Proceedings of the Workshop:
Approaches to Movement - Based Interaction

Astrid Larssen, Toni Robertson, Margot Brereton, Lian Loke and Jenny Edwards (eds)
The Workshop Call for Participation

Introduction
The kinds of movements that enable interaction with technology are changing. New interaction options untether people from the desktop; allowing interaction with technology with the blink of an eye, sweep of an arm, or by simply being present in a location. This increased range and effect of human movement can be seen in technology research in areas such as e.g. desktop computing (touch screens, tablet PCs), tangible computing, mobile computing, ubiquitous computing, physical computing, interactive art and immersive environments.

These developing forms of interaction are seen to take greater advantage of the way we are accustomed to moving our bodies in the physical world, often drawing on peoples’ abilities to act in physical spaces and our familiarity with manipulating physical objects. Such interaction can be driven by the physical structure of the human body and also by the ways in which the body is involved in meaningful actions in a physical and social world. These new forms of interaction are becoming possible as a result of technological developments and research efforts that aim to develop interaction options for able-bodied as well as disabled users.

Workshop theme
This one-day workshop aims to bring together a diverse community of researchers and practitioners working on human-centred approaches to understanding movement-based interaction and on the design of technology to support this form of interaction. We hope to establish a dialogue between various researchers, to enrich our understandings by considering and mapping the varieties of approaches, to articulate commonalities and differences, and to draw implications for better interaction design for movement-based interaction.

We invite submissions that focus on theoretical, methodological and practical (design methods) aspects of movement-based interaction addressing questions including, but not limited to:

- **Philosophical approaches.** Which concepts of, or from, philosophy could/should movement-based interaction be based on?
- **Embodiment.** What would an emphasis on human activities as embodied activities, contribute to HCI in general and more specifically to movement-based interaction?
- **User purpose/need.** What kinds of interactions could be more appropriate for movement-based interaction?
- **Agency.** What are the implications for human agency in movement-based interaction?
- **Human Movement.** What kinds of understandings of human movement can provide useful perspectives for the interaction design?
- **Representations and Design.** How can well-informed approaches to representations of human movements be incorporated into the interaction design?
- **Ethics.** What are some of the potential ethical implications of movement-based interaction?
- **Space and place.** In what ways are different understandings of space and place relevant for the interaction design for movement-based interaction?

We invite participation from a range of domains (from art to rehabilitation) that are either informed by or that could inform discussion on the proposed topic.

Outcomes and dissemination of results
A call for submissions to a special issue of *Personal and Ubiquitous Computing* on movement-based interaction will be announced prior to the workshop. Participants may wish to submit their revised papers to this publication. The deadline for the special issue is yet to be determined, but it will be 2-3 months after the workshop.

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Introduction

Welcome to the workshop “Approaches to Movement-Based Interaction” being held as part of Critical Computing 2005 - Between Sense and Sensibility, The Fourth Decennial Aarhus conference in Aarhus, Denmark on August 21st, 2005.

This is the first such workshop. Contributors come from Australia, Denmark, Ghana, New Zealand, Sweden and the United Kingdom.

The papers focus on a number of different areas within the workshop theme. All the full papers were subjected to at least double refereeing by a panel of researchers in this and related fields. A list of reviewers is included in these workshop proceedings. The ISBN for the proceedings is: 0-9757948-0-9

This workshop is the culmination of the hard work of a number of individuals - the conference committee whom we thank for choosing our workshop, the workshop committee, the referees and all the authors and delegates. We would like to thank them all for their invaluable contribution. Our special thanks go to the sponsors, supporting organizations, website and publications support, as well as our student volunteers for their generous support.

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Webpage
For more details, visit our workshop web site:
or the conference website:
http://www.aarhus2005.org/

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Astrid T. Larssen
Lian Loke
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“Come on momma, let’s see the drummer”: movement based interaction and the embodiment of identity.

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ABSTRACT
This paper presents clothing and dress in the framework of ‘embodied practice’ as opposed to ‘fashion’ in order to show how this shift of analysis can bring valuable perspectives to the study of embodiment. Viewed beyond the limits of fashionable clothing, the ‘logic of fashion’ opens up wider, albeit paradoxical issues of individuality and sociality, of performance and imitation and brings to light the ways that people use systems of artifacts as an interface to the social world, to create identity and to influence others. I refer briefly to various theories of dress, fashion and the body and draw from these and from my own recent empirical research to investigate the potential of personal style as a medium with relevance to HCI. In conclusion, I construct a tentative design strategy for future ‘style devices’ involving movement-based interaction that can have relevance to the changing meanings of identity in 21st century mass society.

ACM Classification
H5. Information Interfaces and Presentation: J.4 [Social and Behavioural Sciences] Psychology, Sociology

Keywords

INTRODUCTION
My interpretation of clothing is that it is not only part of a semiotic, social language but also a significant mode of everyday living and an aspect of the sensual experience of human embodiment. The body and dress operate dialectically: ‘dress works on the body, imbuing it with social meaning, while the body is a dynamic field that gives life and fullness to dress.’ [8]. In this context, dress supplies a means to cover and adorn, but also affects identity of the wearer’s body through the kinesthetic materiality of cloth, cut and detail. Styles of dress define, but also generate styles of gesture, stance and movement, which in turn affect the evaluations of spectators. My particular interest is in the expression of the body through demeanour and body attitude. It is in this sphere of everyday performance that the fleeting, subliminal ambience of human encounter influences the often instant judgments with which we navigate the social world.

I believe that the significance of identity is not yet well understood within the design of new technology, other than through the implementation of the relatively superficial symbolism of branding technique. Wearable computing has proposed the attachment of technology to the body as useful ‘tools’. These wearable concepts operate within the area of technological augmentation, but rarely make it over to the more mainstream area of style, where the fashion system regulates the communal acceptability of novel sartorial expressions. People want to look ‘cool’ not ‘weird’.

I refer to the Apple iPod and its advertising in order to aid the evocation of the concept of a ‘personal style device’, but also take a look at other artifacts that are routinely worn, carried or used to facilitate the expression of identity through movement, as primary or secondary effects. I use the term ‘dress’ to describe the practice of wearing, but also the more colloquial term ‘personal style’ to refer to the affect on both wearer and spectator of a wide range of artifacts. I am interested in the aesthetic, material form of such objects but also in the emotional experiences they offer.

However, my overriding ambition is to use the self-imposed challenge of designing a ‘style device’ as an empirical means with relevance to my own area of practice, to better understand the fashion instinct in its richest possible sense. I should explain that my
background is not in computing; I am approaching the field of Human Computer Interaction from my perspective as a clothing designer.

**DRESS AS SOCIAL INTERFACE**

Human bodies are dressed bodies; all cultures that we know of dress the body in some way, be it through clothing, tattooing, body painting or other forms of embellishment or adornment [13]. However the effect of these practices on social configuration is still not well understood. I believe that the 20th century’s paradigm of ‘fashion’ has tended to cloud our understanding of dress and its affecting relationship with the body. To date fashion has been widely theorised as a symbolic game; an elitist activity where clothing itself has been deemed more important than the experience of dressing in or wearing it, and as a consequence the phenomenological experiences of wearers have been largely ignored [4] [9] [15].

Enforcing the tendency to exclude the individual feelings of users from fashion analysis have been the ways in which the meanings of clothing are fundamentally linked to wider understandings of the relationship between the outer surface and theories of personhood. The western ontology values depth and divides the intangible self, located deep within, from the relatively inconsequential, contrived outer surface. As a result, discourse relating to fashion has largely been seen as superficial and unimportant, where clothing is valued only as material objects situated at the margins of the body. And yet, the popular view of contemporary fashion is that it facilitates expression of ‘the self: that fashion is an enjoyable, ephemeral theatre for the demonstration of individuality and personality. Western society seems rather mixed up about this.

**TECHNIQUES OF THE BODY**

The sociologist Bourdieu articulates his concept of habitus as a set of dispositions that the body learns intuitively through social interaction and that it can use given the right social context. For example the way that a particular group or class may physically carry themselves provides other people with an understanding of who they are. These ‘techniques of the body’ [3] are products of embodied knowledge and which Bourdieu has claimed structure our systems of gender, class and power.

Entwistle draws on the work of Bourdieu and also Foucault, Merleau-Ponty and Goffman in her consideration of fashion and the fleshy, phenomenological body [9]. She writes: ‘The body forms the envelope of our being in the world, and our selfhood comes from this location in our body and our experience of this.’ Bermudez [2] also relates to the boundaries of the body and refers to philosophy, psychology and neurophysiology in his discussion of self-consciousness. He explains that proprioception ‘provides a way, perhaps the most primitive way, of registering the boundary between self and non-self.’ And that it ‘gives us a sense not just of the embodied self as spatially extended and bounded, but also as a potentiality for action.’

The way that clothing works on the body, which in turn mediates the experience of the self, is captured very well by Eco [6] when he describes wearing a pair of jeans for the first time since losing weight. The jeans are still too tight and he describes how they feel; how they pinch and restrict his movement and make him very aware of the lower half of his body. He describes this as “epidermic self-awareness” and explains that he had not felt it before: ‘As a result, I lived in the knowledge that I had jeans on; whereas normally we live forgetting we are wearing undershorts or trousers. I lived for my jeans and as a result I assumed an exterior behaviour of one who wears jeans. In any case I assumed a demeanour…Not only did the garment impose a demeanour on me; by focusing my attention on demeanour it obliged me to live towards the exterior world.’ [6].

