers included in the corpus

ECSCW 2003

Tourism and mobile technology. **Brown, B and Chalmers, M.** pp. 335-354.

Supporting Collaboration Ubiquitously: An augmented learning environment for architecture students. **Iacucci, G and Wagner, I.** pp. 139-158.

Reconsidering Common Ground: examining Clark's contribution theory in the OR. **Koschmann, T and LeBaron, C.**

System Guidelines for Co-located, Collaborative Work on a Tabletop Display. **Scott, S.** pp. 159-178.

CHI 2003

Designing novel interaction workspaces to support face to face collaboration. **Rodden, T, Rogers, Y, Halloran, J, Taylor, I.** pp. 57 - 64.

CSCW 2004

Influencing Group Participation with a Shared Display. **DiMicco, J.M, Pandolfo, A and Bender, W.** pp. 614 – 623.

Concepts that Support Collocated Collaborative Work Inspired by the Specific Context of Industrial Design. **Wang, H and Blevis, E.** pp. 546-549.

Collaborating around Collections: informing the continued development of photoware. **Crabtree, A, Rodden, T, Mariani, J.** pp. 396 – 405.

FishPong: encouraging human-to-human interaction in informal social settings. **Yoon, J, Oishi, J, Nawyn, J, Kobayashi, K, Gupta, N.** pp. 374 – 377.

Avoiding Interference: How people use spatial separation and partitioning in SDG workspaces. **Tse, E, Histon, J, Scott, S, Greenberg, S.** pp. 252-261.

Assembling the Senses: Towards the Design of Cooperative Interfaces for Visually Impaired Users. **Winberg, F and Bowers, J.** pp. 332 – 341.

Territoriality in Collaborative Tabletop Workspaces. **Scott, S, Carpendale, S and Inkpen, K.** pp. 294 - 303.

Exploring the effects of group size and talbe size on interactions with tabletop shared-display groupware. **Ryall, K, Forlines, C, Shen, C, Morris, MR.** pp. 284-293.

Lumisight Table: a face-to-face collaboration support system that optimizes direction of projected information to each stakeholder. **Matsushita, M, Iida, M, Ohguro, T.** pp. 274 – 283.

Individual Audio Channels with Single Display Groupware: effects on communication and task strategy. **Morris, MR, Morris, D and Winograd, T.** pp. 242-251.

Beyond "Social Protocols": multi-user coordination policies for co-located groupware. **Morris, MR, Ryall, K, Shen, C, Forlines, C, Vernier, F.** pp. 262 – 265.

Supporting Informality: team working and integrated care records. **Hardstone, G, Hartswood, M, Procter, R, Slack, R, Voss, A, Rees, G.** pp. 142 – 151.

Physiological Indicators for the Evaluation of Co-located Collaborative Play. **Mandryk, R and Inkpen, K.** pp. 102-111.

Situating Evaluations in Scenarios of Use. **Haynes, S, Purano, S, Skattlebo, A.** pp. 92 – 101.

Collaborative Knowledge Management Supporting Mars Mission Scientists. **Tollinger, I, McCurdy, M, Vera, A, Tollinger, P.** pp. 29 – 38.

CHI 2004

Tangible Interface for Collaborative Information Retrieval. **Blackwell, A, Stringer, M, Toye, E, Rode, J.** pp. 1473-1476.

Release, Relocate, Reorient, Resize: fluid techniques for document sharing on multi-user interactive tables. **Ringel, M, Ryall, K, Shen, C, Forlines, C, Vernier, F.** pp. 1441- 1444.

Production of Pace as Collaborative Activity. **Galani, A, Chalmers, M.** pp. 1417 – 1420.

Finger Talk: collaborative decision-making using talk and fingetip interaction around a tabletop display. **Rogers, Y, Hazelwood, W, Blevis, E, Lim, YK.** pp. 1271-1274.

Caretta: a system for supporting face-to-face collaboration by integrating personal and shared spaces. **Sugimoto, M, Hosoi, K, Hashizume, H.** pp. 41 – 48.