So in “normal” or habitual circumstances we experience clothing as an extension of the body, as a second skin, but when dressed uncomfortably, or perhaps in a new or less familiar way, our clothing can reawaken awareness of the limitations and boundaries of our body. Dress offers agency: it is both a personal and a social experience and as such brings important insights into the ways that people interact with each other in an increasingly complex social world. However this is so often seriously overlooked in philosophy and in practical studies of embodiment, where the body in action is portrayed as an impersonal diagram (e.g. Figure 1) or as a stylized nude where cultural nuance or idiosyncratic movement is difficult to document.

**Figure 1:** An impersonal diagram. (Lebourque). Epidermic self awareness, kinesthesia or proprioception begin to approach the neurophysiologic workings of ‘sense of self’ i.e. how we feel as individuals but also as social beings, and bring designers of HCI practical ways to quantify how styles of dress may affect not just semiotic appearance but the very sensory mechanics and skeletal apparatus of the bodily-self.
In a recent interview Dior’s Hedi Slimane seems to be referring to Bourdieu’s concept of habitus when he says: “Dior Homme is not a construction of the mind, but a gut feeling, almost non-design. For me, it's so much about the way people wear clothes, the way they behave, not so much about the clothes themselves. In France, it's called le porte. It's a very old-school way of dressing based on how the clothes fall on the body. I work on this natural level of understanding clothes. It comes from getting so into my own world and chasing my own moods. I pay attention to movement, the way the clothes translate on the body, even the way they translate to a girl.” [5]. Slimane’s designs are intended for fashion’s elite, and his words reveal the contemporary insight and embodied knowledge of a highly successful practitioner. His interest is in the way that clothes are worn and differentiate behaviour and how styles of dress can prompt styles of movement via the transformation of kinesthetic materiality into corporeal performance. For Slimane, everyday observation, knowledge of the properties of cloth and the techniques of cutting and garment making combine to form an empathic system for understanding emotional and postural schema and how the body moves through space.

THE EVERYDAY EXPERIENCE OF ARTEFACTS
In our mass society mass production provides. Thus for consumers, expressions of individuality are a constant paradox: ‘the logic of fashion’ (as opposed to its look) [16] relies on perpetual tension between original identities and their copies. Yet it is thought that we may now be in an era of post fashion or of ‘consummate fashion’ [12]: our instinct to imitate others has been exploited by the mass production system until much of fashion’s traditional cachet has been expended. But there are many new socio-cultural hybrids of identity emerging; of ethnicity, gender, sexuality, youth and age, where groups seek to express individuality with ever greater intricacy and autonomy. So can designers of HCI learn to appreciate the somatic affect of artifacts and enable computer users to express identity or fashionable virtuosity in their everyday performance of self? To help develop a perspective on this it is useful to investigate existing movement based interactions and style artefacts.

iPod
Recent commercials for Apple’s iPod show lithe dancers expressing themselves in stark silhouette against backdrops of pure colour, to the music of hip-hop (The Black Eyed Peas sing “Come on Momma, Let’s See the Drummer...”) or of rock (Figure 2). Each energised figure carries a small rectangular ‘device’ in their hand, which connects to their ears via its signature white lines. These eloquently edited sequences create a synthesis of sound, rhythm, body movements, facial characteristics, gestures, haircuts and clothing that clearly convey particular fashion and ethnic identities. The commercials seem to imply that this shiny device can dispense not just a favourite playlist, but also a dynamic bodily experience to its users. In this interpretation, the iPod is proposed as more than a mere symbol of a fashionable lifestyle, the agent of stylish dress and adornment, or of technological augmentation. The device appears to connect with the fashionable-self as an expressive somatic entity. It implies that individual fusions of dress and musical preferences manifest differing styles of experiencing and inhabiting one’s own body.

Of course, an alternative interpretation of Apple’s advertising is that the iPod is an inert, mass-produced, digital commodity, where the molten mixture of popular music, ethnicity and fashion has been shrewdly appropriated in order to generate emotion, seduce sensibilities and promote sales. But either way, I refer to these animated human silhouettes and their expressive ‘techniques of the body’ as graphic demonstrations of the ways that contemporary identities are embodied.

Jeans
More than many other contemporary mass-produced garments, denim jeans have a strong propensity to stimulate body awareness and demeanour. Eco’s personal experience of wearing them [6], and my own research [4] have indicated that an aspect of jeans’ continuing popularity lies in their familiar and relatively uniform materiality. This has led me to confront the apparent paradox that somatic communication and bodily differentiation can be much aided by such homogenous artefacts. The subtle denim taxonomy of cut and fit combines with the customising process of wearing them over time, so that jeans offer very many of us a favourite, personal uniform. It is jeans’ near uniform styling, combined with their cultural complexity that affords (or denies) cultural currency: it is how you wear your jeans that counts.

Cigarettes
The prosaic cigarette is another example of the paradox of individuation. The act of smoking a cigarette can be incorporated into the cadence of body style in many different ways: from grandiose and languid movements to the staccato or furtive. Individual, habitual smokers may use different combinations of the fingers and thumb to hold the homogenous white stick, or inhale/exhale the
smoke in distinctive ways. The ‘dynamically embodied action’ [10] attributable to cigarette smoking conveys complex, tacit information about the identity of individual smokers to spectators.

Similarly, the homogeneity of the ubiquitous baseball cap, of men’s ties, the walking/ski stick, or of the components of school uniforms are further examples where subversive expressions of individuality seem to be indirectly generated by a perceived imperative to comply, and where people (consciously or otherwise) find subtly different ways to personalise mass manufactured artefacts via the ways that they use, wear or otherwise interact with them.

**Figure 4:** the paradox of individuation. The homogenous baseball cap.

I aim to construct a design strategy for a technological ‘style device’. What other factors can be established that may bring detail to a relevant design brief?

**PUBLIC PERFORMANCE**

By drawing on a range of example interfaces and previous studies of interaction, Reeves et al. [14] have developed an accessible taxonomy that explains how current HCI design approaches can be related to one another by using just a few underlying ideas. They consider what it means to ‘perform’ with an interface in a public setting and explore the challenge of designing the spectator experience. Their key question is how should a spectator experience a user’s interaction with a computer? The resulting taxonomy [14] deconstructs performers’ interaction into manipulations and effects and uncovers four broad strategies: ‘secretive’ where the manipulations and effects of the performer are largely hidden; ‘expressive’ where they are revealed and enable the spectator to fully appreciate the performer’s interaction; ‘magical’ where effects are revealed but the manipulations that caused them are hidden; and finally ‘suspenseful’ where manipulations are apparent but effects are only revealed as the spectator takes their turn.

In an everyday scenario, personal style (qualitative social performance) exists in spectators’ assessments of the individual performances of others. Can parallels be drawn between the taxonomy of formal public performance and the everyday interactions of social actors in their ‘presentation of self’ in daily life [11]?

‘Expressive’ interfaces tend towards revealing, even amplifying, both manipulations and effects. This description brings to mind the performance of a fashion model at a catwalk show. Catwalk models are often briefed by the designer to move in a certain way as a means to convey the mood of the collection and this is emphasised by the show’s music. If sound or visual effects could be manipulated via the body, by the movement of the clothing, or by other manipulations, then the virtuoso fashion performer could strut or slink to his or her own rhythmic accompaniment. Their body cadence could influence the colour and patterning – the emotional mood - of their garments. Some fashion designers (e.g. Victor and Rolfe), have used aspects of this latter effect, but to my knowledge only in postproduction through colour separation overlay techniques in promotional videos.

‘Magical’ interfaces reveal effects while hiding the manipulations that led to them: they reveal the performer as the creator of the effects whilst not revealing the manipulations. If certain parts of the body could be selected by the wearer/performer to interact with a computer (e.g. ends of hair, the hem of a skirt, or a single earlobe) then manipulations could be made mysterious: effects would be evident but not directly explicit.

‘Secretive’ and ‘suspenseful’ inspire the design of interfaces that can bring cachet and ‘phantasmagoria’ [7] to personal performance.

**CONCLUSIONS**

So can designers learn to appreciate the somatic connotations of artefacts for the fashionable-self and create ‘style devices’ for individual computer users to express identity or fashionable virtuosity in their everyday social performance? What design tactics are relevant?

The homogenous materiality of the style artefacts I have briefly discussed: jeans, baseball caps, cigarettes, suggest an indirect affect. These artefacts stimulate expressions of individuality in reaction to conforming imperatives on the bodily-self. It seems counterintuitive, but a future style device may therefore necessitate homogenous or generic qualities, rather than offer differentiation or variety at the outset. Qualities of variety in an artefact may mean that it will be interpreted as purely decorative or communicative
in a symbolic way – like a tee shirt, or a badge. This might limit impulses to customise it with personal idiosyncrasies. Perhaps like jeans, a style device could be given the potential to learn about the wearer’s body over time, and to recognise its wearer/user so that it would not ‘fit’ anyone else. Or alternatively, like in the Levis ad where the soldier leaves his jeans for his girlfriend, bring a sense of inhabiting another’s body when worn by a new user.

In the case of the iPod, fashionable identity is manifested by carrying/wearing its stylish materiality and using its sensuous interface, but can also be articulated by styles of body movement (dance, demeanour) that are stimulated by the user’s emotional experience of its personalised contents. There are many more movement based interactions that have relevance to style – bags, shoes, haircuts. Combining aspects of these with the possibilities of magical, expressive, secretive or suspenseful interfaces brings thought provoking approaches with relevance to the world of dress and style and to new ways of thinking about our socialising instinct to impress and imitate others.

My intention in this paper has been to draw attention to the emotional world of social encounter and to consider ways that new technologies can engage with this. Contextualised beyond ‘fashion’, clothing and dress offers a site from which to gain empathy for the emotionally charged experiences that are derived through our minds and bodies. As a concluding emphasis, I draw attention to the work of anthropologists Banerjee and Miller who gained a strong empathy for the changing lives of women in India today by focussing on the sari not just as an object of clothing, five metres of decorated cotton cloth, but as a lived garment [1]. They ask us to imagine that we have encountered a sari metaphorically, ‘Suddenly the cloth becomes alive: it exaggerates her vivacity as she turns around, her elegance as the pleats rustle at her ankles, her flirtatiousness as it slowly threatens to slide off her shoulder and dexterity as she controls its folds. Meanwhile, although we may not realise it, the sari is also scratching her with its home made rice starch and scaring her with its constant threats to lose its shape.’ They conclude: ‘In the hybrid world of everyday life, it is often these intimate and sensual realms that are the most effective in determining the acceptability of realms of thought that we call reason and rationality. Through the realm of clothing we can see how for most peoples, systems of thinking about the world also have to “feel” right.’

ACKNOWLEDGMENTS
I gratefully acknowledge the support of the UK’s Arts and Humanities Research Council.

REFERENCES
ABSTRACT
There is a mismatch between the kinds of movements used in gesture interfaces and our existing theoretical understandings of gesture. We need to re-examine the assumptions of gesture research and develop theory more suited to gesture interface design. In addition to improved theory, we need to develop ways for participants in the process of design to adapt, extend and develop theory for their own design contexts. Gesture interface designers should approach theory as a contingent resource for design actions that is responsive to the needs of the design process.

Keywords
Gesture, Gesture Interfaces, Theoretical Framework, Design methods

INTRODUCTION
Gesture interfaces are computer interfaces that allow people to interact with computers through the movements of their bodies. Gesture interfaces seem a promising avenue of inquiry for researchers in Human-Computer Interaction because they may be more responsive to people’s abilities for skilful action and be more intuitive and delightful to use than the traditional set-up of keyboard, mouse and display.

So far, gesture interface researchers have been more concerned with the technical challenges of detecting and recognising gestures than with considering how theory can inform the design of gesture interfaces. Where gesture interface researchers have considered theory, they seem to have assumed that theoretical understandings of human gesture can be applied to the design of gesture interfaces without difficulty. However, if one compares the movements that current theories understand as gesture with the kinds of movement that gesture interfaces employ, one discovers a mismatch. In this paper, we examine this disparity and suggest other theoretical understandings that could usefully be applied to gesture interfaces.

We also argue that what designers of gesture interfaces require is not just theoretical frameworks of movement, but also methods by which people involved in the process of design can explore the kinds of movement that are most appropriate for the particularities of the skills, work traditions and values of the design context. Above all, gesture interface designers should handle theory as a contingent resource for design actions that is responsive to the needs of the design process.

Outline of the paper
The paper begins with a summary of some influential theoretical understandings of natural human gesture. Next, we look at the movements employed in some gesture interfaces and point to a disjunction between these and the theoretical understandings of gesture described in the first part. The final part of the paper sketches a two-fold response to this disparity, involving a reconsideration of theory and an examination of how design participants can appropriate, develop, and adapt movement theory.

SOME THEORETICAL PERSPECTIVES ON GESTURE
Gestures have been a phenomenon of interest for many different fields and this has resulted in a variety of theoretical perspectives on the subject. Theoretical perspectives are important to consider for applied gesture research for a number of reasons: They influence what movements we consider as gestures, they may engender a particular analytical stance toward people’s movements, they may be more amenable to particular design methods and they may have implications for the type of interaction paradigm a gesture interface employs. In this section, we give an outline of some influential theoretical understandings of gesture.

Defining gesture
Researchers have tried many different ways of defining gestures. As Corradini and Cohen wryly observe, ‘everyone claims to know what a gesture is, but nobody can tell you precisely’ [3]. One aspect of gestures that all definitions agree on is that they consist of movements of the body. However, most definitions choose one or more further characteristics to distinguish gestures from other types of human movement. Nespoulous and Lecours [12] list four basic dichotomies that gesture researchers have found useful for distinguishing gestures from other kinds of movement (listed and summarized in Table 1).
Table 1: Four basic dichotomies in definitions of gesture [12].

<table>
<thead>
<tr>
<th>Act</th>
<th>Symbol</th>
<th>Transparent</th>
<th>Opaque</th>
<th>Centrifugal</th>
<th>Centripetal</th>
<th>Autonomous</th>
<th>Partial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movements that effect a material action in the world</td>
<td>Movements that serve a communicative purpose</td>
<td>Movements whose meaning is self-evident</td>
<td>Movements where meaning is not self-evident</td>
<td>Intentionally directed towards another</td>
<td>Not intentionally directed towards another</td>
<td>Movements that exist independently of other modes of communication</td>
<td>Movements that rely for part of their meaning on another modality</td>
</tr>
</tbody>
</table>

Of these dichotomies, the one most commonly used to separate gestures from other types of movements is the act – symbol dichotomy. Researchers usually define gestures as movements that play a symbolic or communicative role. However, most researchers also admit the difficulty in drawing the line between purely communicative and manipulative movements. Kendon, who defines gestures as movement where ‘an individual engages in movement whose communicative intent is paramount, manifest, and openly acknowledged’ [8, p.31] also recognises that ‘it is not possible to specify where to draw the line between what is gesture and what is not’ [9]. McNeill is very specific in the kinds of movements he regards as gesture. By his definition, only the spontaneous communicative movements made to accompany speech are gesture [11, p. 37]. Quek, McNeill et al. [14] highlight what they see as three important differences between manipulative and communicative movements. First, because the purpose of communicative movements is communication, the meaningful parts of the movement are made visible, whereas in manipulative movements, the important parts may be hidden. Second, the dynamic qualities of manipulative and communicative movements differ. Third, communicative movements are usually performed empty handed and thereby lack the tactile, audible, or visual feedback generated by manipulative movements, which involve contact with objects. Following from this differentiation, they go on to assert that

Gesture and manipulation are clearly different entities sharing between them possibly only the feature that both may utilize the same body parts. [14 p. 173].

Classifications of gesture
Related to the question of definition is that of typology or classification. Table 2 below compares four well-established taxonomies of gesture. The gestures in each row are broadly equivalent. Where no corresponding category exists, we have left the cell blank. The movements described here are all ‘gestures’ by McNeill’s definition, and we describe them using his terms.

Table 2: Comparison of gesture taxonomies, [adapted from 17, p. 4]

<table>
<thead>
<tr>
<th>McNeill</th>
<th>Kendon</th>
<th>Rimé &amp; Schiaratura</th>
<th>Elton</th>
<th>Identifying Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iconic</td>
<td>Physiographic</td>
<td>Physiographic</td>
<td>Kinetographic</td>
<td>Picture the content of speech</td>
</tr>
<tr>
<td>Metaphoric</td>
<td>Ideographic</td>
<td>Iconic</td>
<td>Ideographic</td>
<td>Portray the speaker’s ideas, but not directly the speech content</td>
</tr>
<tr>
<td>Beat</td>
<td>Gesticulation</td>
<td>Speech-marking</td>
<td>Baton</td>
<td>Marking the rhythm of speech</td>
</tr>
<tr>
<td>Deictic</td>
<td>Descriptive</td>
<td>Descriptive</td>
<td>Descriptive</td>
<td>Pointing at thing/area; space around body used.</td>
</tr>
</tbody>
</table>

Iconic gestures are gestures where the movements of the body directly mimic the content of the speech. For example, when a person recounting a story in which a character bent back a tree makes a hand motion that mimics the act of bending the tree, that person is making an iconic gesture. Metaphoric gestures are similar to Iconic gestures in that they also picture the content of the speech, however metaphoric gestures do not represent a physical action or object, but an abstract idea. An example of a metaphoric gesture is a person making a gesture that presents an abstract idea, such as genre, as a space bounded by two hands (a conduit metaphor, in McNeill’s terms [11]). Beats are rhythmic movements of the arms and hands that correspond to the rhythm of speech. Beats differ from Iconic and Metaphoric gestures in that the form of the gesture does not vary depending on the content of the speech. Beats tend to be quick movements of the hands up and down, side to side or in and out. Although beats can appear insignificant compared to other gestures, they still play an important role, because they emphasise the structural aspects of the communication (for example, introducing new characters, themes or summing up). Deictic gestures are pointing gestures. The thing they point to may or may not be physically present and can be either a physical object or place or an abstract idea. In conversation and narratives, most pointing gestures are abstract in nature.
In this way, abstract ideas obtain a physical location in an unfolding conversation or narrative.

Other kinds of communicative movement
There are communicative movements that are not gestures by the definition described in the previous section (idiosyncratic, spontaneous movements accompanying speech). We can arrange these other kinds of communicative movement on a continuum based on their relationship to speech as shown in Figure 1 below [11]. As we move from left to right on this continuum, the movements become more language-like, more independent of speech and more subject to convention. The gestures described in the previous section correspond to just the leftmost end of this continuum, or ‘gesticulation’.

Figure 1: Kendon’s continuum of communicative movements
Language-like gestures, while similar in form to gesticulation, differ in that the gesture is integrated into the grammatical structure of the speech. Pantomimes depict objects or actions independently of speech (though they may be accompanied by onomatopoeic vocalisations). Emblems are culturally conventional gestures such as a ‘thumbs-up’ sign or an okay sign. Emblems have standards of well formedness, for example, a ‘thumbs-up’ sign requires that the hand is held as a fist not open-palmed. Like pantomimes, emblems are usually produced independently of speech. Sign languages are fully formed language systems that consist only of movements, such as the sign languages used by deaf people.

MOVEMENT IN GESTURE INTERFACES
Turning from theory to application, we can now examine how movements are treated in gesture interfaces. Our intention here is to highlight a difference between the movements employed in gesture interfaces and the theoretical understandings of gesture described above. We do this not in order to browbeat gesture interface researchers for misappropriation of theory, but to stress what we feel is a weakness in current theoretical understandings of gesture that applied gesture interface research has made apparent.