ECSCW 2005

Between Chaos and Routine: boundary negotiating artefacts in collaboration. **Lee, C.** pp. 388 – 406.

A Design Theme for Tangible Interaction: embodied facilitation. **Hornecker, E.** pp. 23 – 43.

An evaluation of techniques for reducing spatial interference in single display groupware. **Tsandilas, T and Balakrishnan, R.** pp. 226 – 245.

CHI 2005

Life on the Edge: supporting collaboration in location-based experiences. **Benford, S, Rowland, D, Flintham, M, Drozd, A, Hull, R, Reid, J, Morrison, J, Facer, K.** pp. 721-730.

Livenotes: a system for cooperative and augmented note-taking in lectures. **Kam, M, Wang, J, Iles, A, Tse, E, Chin, J, Glaser, D, Tarshish, O, Canny, J.** pp. 531 – 540.

Roomquake: embedding dynamic phenomenon in the physical space of the classroom. **Moher, T, Hussain, S, Halter, T, Kilb, D.** pp. 1665-1668.

Giving the Caller the Finger: Collaborative Responsibility for Cellphone Interruptions. **Marti, S, Schmandt, C.** pp. 1633 – 1637.

The Syntax or the Story Behind It: a usability study of student work with computer-based programming environments in elementary science. **Louca, L.** pp. 849 – 858.

CSCW 2006

Representations at work: a national standard for electronic patient records. **Bossen, C.** pp. 69-78.

Formalizing work: reallocating redundancy. **Munkvold, G, Ellingsen, G and Koksvik, H.** pp. 59-68.

SIDES: a cooperative tabletop computer game for social skills development. **Piper, AM, O'Brien, E, Morris, MR, Winograd, T.** pp. 1-10.

CHI 2006

Tabletop sharing of digital photographs for the elderly. **Apted, T, Kay, J and Quigley, A.** pp. 781-790.

Collaborative simulation interface for planning diaster measures. **Kobayashi, K, Narita, A, Hirano, M, Kase, I, Tsuchida, S, Omi, T, Kakizaki, T, Hosokawa T.** pp. 977-982.

Designing appropriate affordances for electronic photo sharing media. **Lindley, S and Monk, A.** pp. 1031-1036.

Cooperative Gestures: multi-user gesture interactions for co-located groupware. **Morris, MR, Huang, A, Paepcke, A, Winograd, T.** pp. 1201-1210.

Disruptions of meetings by laptop use: is there a 10-second solution . **Newman, W and Smith, E.** pp. 1145-1150.

Collaborative coupling over Tabletop Displays. **Tang, A, Tory, M, Po, B, Neumann, P, Carpendale, S.** pp. 1181-1190.

BodyBeats: whole-body, musical interfaces for children. **Zigelbaum, J, Milner, A, Desai, B, Ishii, H.** pp. 1595-1600.

Towards Computer-supported Face-to-Face Knowledge Sharing. **Iwasaki, S, Hirakawa, Y, Masa, H, Tokunaga, E, Nakajima, T.** pp. 911 – 916.

Interaction in Creative Tasks: Ideation, Representation, and Evaluation in Composition. **Coughlan, T, Johnson, P.** pp. 531 – 540.

Getting a Grip on Tangible Interaction: a framework on physical space and social interaction. **Hornecker, E, Buur, J.** pp. 437 – 446.

TeamTag: exploring centralized versus replicated controls for co-located tabletop groupware. **Morris, MR, Paepcke, A, Winograd, T, Stamberger, J.** pp. 1273 – 1282.

ECSCW 2007

Unavailable when commencing research.

CHI 2007

Encouraging contributions to shared sketches in brainstorming meetings. **Bastea-Forte, M and Yen, C.** pp. 2267-2272.

Physically Present, Mentally Absent: technology use in face-to-face meetings. **Kleinman, L.** pp. 2501 – 2506.