The motivations for gesture interface researchers are different to those from other fields that have looked at gesture. Gesture interface research has a design and technical agenda, and so the focus of gesture interface researchers is often not on gestures as such, but rather, on the possibilities they offer for interactions with computers and electronic devices or on the technical challenges of detecting and recognising them.

In gesture interface research, definitions and classifications of gesture (which are so central to the research presented in the last section) are of little concern. Usually, the question of what is or is not a gesture is outside the scope of the research, so an existing definition from another field is adopted or the researchers rely on the commonsense understandings of the reader and the definition remains implicit. Therefore, the best way to understand how movements are treated in gesture interface research is to look not for stated understandings of gesture, but for how movements are actually employed in the interfaces that researchers have built.

There certainly are examples of gesture interfaces where the kinds of movements used fit well with McNeill’s definition of gestures as spontaneous idiosyncratic movements accompanying speech. For example, the early gesture interface ‘Put that there’ [1] allowed people to point to a position on a screen and issue an accompanying speech command to create, move or alter a shape. People could point to any position on the screen and had some freedom in how the speech and gesture parts of a command could be combined. The pointing movements involved in this interface seem to be clear examples deictic gestures.

However, the movements used in most gesture interfaces do not fit as well with McNeill’s definition. Many gesture interfaces use static hand postures as commands to the system. Figure 2 shows an example of the use of such hand postures in a gesture interface used to control the motion of a virtual avatar [10]. One could argue that these movements are still communicative in the sense that they communicate the user’s intentions to the computer and it would be fair to classify them as emblems using the continuum in Figure 1. However, their communicative status is confused if we consider that they are used to control the movement of a screen-based avatar of the user in a virtual environment.

Other gesture interface researchers have worked on the problem of recognising sign languages. Like emblems, signed languages are not gestures by McNeill’s definition. Although, signed languages are obviously communicative in nature, this is not so clear in way sign languages are treated in gesture interface research. Braffort, raised some ethical concerns with the way that computer scientists have engaged with the problem of sign language recognition, noting that:
Unfortunately, the real aim of the studies is often to validate a given technique, which is supposed to be able to give a better recognition rate, a better precision in image processing, etc. It appears inappropriate to use the terms ‘Sign Language recognition’ in this context. [2, p. 6].

There are also examples of gesture interfaces that challenge our notions of what movements could be called gesture in ways that are more radical. Tailor was a system for generating speech synthesis using gesture input [13]. The system used the continuous movements of a person to control a computer model of the parts of the mouth and thereby the sound produced by the model. The purpose of this system was to allow people with disabilities such as cerebral palsy to produce speech. Although the purpose of this system is to allow people to communicate, the movements used to achieve this do not seem especially communicative in themselves, and one would certainly not consider them gestures in the ways described in the previous section.

RESPONDING TO THE DISPARITY BETWEEN GESTURE THEORY AND GESTURE INTERFACE RESEARCH

The examples above are not intended as an exhaustive survey of the ways movement is treated in gesture interface research. The point is rather to highlight some disparities in the way movements are treated in theoretical gesture research and gesture interface research.

One could respond to this disparity by criticising gesture interface researchers for sloppy and uncritical use of the notion of gestures, or respond by saying that such interfaces should not be called gesture interfaces. Although these might be valid criticisms, even sloppy and uncritical work can serve to highlight shortcomings in theory if theory is unable to accommodate the movements that these gesture interfaces employ.

Instead, we believe that a two-fold response is required. First, researchers should return to theory to look for and develop alternative and more inclusive understandings of movement. Second, we should consider the relationship between theory and application and focus how design process participants can adapt, extend and develop theory for their own design contexts. In the remaining space, we give a brief outline of what these ideas might involve.

A broader conception of movement

The task of reconsidering our theoretical understandings of movement will not be a simple one. As some gesture interface researchers have recognised, there is no comprehensive classification of human gestures that would help us to understand gestures in Human-Computer Interaction [3]. We should be cognisant that the kinds of interactions we can engage in with other people are qualitatively different from the ways we can engage with computers [15]. Reflecting on his experiences of applying gesture classification systems to the task of transcribing human gesture, Wexelblat highlights this problem when he writes:

…to write down classifications of the gestures required using knowledge about the scene being described and about subjects’ intentions. This information would not be known by a computer system attempting to understand the same gesture. [16, p. 186].

This does not mean that understandings of human gesturing (or other kinds of movement) cannot be useful for the design of gesture interfaces. However, designers should employ them pragmatically and with regard for the dangers of uncritical acceptance.

In particular, the dichotomies that have proved so useful to gesture researchers in separating gestures out from other kinds of movements should be reconsidered. Recent moves in anthropology could be especially useful in this undertaking. Farnell has described a shift ‘from an observationist view of behaviour to a conception of body movement as dynamically embodied action’ [4, p. 341]. Rather than relying on dichotomous relationships (such as those summarised in Table 1) to separate gestures from other kinds of movement, this approach instead takes a holistic view. As Farnell writes:

Older dualistic divisions of such intelligent embodied activities into practical and expressive, instrumental and symbolic, technical and ritual, verbal and nonverbal, and the notion of ‘discursive and practical consciousness’ … have proved unhelpful in understanding the range and complexity of human action. [4, p. 343].

Working from a similar perspective, Ingold has developed a conception of skilful action, which rejects divisions between mind and body, language and action, art and technology [5-7]. Recovering an appreciation of skill as ‘both practical knowledge and knowledgeable practice’ [5, p 20], allows researchers to move beyond dichotomous conceptions to a ‘more satisfactory account of the socially and environmentally situated practices of real human agents’ [5, p. 20].

Designing with movement

To apply theory successfully to the design of gesture interfaces, we need to investigate the methods and processes by which design proceeds. We also need ways for design process participants to adapt, extend and develop theory for their own design contexts. Theory should be resource for design that is contingent on the particulars of the design context.

Space permits only the barest sketch of how such an approach could proceed, but we propose the following three points. First, designers of gesture interfaces need to be sensitive to the fact that people’s movements are meaningful not in universal terms, but in ways that are dependent on the skills, values and traditions of their work.
Second, it is as important to develop methods by which design participants can engage in the process of design with their bodily movement skills, as it is to bring appropriate theory to bear on understanding their movements. Third, Gesture interface researchers have an important role to play in further developing theory and we need to develop ways of drawing theoretical insights from applied gesture interface research.

CONCLUSION
In this paper, we have highlighted a shortcoming of current theoretical understandings of gesture for the design of gesture interfaces. The kinds of movement identified as gesture in our current theory do not line up with the kinds of movement used in gesture interfaces. The response we propose to this divergence is two-fold. First, researchers need to return to reconsider our theoretical understandings and develop theory that does not rely on dichotomous conceptions of movement, but which embraces the socially and environmentally situated practices of people. Second, we should consider how designers could use theory in ways that are responsive to the particulars of their design situation.

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Where the Body Acts: Towards a foundation for Movement-based Interaction.

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ABSTRACT
User interaction design has for many years been concerned with the cognitive skills required in operating computers and machines, with only little regard to the body and the context.

A shift from keyboards and computer mice to interaction design that regards the body requires one to study the skills built through bodily movement and the context that allows this skill building. The emerging field of Anthropology of Movement can help in studying and understanding human movement.

With inspiration from anthropology, philosophy and sociology, I have analyzed a short video sequence of a plant operator operating very tangible machinery. Based on the analysis I will argue that the movements in between hands-on actions are crucial to understanding the role of the body in interaction. Possibly designing with respect to the in-betweens - when the body adjusts towards the next action - holds great promise for bringing tangible, movement-based interaction design forward.

Keywords
Movement-based interaction tangible interaction, anthropology of movement, skills, action theory.

INTRODUCTION
With computers moving away from desktops and becoming embedded in artifacts and in the environment, we need a revision of the way we as designers look at interaction.

The body has generally been neglected in interaction design. Until recently, the dominating focus has been on cognition, with only little regard of the dexterity with which people can manipulate objects, and of the context in which this takes place.

Realizing that interaction is not just a single movement, rather it is a series of interconnected movements; the goal of this paper is to expand this view of interaction to look at more complex sequences of movements, and to look at human skill building as an important building block for designing movement-based interaction. For this we need a slightly different approach than we have used so far. We now need to broaden our view; what are the implications of movements, what leads from one action to the next, how can we make sense of it?

This paper is based on the analysis of a 19 sec. video sequence showing a skilled brewery operator performing a sequence of very physical actions when interacting with a machine in the brewery. Noting the details of the single movements helps defining the sequence as a whole, but a detailed analysis of the entire flow of movements is necessary to get closer to an understanding of what is actually going on and how that knowledge can be used to inform the design of tangible interaction.

In his essay ‘Up, Across and Along’, Ingold [6] provides a clue to possible ways of gaining further insight. In particular the metaphor of the wayfarer helps to shed a new light on the video clip. This insight is discussed with Suchman’s notion of situated actions [10], followed by a delegation of the work, between human and non-human actors in the video clip, in order to bring the analysis further. Strauss’s theory of action [9] has proven to be valuable to deepen the understanding of movement and to inspire principles for tangible interaction design. The paper will close with a discussion that seeks to identify possible design principles.

What is a movement?
‘We come into the world moving; moving and feeling moved to move are what are gone when we die.’ [8, p. 275] In this short sentence Sheets-Johnstone states her understanding of movement. This statement differs from the understanding presented in philosophy, namely that movement is something that is forced upon a body, something done involuntarily, and action is what a body (an agent) will do intentionally. Davidson “follow(s) a useful philosophical practice in calling everything an agent does intentionally an action” [1, p. 686 fn] and points to how we will have a problem in understanding and describing, “if we assume as Meldon does (Free Action 85), that an action ("raising one's arm") can be identical with a bodily movement ("one's arm is going up")”[1p. 687fn]. Throughout this paper, my understanding of movement will be closer to the former rather than to the latter. Reading this paper one should think of movement not simply as mechanical displacements of the body and limbs, rather that movement is from the body, that movement is emotion and movement is expression.
LANGUAGING MOVEMENT
Written language without the possibility of showing the movement itself is severely limiting for describing physical movements, so it is a comfort to me that Sheets-Johnstone comments on the same problem saying: ‘Languaging the dynamics of movement is a challenging task, perhaps so more than languaging any other phenomenon one investigates phenomenologically.’ [8, p. 268 fn]

I have looked towards the anthropology of movement to find an angle for analyzing movements caught on video. Farnell discusses the emergence of a holistic ‘anthropology of human movement’ and how this nondualistic (non-Cartesian) approach has challenged researchers, not only in ways of thinking, but also in the use of new methods and tools: ‘The current challenge for anthropology is to develop modes of registration and specification that will facilitate the learning and analysis of action, allow records of visual-kinaesthetic action – alongside records of speech – to become a normal part of fieldwork practice, and so lead to the presence of enacted forms of knowledge in ethnographic accounts.’ [3, p. 354] Farnell proposes the use of video and a transcription system, emphasizing the qualities of the notation system developed by Rudolph Laban.

Movement and Labanotation.
Labanotation is a system for recording and analyzing human movement, first published in 1928. Rudolph Laban based his system on natural human movement and not on a particular kind of dance, as most other movement notation systems are. One can start on a simple level and expand as the need for more details grows. What is very important is how it can work as an eye-opener and a sensitizing tool in the training of movement observation. This has been my prime angle on Labanotation; a heightened sensitivity towards movement, in combination with terms expressed in a natural language. In the current project I have mainly benefited from the former, the heightened sensitivity, due to the explorative approach. As my research will come further, I can take up parts of the system to fill my needs, but for now the categories and the grammar seems the most valuable.

Movement And Embodiment
The non-dualistic approach to understanding people in their world is in the centre of Dourish’s ‘Where the Action Is’ [2]. Drawing on the work of a number of phenomenologists, Dourish stresses our embodiment in the world as the core element in understanding and making sense of interaction. ‘If we are all embodied, and our actions are all embodied, then isn’t the term, embodied interaction, in the danger of being meaningless? How after all, could there be any sort of interaction that was not embodied? What I am claiming for ‘embodied interaction’ is not simply that it is a form of interaction that is embodied, rather that it is an approach to the design and analysis of interaction that takes embodiment to be central to, even constitutive of, the whole phenomenon. This is certainly a departure from the traditional approaches to HCI design.’ [2, p.102] This is the approach I will take as I make my way into the brewery video.

THE WATER STATION VIDEO
In the video sequence the camera follows the process operator Trevor in a brewery with the environment dominated by pipes and machinery in stainless steel. He is walking down an aisle with machinery on both sides with his attention directed towards the water station to his left, a small cluster of machinery, approximately 1 meter deep and 1,5 meter wide. The water station is a collection of pipes, valves and a filter tank. The function of the water station is to dilute the beer to the correct alcohol content and it is the last step in the filtration process, before the beer ends up in the beer cellars.

The video shows the third step in a procedure of four steps. Between each new batch of beer Trevor must flush pipes and filters and the filter of the water station. The pipes and filters are flushed first with hot water, then with ‘caustic’, then again hot water and finally cold water. In the clip we see how Trevor is flushing with hot water after the caustic, a procedure similar but not quite identical to, the preceding and the following steps.

Interacting With The Water Station
Standing in front of the water station with his left hand resting on a handle, Trevor now leans forward to close a valve with his right hand (Figure 1.a). Then he reaches up with his right to flip a second valve on top of the filter tank (Figure 1.b), moves it to a third valve under his left hand. He pulls the handle upwards (Figure 1.c) and moves the hand to assist the left hand closing a fourth valve (Figure 1.d). He then moves his left hand to open a fifth valve on the left side (Figure 1.e) and steps back. In this sequence he operates 5 out of 8 valves on the water station.

What is not visible in the video is the fact that Trevor ‘pushes’ the caustic out of the pipes with the hot water; he does not open a valve until enough pressure has built up in front of it to provide an efficient push.

At this point I have to say that what Trevor can do and what actions he can take are naturally restricted by the fact that it is a brewery he is working in, and that the design for the layout of pipes and valves has been made as it has. What he makes is beer, but what he does is basically to move fluids from one place to another in a particular succession. To enable him to do that he has a number of pumps, pipes and valves at his disposition.

Figure 1: The five hands-on interactions at the water station
and though he is rarely in actual contact with the product as such, the quality of the beer is still influenced by the way that he interacts with the afore mentioned objects. The social aspect also has influence; I guess there is a limit to how flamboyant and expressive he can be in his actions, according to local ‘rules’ governing in the brewery. Nevertheless it is my conviction that Trevor, within those limits, has developed his practice to a point of perfection, and it is within those limits I will do my findings.

**Video Transcription**

To analyze the movements I first made a transcription of the 19 sec. video using the linguistic annotation tool, Elan [3], to meticulously pin out every position and movement of limbs and body. This helped me reveal details about timing, the succession in which the different body parts were brought into use, and to making an accurate description of the sequence as a whole.

**Movement as skill building**

Ingold advocates five qualities of human skill, out of which I will highlight three that can help, elicit the elements of skill and skill building in the video sequence:

1. Skill is a property not simply of the human body, but of the total field of body, mind, and richly structured environment.
2. Skilled practice is not just the application of mechanical force to exterior objects, but entails qualities of care, judgment, and dexterity.
3. Skilled practice is learned through introduction into contexts that afford selected opportunities for perception and action, and through scaffolding, rather than through representations and schemas.[5, p. 353]

Looking at the video from this angle, what strikes me first is the framework created by the layout of pipes and valves and how this together with, what seems to be, a natural sequence of actions, supports the process operator in his work. The second thing that strikes me is how the different valves are dealt with, it seems that each valve has its own character and hence requires different handling. I do not see a simple application of mechanical force, but rather a reflection on the state of the system, an adjustment of the action as a feedback to the situation.

**Wayfaring And Transport**

Ingold contrasts the movement along a line with movement from point to point across a surface and uses the term ‘wayfaring’ for the first, and ‘transport’ for the latter. He uses a similar dichotomy for knowledge and description, namely that knowledge used to be thought of as growing along a line, but now seems to be thought of as something that is as being built up in a spot[6, p. 7].

**The Wayfarer And The Tourist**

To illustrate the idea of wayfaring, Ingold introduced the line in Figure 2.a. The wayfarer walks along, comes to a place and hangs around, walks to another place and hangs around there for a while. The little knots represent the rests on the way, but the wayfarer is in constant motion, the movement never really stops. Where the wayfarer rests is where the tourist jumps into action. As in Figure 2.b he jumps from place to place but unlike the wayfarer who is constantly adjusting his locomotion to the perception of his environment, for the tourist the bond between locomotion and perception is broken.

Having looked at the actions in the video sequence very much as point-to-point or as ‘transport’ with little ‘somethings’ in between, it now made sense to look at it as wayfaring and in this way give equal weight, and thereby full justice, to the in-betweens.

**Movement as Wayfaring**

Looking at Trevor, or maybe rather his hands, from a wayfaring point of view, I will regard the places in which he interacts with the system as the ‘rests’. See Figure 3. In those spots, I will be able to explain what he is doing without much discussion, namely that he is opening or closing valves by either turning them clock- or counter clockwise, up or down etc. The in-betweens on the contrary are a challenge.

'Blessing' the gauge

Moving his hand from one valve to the next, we see Trevor holding his hand in the air above a gauge, as if ‘blessing’ it, see Figure 4.a. This could be seen as simple displacement of the hand from A to B with a little mistake in between, but the fluency with which the action is performed, as well as the timed adjustment of the body posture, tells me that this is indeed a skilled practice. Before this little section, moving his hand to the valve first referred to, Trevor briefly touched the gauge that he later ‘blessed’, but the little stop in the air above the gauge convinces me that this is a reflection and adjustment to his movements in the action. I am here dealing with a skilled person acting in the environment in which those skills were incorporated. What at a first glance could look like a sequence of programmed actions...

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Figure 2: The Wayfarer and the Tourist

Figure 3: The water station sequence viewed as "wayfaring"
is indeed a fluent succession of continual adjustment to the situation.

**Between Two Valves**

In one instance Trevor closes a valve, moves his hand but returns it to the valve to make sure that it is properly closed; he needs the feedback from the handle to make sure that the system is in the desired state before proceeding to the next valve. Figure 4.b shows where Trevor is making sure the valve is closed, but with his attention turned towards the next valve.

**Resting the Hand**

Since Trevor approached the water station, his left hand has been resting on a valve as it can be seen in Figure 4.c, and it remains there until he has to open the valve. To open the valve he needs support from his right hand since the valve is tight (eventually see Figure 1.d) Trevor gradually loosens the grip of the right hand as the valve opens and the need for support decreases. Trevor moves his left hand to the next valve, and his right hand rests on the valve for the remaining time of the sequence. There is a good reason for holding the hand there; the pipes are very hot since the water is 80.