Supporting Multi-disciplinary Collaboration: requirements for novel HCI education. **Adamczyk, P, Twidale, M.** pp. 1073 – 1076.

Engaging Constable: revealing art with new technology. **vom Lehn, D, Hindmarsh, J, Luff, P, Christian, H.** pp. 1485 – 1494.

Appendix C

FIELDNOTES EXCERPT

Fieldnotes are a very personal tool. This example is to help those unfamiliar with them gain an idea of what they might look like. They should not be used to draw conclusions on the data, as they are only a partial representation. These were taken on my third visit to the hospital just before they switched from a paper record to an electronic record. Names have been changed for the privacy of the individuals.

20 October 2009

I arrived to the unit early today and had a good half hour before the round. I sat on a chair that the receptionist gave me and peaked at Bay B. The nurses were actively involved with their patients, feeding them, sitting them up, and generally starting the day's activities. There were a lot of people coming and going and the nurses did not engage with the records much, although I believe they are supposed to chart vital signs every 15 minutes. One nurse did spend some time with the record, jotting notes on a paper napkin. *It would be interesting to understand what these notes are for?*

Several nurses came to me while I sat waiting for the ward round and asked me what I was auditing. They looked visibly relieved when I said that I was doing a research project on patient records and was just waiting for the round. One of the bay nurses commented: "it's a pity you aren't auditing handwashing, we are doing well with that today." Her tone of voice suggested that she was not afraid of audits as the nurses were. Perhaps in her supervisory role, they are a tool for her.

As people gathered for the ward round they stood around in loose formations – no consistent shape and standing at funny angles and large distances apart (50 cm or so). People seemed to wander in and exchange chit-chat with another one of the ward round team and then decide that the ward round wouldn't be happening soon and wander off to do a short task. I was wondering whether everyone would manage to converge and the ward round start. As soon as the lead consultant arrived, people seemed to appear very quickly out of the wood work. I'm not sure how they knew he had come out of his office, but it is clear that his presence has a very strong effect.

Briefly he looked around to see who was missing and asked why one of the registrars was not there. The other registrar replied that he had gone to see Mrs. XXXXXX, who had been extubated recently and was having problems. I didn't get what the problems were and I'm not sure what extubation is – perhaps I should ask XXXXXX to explain a bit more of the context of the medicine here. There are so many terms that I don't understand.

XXXXXXX (the consultant) strided off towards the first bed and everyone else followed. The registrars were close behind, but the others were a bit more casual and were chit-chatting a bit.They always seem to start at the same place in the farthest corner.

The first two beds were fairly quick. There wasn't much movement once the original formation was started. The third bed took nearly 10 mins. It seems that the registrar who presented the patient (Mrs. XXXXXX is a 88 year old women who has had bypass surgery and been with us for three days was woken up yesterday….) wasn't very confident. His eyes were darting around and he kept taking his notes in and out of his pocket, turning them around this and that (they were folded in quarters) to glance at something and then continuing. XXXXXXX (the consultant) interrupted him several times asking questions. It appeared as if he was trying to focus the registrar's presentation. XXXXXXX (the consultant) picked up a binder from under the nurse's table and started flipping papers this and that. I think they were looking for a form from the patient's previous hospital but it was difficult to hear. The registrar at the same time, disengaged himself from the group and went over to the medical machines to check the prescriptions. He read them out. I'm not sure why they didn't look at them on the drug chart – was it not available? Would it have disturbed the consultant? Could they not read it? The steering group mentioned prescription legibility as an issue in the ward and one of the reasons electronic records were being implemented.

The ward round didn't seem to gain its coherence again. The bay nurse also left, the registrar did not return to his same position, the other registrar showed up. This would have been an interesting round to video to understand all this movement and changes in formation and why the formation was not re-established properly.

….

Questions for next time:

1: How do teams enter and exit the ward rounds?

2: What is the standard treatment in the ICU? What are the terms used?

3: What do the nurses do with the notes that they keep off the record (e.g. on napkins, kidney charts ect)?