**MOVEMENT AS SITUATED ACTION**

Suchman has used the example of the Trukese and the European navigator to represent two different views on human intelligence and directed action. The European navigator begins with a plan and carries through with his journey by executing every step of the plan. Should he run into trouble, he would have to alter the plan before he can continue. The Trukese navigator in contrast, sets off with an objective and responds to the conditions as they occur; his actions are situated. In this line of thought I could say that Trevor acts like the Trukese, that his actions are situated; meaning that they are ‘taken in the context of particular, concrete circumstances.’ [10, p.vii] If I asked Trevor what he was doing I am pretty sure that he would describe his course of interactions as I did in the beginning of this paper, maybe with some details about the purpose of the individual valve or handle, but still as the European, as a plan with clearly defined steps. In that case I could confront him with my observations, ask him whether he had planned to ‘bless’ the gauge or double-check the valve as mentioned earlier, I would expect a ‘no’, and I assume that he would prove me right, that he was adjusting his movement to the situation.

**Non-Human Actors**

In the brewery different fluids are transported from place to place via a vast system of pipes. One could choose to see Trevor surrounded by pipes, valves and machinery, but with the words of Latour: ‘I do not hold this bias but see only actors some human, some nonhuman, some skilled, some unskilled that exchange their properties.’ [7] The work that is executed in the brewery is delegated among several actors, some human and some non-human. In this instance, part of the work has been delegated to actors of a more technical origin, namely valves; they are responsible for directing and controlling the beer, as well as hot water and etching fluids. The human actor has a line of colleagues with ‘whom’ he needs to interact. Those colleagues/actors are illiterate and deaf, and the interaction with them is rather physical, tangible. They respond only to touch, and their feedback is haptic and visual, perhaps also auditory.

Following this line of thought, I can make my way into Strauss [9] and a pragmatist/interactionist approach to interaction.

**Movement As Trajectory**

Trajectory is the word Strauss uses for ‘The course of any experienced phenomenon as it evolves over time and (...) the actions and interactions contributing to its evolution.’ [9, p.53] Viewing the water station sequence as a trajectory, Strauss’s ‘Basic Assumptions of a Theory of Action’ provides another possible angle that can deepen the understanding of actions and interaction, and inform design of tangible interaction. Regarding the valves, that Trevor interacts with in the video clip, as his colleagues, I will highlight assumptions, discuss and reflect on my observations in the following.

**Valves and assumption no. 15**

‘15: The several or many participants in an interactional course necessitates what Blumer termed the ‘alignment’ (or ‘articulation’) of their respective actions.’ [9, p. 40]

The actors have to align, they need to find a level at which they can interact, a coherent language that both understand. Suchman points towards this view on that matter: ‘A more profound basis for the relative sociability of computerbased artifacts, however, is the fact that the means for controlling computing machines and the behavior that results are increasingly linguistic, rather than mechanistic. That is to say, machine operation becomes less a matter of pushing buttons or pulling
levers with some physical result, and more a matter of specifying operations and assessing their effect through the use of a common language.’ [10, p. 11] From a tangible interaction point of view, that common language should be rather the opposite of linguistic, namely a physical language: The valve responds only to direct manipulation, but in return it can physically show its current state, the level of open- or closedness, and supported by the friction felt through the handle, and sound and vibration it might indicate the amount of fluid passing through the valve. The human actor is in fact quite competent in this relatively simple, but still sophisticated language and the valve can reveal an impressive range of information that only needs little or no translation. Information about state, temperature, wear, flow, need for maintenance etc. would call for a fair amount of translation, had it been displayed through a computer screen. One cannot really hold the valve itself responsible for the way it acts in the world, rather the designer of the valve, the person or team behind the choice of delegation of work, materials and shape.

Valves and assumption no. 7

‘7: Actions are not necessarily rational. Many are irrational or, in common parlance ‘irrational’ Yet rational action can be mistakenly perceived as not so by other actors.’ [9 p.30]

Watching Trevor ‘blessing’ the gauge could lead the uninitiated to the misconception that he was suffering from involuntary hand movements, where in fact he was adjusting the movement of his hand to the situation. As mentioned earlier, this is the second of four ‘flushings’ and in the first one; Trevor actually touches the gauge, feeling how hot it is. This movement has been incorporated into his modus operandi and the ‘blessing’ indicates that Trevor is in the same place at different times, performing different tasks. ‘If, as history, the past lies behind us, as memory it remains with us, not only in words but also in our neuromuscular patterning and kinaesthetic memories—the way in which specific experiences and concepts of time/space are built into our bodily modus operandi’ [Behar in 4, p.353]

CONCLUSION

‘Why do this?’ asks Dourish ‘The intuitive behind tangible computing is that, because we have developed skills for physical interaction with objects in the world—skills of exploring, sensing, assessing, manipulating, and navigating—we can make interaction easier by building interfaces that exploit these skills.’ [2, p. 206] Harnessing these skills could be the way to make interaction easier, but the question is whether interaction should be, at any price, easier? Maybe easier to learn would be more valuable? Designing interfaces that would require the acquisition of new skills could make the learning easier and more intuitive.

In this paper four different perspectives have been brought to an interaction sequence, to investigate how the understanding of skilled actions might support tangible interaction design.

Ingold’s distinction between wayfaring and transport draws attention to the in-betweens, to the movements between the points of interaction. In our quest for finding ways to design engaging tangible interaction, we must consider the entire sequence of movements, not just the contact points. This is where time becomes an issue; operations with technology should not be considered in isolation, but in the stream of activities in which they will be part.

Suchman’s notion of situated action puts a focus on the vital role of the situation when looking at action. To accurately understand Trevor’s sequence of actions we cannot use them to reconstruct a plan, rather see that the equipment provides him with (in this case at least) practical and appropriate actions, actions that are made relevant in the context of ‘flushing the pipes’, or ‘diluting the beer’.

Latour’s non-human actors remind us that the technology takes part in the work, rather than just being tools for the activity of work. Work has been delegated to them, skills—to greater or lesser degrees—have been incorporated in them and they are interacted with.

Finally, Strauss’ interactionism highlight that there is an alignment required between operators and equipment (particularly so as we move to intelligent systems that occupy Suchman, and the humanness of non-human actors that Latour discusses). This alignment, I have proposed, needs to be achieved through a physical language if we are concerned with embodied interaction and skill building through action. Furthermore, the rhythmic quality of the activity provides us our familiarity with the ways of working ‘alongly’ (rather than ‘building up’).

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Using Empirically Derived Personas and Scenarios

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ABSTRACT
This research project draws together two areas; interactive art and Human-Computer Interaction (HCI). This paper describes the data collection of audience behaviour in a variety of museum and gallery locations. Subsequent data analysis leading to persona and scenario design illustrates how empirical data can inform the design of a movement-based interface. Finally, low level prototypes were developed to aid the artist/designers in their aims to create an interactive installation in which visitors could learn contextually driven behaviour.

Keywords
Scenarios, personas, prototypes, audience behaviour, interface design

INTRODUCTION
This paper describes how scenarios and personas were used to provide a range of design options for the interface design of an immersive installation in which the audience experiences a sense of being psychologically and/or physically present in a computer-mediated space. The rationale for using HCI methodologies developing personas and scenarios grounded in field studies are that they offer essential theoretical and methodological tools to develop a better understanding of the audience experience of interactive art, and an expanded critical vocabulary to describe it. This paper offers a case study of how observations informed the development of personas and scenarios, leading to low level prototypes.

The overall aims of this project were to design an interface that allows users to access an archive of historical crime scene photographs and accompanying poetic texts. Secondly, to reflect on how traditional HCI practices might be used and developed to maximizing the potential interaction and experiences of audiences in multi-user, immersive, interactive gallery or museum environments.

The following sections describe the key features of this installation project and then explain the ways in which HCI has been applied to its design. Subsequent sections describe how personas, scenarios and low level prototyping, grounded in user observations, were used to inform the design of an interactive installation. Finally, reflections and recommendations for future use of HCI approaches to installation design are discussed.

INTERACTIVE, IMMERSIVE INSTALLATION
This project is based on an installation that is the most recent work in a suite of multimedia artworks ‘Life after Wartime’ created since 1999 by Ross Gibson and Kate Richards, assisted by a production team that has included a graphic designer, a composer and several programmers. The designer goals of the interactive, immersive multi-walled room were that it would intuitively teach visitors to be attentive, respectful, cautious and custodial to historical material (archival crime scene photos).

The original idea was that when someone enters this room they would immediately be able to respond to the historical material and the technology-surveyed room itself would respond to the presence and activity of those in the room by changing what material was revealed and how it was displayed. The corresponding audience response encouraged by historical material was envisaged by the artists to include quiet, slow movements and general bodily stillness. The interactive space would be a ‘hypersensitive’ and ‘haunted’ environment. Key goals included that the interface would be intuitive and would encourage collaborative group behaviour.

The design specifications of this exhibition included a multi-walled environment with computer fed crime scene photos and poetic text moving across the walls in a pattern similar to that of flocking birds. Motion sensors would detect the movement of visitors to the room and depending on the movement detected, cause the pictures and text to move differently. The designers envisaged that the pictures and text would ‘flock’ around the space at different speeds depending on the behaviour of the people. They assumed that if people were too active (i.e. not attentive, respectful, cautious etc.) the room would ‘react’ by moving pictures and text in an incoherent, disturbed manner. This was seen by the artist/designers to be a punishment for incorrect behaviour. Conversely, if people were respectful and...
cautious etc. the room would slowdown, become calmer and more coherent. This was seen by the artist/designers to be a reward for appropriate behaviour.

However, the designers’ visions of how the installation and audience would interact, assumed user behaviour with no empirical evidence of whether audiences would interact with the room or learn from the room in the manner described. In order to address these assumptions, and to better understand audience behaviour, techniques and methodologies from HCI were called upon to inform the installation’s design process.

HCI INFORMING INTERACTIVE ART

HCI approaches are envisaged to improve the ‘efficiency’ of the process of designing such a complex environment. In this context the meanings of ‘efficiency’ included: that already understood potential problems of technology use might be anticipated and avoided during the design phase; that the ‘usability’ and ‘usefulness’ of this installation could be defined according to audience experience and the situated use of the technology; that the technology did not drive the process and become the content of the final environment; and, most importantly, that the effects of multiple users on the behaviour of the room, and on each others’ experience of it, could be explicitly addressed and kept active during the installation’s design and development.

With the advent of computer-based interactivity a new kind of art-experience has come into being which is beyond the reach of existing art-theoretical approaches [7]. The experience of art is fundamentally interactive, comprising interplay of environment, perception and the generation of meaning in the mind of the audience. However, whilst lines of inheritance and continuity can of course be traced through aesthetic and technical developments that inform interactive art there is something new that appears with the arrival of the computer [5, 6]. In computer-based interactive art, interactivity itself is the very medium of the work. All technologies reflect the humans that create them; Latour [4] describes this process as bi-directional, with tools also forming human behaviour. Technologies are the means by which humans shape the world, and in return they shape our relationship with it. Art and new technology practice is conceptually very rich. It helps us begin to understand how human-computer interactivity itself can work as a medium. An artwork’s location of meaning is not just interactivity in an abstract sense, but situated interactivity. Within this project’s environment, the room is not ‘used’ in any traditional sense in that it has no tasks and supports no active goal related activity.

Through the use of human-centred methods that have been developed and used in more traditional technology design environments it is intended that development of this installation could reduce the risk of a chaotic user experience. This would result in more meaningful, reflective and satisfying engagements with both the semantic and aesthetic content of the environment.

USER RESEARCH

In this project, personas, scenarios were developed from participant observations of interactive, immersive museum and gallery spaces in Australia and France. The results of these techniques were then used to generate design possibilities that maintained a connection with audience experience.

RESEARCH DESIGN

Our approach was to gain an understanding of the behaviour of visitors to similar cultural spaces. This understanding was used in two ways; firstly to develop design options which related the design aims and specifications of the project HCI techniques, and secondly to create personas that could help us to evaluate, from the point of view of user experience, the effectiveness of the design options through the construction of scenarios. Techniques used in this project were informed by descriptive and imaginative approaches to developing personas and scenarios [1, 2, 3]. These techniques offer a framework of formative evaluation based on an iterative process that can be appropriated maintain accountability to the primacy of real, lived audience experience. Based on this evaluation we selected and further refined one design option from three initial design options for which we created a paper prototype. The observations, persona and scenario development are now described.

OBSERVATIONS

Two separate studies of audience behaviour in immersive spaces were completed. The main study in three prominent gallery and museum spaces in Sydney involved several researchers. A smaller parallel study of similar spaces in Paris was conducted by a single researcher. In total, over one dozen immersive spaces were observed.

Suchman [8] also situates the creation of meaning in interaction. She applies theories of how humans achieve meaning with each other to their relationship with interactive artefacts. Additionally, she identifies the way in which meaning is absolutely rooted in specific contexts.

Applying this understanding to interactive art is conceptually very rich. It helps us begin to understand how human-computer interactivity itself can work as a medium. An artwork’s location of meaning is not just interactivity in an abstract sense, but situated interactivity. Within this project’s environment, the room is not ‘used’ in any traditional sense in that it has no tasks and supports no active goal related activity.

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Both studies investigated audience behaviour within available examples of cultural/artistic installations that shared one or more qualities with the aims of our design project. Traditional museums as well as a range of art gallery environments were visited in both cities because it was (correctly) assumed that audience behaviour would vary according to the prevailing social protocols of the particular institutions. All observations were written up, including the physical configuration of the exhibit and the behaviour of the audience. Raw data was shared with the group, and findings extracted and recorded.

RESULTS OF OBSERVATIONS
One of the key findings was that audience behaviour was unlikely to be controlled or predicted by the design team. Other important observations related to the designers’ original assumptions of their future audience including, uncontrolled, unpredictable audience behaviour and numbers; visitors not responding to others’ verbal suggestions; lack of visitor understanding as to what the art and interaction was trying to achieve; a lack of reading or heeding instructions; lack of knowledge that art was interactive; interactivity distracting from content and meaning.

Specific behaviours observed that also challenged designers’ original assumptions included audience members performing one (or more) of the following behaviours, ‘poking their heads in’ and retreating; walking into the space, standing still and walking out (30 seconds to 3 minutes); ‘skimming’ through the museum or gallery for something to catch their eye and then performing the former behaviours; attempting to work any and all devices but disinterested in the content; or ‘serious engagement in participation and non participation, within the immersive environment, standing still and moving around the edges of the room.

In addition, museums and some galleries function as childcare/entertainment and places where people do not have to keep still. Children ran wild in these large spaces and touched as many things as they could.

PERSONAS AND SCENARIO DEVELOPMENT
Based on the observations of different behaviours and types of people, three key personas were developed. These personas reflected the observations made by the researchers. The personas included a middle aged woman visiting with a friend; an 11 year old, very active boy; and an audience member who regularly attended such exhibitions. The following excerpt is an example of the latter persona based on some typical behaviour observed in several museum spaces.

Luke, aged 25, is a full-time arts student, a painter. Luke is a regular visitor at exhibitions, going fortnightly to different spaces. He prefers art galleries like the MCA, and avoids places like the Powerhouse Museum where there are lots of kids. Luke is very interested in the significance and meaning of art works. He spends a large amount of time in each exhibition, absorbing the art and the artist’s intention. Luke visits galleries with his girlfriend, Gemma, or with friends who are similarly involved in art. They often whisper to each other or point out things of interest within the space, and then stand outside of the entrance afterwards, either re-reading parts of the info panel or discussing their experience of the art. Luke is highly irritated by people who interrupt his experience of the art, such as talking people or active children. When irritated, he often leaves the space and attempts to return later when no one is there.

SCENARIO DEVELOPMENT
In order to highlight audience behaviour observed in similar installations, the scenarios were created to explicitly address the following three issues. Firstly, we found that individual versus group experience is a very challenging negotiation especially when considering the number of different types of people that may enter a public exhibit. Our answer was to create scenarios that highlighted both participation and non participation, within the immersive experience which could allow for different behaviours of others in the space and limit the frustration of individual users whose experience is disrupted. Secondly, we constructed scenarios describing personas intuitively understanding, or failing to understand, the interface. The following is an excerpt of a scenario developed for the project.

…He starts to become absorbed in the pictures and their related texts, but the children in the room are becoming restless and more confident in their environment. They start to play games with the light, pushing one another in and out of the beams. Their giggling disturbs him and begins to annoy him, but what is worse, the images and texts on the walls begin to move too quickly for him to read. As the children become more and more boisterous running in and out of the light the images begin to swirl frenetically. He gives up reading and concentrating on the images and text and moves back to the centre of the room still sticking in the dark. The chaotic swirling of images and text are almost nightmarish and the noisy children are becoming incredibly annoying. Luckily, they are also getting bored and leave quite quickly. However the room does not settle down when they leave. When the room is empty Luke feels like stepping into the light himself. As soon as he steps into the beam of light the images suddenly slow down, though not completely, their movement is definitely more sedate. He steps towards the wall to examine them more closely, and they begin to swirl crazily again. He steps back into the light and they slowdown. He realises that this is the interactive element, and that he has a great deal of control over how the room behaves.
For many users exploring and discovering the interface was a key factor deciding their quality of their experience. Furthermore, we considered the process of discovery versus explicit instructions. Thirdly, we explored the designers’ assumptions that the intuitive interface should encourage stillness. From our observations, children tended to actively interact with such interfaces and could potentially learn the opposite lesson from the interface; more action resulting in faster ‘flocking’ behaviour. This could also be the case for audience members who would actively explore any and all perceived interfaces.

Our observations showed that achieving the design aims of the interactive immersive installation would be very challenging, as the hoped-for behaviour contrasted with much of the user interaction we had observed. Drawing on Bodker’s development of plus and minus scenarios to caricature future use situations [1], we brainstormed “extreme” design options to stimulate creative responses and to illustrate some of the problems we foresaw in controlling the behaviour of visitors to the space. As Bodker notes “it is just much easier to use one’s common sense judgement when confronted with a number of extremes, than when judging based on some kind of “middle ground” [1, p. 73].

Key features for achieving the desired behaviour included very direct imperative instructions such as, obvious visual cues such as warning signs and flashing lights, sonic cues such as alarms, and attendants correcting behaviour within the space. Drawing from the key findings from our observations of more and less effective interaction design choices, our knowledge of different audiences expressed in our personas and the ideas generated from our brainstorming session we came up with three design options. Figure 1 is an example of one design option.

Figure 1. Light Beam Option

This Light Beam design accounted for varying numbers of visitors. A sign on the wall outside of the entrance could provide an ambiguous description to interested visitors of the historical nature of the work without informing the visitor that the space is interactive. The light beams are the point of interaction. The interaction is activated when a visitor steps into the light beam (e.g. there is a sensor pad on the floor). The rest of the room is in semi darkness. Further rewards are given to the visitors when they work together as a group. i.e. when two people stand in two light beams, a noticeable difference occurs (than for one person) with greatest effect when all four light beams are occupied. There is continual ambient meditative noise in the room which remains peaceful, no matter what state the images and text are in. The default state of the images and text involves both ‘swirling’ fast. When a visitor stands under a light beam, the images and text slow down and are ‘peaceful’.

This design was based on a number of field observations. For example, the tendency of visitors to enter a space, pause at the door and then decide whether or not to explore the space further, and secondly, that people tend not to talk to each other, and that people tend not to explore their surroundings in an exhibition. The idea of using lights was to draw people’s attention and curiosity, and to reward people when they step into the light (bathing in light being equivalent to warmth and attention). This design solution aims to allow both participation and non-participation within the space (choice), to encourage group work, and to provide a direct and obvious mapping between a person’s movements and the response (slowing down) of the images on the screen.

The following are key features based on the observations, scenarios and personas that we explicitly included in the prototype design requirements.

- Interface allowed participation and non-participation
- Atmosphere: light/dark and sound are very important
- Implicit instructions and not being able to see in the space could create sense of mystery
- Darkness makes people move more slowly
- Children need close supervision
- Quite good possibilities for group work
- Hard to make adequate differentiation between one and many in light, whilst still making it workable for single user
- Not everyone will understand or be aware of the interface
- Content is prioritized.

**DISCUSSION**

HCI techniques informing interactive, immersive installations such as the Bystander Field provide multiple potential benefits for designers in this field by incorporating a wealth of user based approaches to maximise user/audience experience.
It is important to note that this observation and scenario writing phase occurred before a prototype of the bystander field was created. Uptake and incorporation of the findings and scenarios into the design process requires further exploration and development. Similar to this project’s goal of facilitating audience-installation interaction, further critical reflection needs to be conducted on facilitating designers to understand and incorporate the results of studies such as this one to maximise user experience.

One development currently being explored by another researcher on the Bystander Field project comprises designers playing the parts of personas acting out scripts based on scenarios within a low level prototype in order for them to experience the situation for themselves.

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REFERENCES


Mechanics and Meaning: Methodological Considerations when Studying Movement in HCI
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ABSTRACT
The ability of technology to detect interaction with bodily movements is changing. In order to inform the design of technology that relies on movements of the body for interaction, we need methods that allow us to study movement with appropriate analytical rigour. In this paper we explicate some of the philosophical foundations and underlying assumptions when studying movement from the perspectives of biomechanics and phenomenology. Further, we briefly outline some implications for the design of methods in HCI for studying movement-based interaction with technology.

Keywords
Body, human movement, interaction design, interaction techniques, methodology.

INTRODUCTION
Into the mix of interaction options for the able-bodied and or disabled user, enters the question of how to study movement in relation to bodily interaction with technology. Can appropriate methods be adopted from other disciplines or is the nature of hybrid physical-digital technological environments such that new methods and approaches are necessary? What kinds of understandings of human movement can provide useful perspectives for interaction design? These questions are of both methodological and epistemological significance.

This paper will briefly introduce biomechanics and phenomenology, and revisit their philosophical foundations and underlying assumptions to see how they impact our study of movement. We then describe empirical work with the SONY PS2® Eyetoy™ [9], which applied current frameworks in human-computer interaction (HCI) to studying and conceptualising movement-based interaction.

We conclude by outlining implications for HCI where the moving body is enabling interaction.

REVISITING PHILOSOPHICAL FOUNDATIONS AND UNDERLYING ASSUMPTIONS
We start by examining biomechanics and phenomenology as representatives of two main approaches to the study of movement in current HCI.

Biomechanics
Biomechanics stands in the tradition of Western science with roots in the methodologies of Galileo and Descartes. At the core of the discipline lies Newtonian mechanics with its theoretical framework of clearly formulated and internally consistent general laws. Based on these laws, knowledge of the motion of all objects or bodies can be articulated in exact, mathematical terms and given clear-cut causal explanations.

Newton held the view that the basic laws of motion were creations of God (and therefore absolutely true) and could be observed in terms of “objective” observations. This view of a scientific approach as leading to absolute truth is usually linked to inductive reasoning, built on the Baconian thesis that it is possible to generalise on a sufficiently large number of objective empirical observations. This position has been attacked by philosophers from Hume to Popper, stating that induction can, at best, give probability never certainty.

Understanding human movement from the Newtonian perspective leads to a consideration of the physical makeup and movement potential of the human body in terms of bones, joints, muscles, tendons and ligaments that can be subjected to measurement. The field of movement science and ergonomics tends to focus on the anatomical characteristics and constraints of the moving body. This view is useful for HCI as it provides both constraints and resources in the determination of possible movement profiles for movement-based interaction with technology. The area of human factors engineering has taken this view of movement with its focus on the ergonomic relationship between people and technology.
Phenomenology
Phenomenology is the science of phenomena, the philosophy of experience. It differs from the various human science approaches such as ethnography, symbolic interactionism, and ethnmethodology in that phenomenology makes a distinction between appearance and essence. “Phenomenology is the study of essences”, says Merleau-Ponty [7, p. vii]. This means that phenomenology always asks questions of what is the nature or meaning of something. It offers accounts of experienced space, time, body and human relations as we live them. A search for knowledge concerning meaning and experience seems in Western science to stand in the Aristotelian tradition. Where the analytical Galilean approach searches for exact descriptions and causal explanations, the Aristotelian approach searches for holistic understanding of the phenomenon under study.

A phenomenological understanding of human movement is to see the body not in terms of a biomechanical analysis, but in the awareness and meaning of movement. It is to understand body movement as a component of social action, not as muscles, bones, angles of displacement, locomotor patterns, or positional behaviours. In contrast to the “objective” body studied in biomechanics, the “body subject” studied in phenomenology refers to the basic, intuitive experience of bodily existence as being-in-the-world.

Biomechanics and Phenomenology – a perfect match?
It would seem that taken together the biomechanical and phenomenological approaches would complement each other. Biomechanics offers mathematical exact descriptions and causal explanations and has strong predictive force, but it is criticised for not being able to give an account of lived, practical experience. Phenomenology, on the other hand provides less reductionist descriptions making use of practical lived experience, however these descriptions can be hard to test empirically. Combined they seem to be able to give us the best of two worlds.

However, the biomechanical and phenomenological approaches are built on fundamentally different methodological and epistemological premises; the body seen as levers and weights can be explained only by the deterministic laws of mechanics, and shares no common ground with the idea of the body-subject intentionally seeking meaning in movement. The two approaches are incompatible in that the basic concept of one cannot be translated into the basic concept of the other.

Moreover, this incompatibility implies methodological incompatibility. There is no method acceptable to proponents of both approaches on which to settle possible disputes and disagreements between the two. Studying movement as a meristic structure that can be fully explained if broken down into its basic components radically contradicts an understanding of movement as a holistic whole which loses its meaning if analysed into the parts that compose it.

However, all is not lost; the two approaches can lead to significant knowledge not reachable through the other. They incorporate alternative ideas of what count as good understandings of human movement, and geared towards problem solving, they can be systematically elaborated and thus be opened to discussion.

Some examples
Consider the following four examples as basic examples of descriptions of movement - using biomechanical or phenomenological methods of investigation:

1. The humeral appendage is raised to an 80 degree angle to the torso - anatomical description of movement from observer’s pov;
2. The arm goes up - description of gross physical movement from observer's pov;
3. I wave to my friend (or play Eyetoy™) - description of an action from actor's pov;
4. I raise my arm to shake out tiredness - description of awareness of movement from actor's pov.

The examples illustrate important points for the ensuing discussion. The first and second examples carry information of anatomical and functional nature, but do not explain the semantic content of the scene, which is quite succinctly revealed in the third. The fourth example emphasises the kinaesthetic aspects of movement for the actor. A fifth example could be added:

5. I raise my arm to... I become aware that I am being observed – description of awareness of movement being observed from an actor's pov.

Being observed could elicit a range of reactions from embarrassment to excitement, depending on the person and the setting. What is important is the fact that the observer has an impact on the situation and the extent to which people are aware of being observed.

In addition, the examples implicitly highlight the aspect of perspective. Put diametrically, when studying and describing movement, do we adopt the perspective of the actor as in phenomenology, or that of the observer in biomechanics? Furthermore, does adopting either perspective yield the information necessary for our task at hand? We will return to these points in our discussion.

STUDYING MOVEMENT IN HCI
In order to bring these ideas into HCI we now review some current frameworks for studying and designing movement-based interaction. In previous work (e.g. [5] and [6]) we have explored the questions of how to describe and represent movement for interaction, and what forms of human movement make sense when movement is driving interaction. As a way of conceptualising the problem, we used a three-prong approach, sensemaking, interaction and movement analysis, for analysing movements produced through interaction with two Eyetoy™ games. In this
section, we review our approaches, and then proceed to examine these approaches critically.

**Sensemaking Analysis**
The *Sensible, Sensable, Desirable: a Framework for Designing Physical Interfaces* [2] and *Making Sense of Sensing Systems: Five Questions for Designers and Researchers* [1] are two frameworks that have emerged to explore forms of human movement that can make sense when movement is the driver for interaction.

The frameworks provide useful tools for thinking, and for sorting and categorising identified actions and movements. Both frameworks lead to an examination of the relationship between the user and the technology (in our study the Eyetoy™), but from different perspectives. Benford et al. [2] consider the relationships between the user’s movements with the technology and the environment. Bellotti et al. [1] on the other hand, focus on what happens when the technology moves into the environment around us and the challenges this poses to the interaction between people and computers. The two frameworks overlap in determining the relationship between the user’s movements and the capabilities of the sensor technology.

**Interaction Analysis**
Inspired by Suchman’s [10] analytic framework for conversational analysis, the interaction between the player and the Eyetoy™ technology was analysed in terms of user perception and action vs. machine perception and action. This analysis revealed a large disparity in terms of the technology’s comparatively limited perception. However this may result in a movement that is unwieldy and obscures the general forms of movement e.g. forward high (with a ‘gliding’ quality) or very specific and detailed body parts moving e.g. *using fingers to tap the virtual button in the game*. However this may result in a design representation that is unwieldy and obscures the relevant aspects of the interaction to be modelled. Relevance is of course dictated by the particular application under design.

We will now go on to examine to what extent our approach of sensemaking, interaction and movement analysis addresses the *anatomical, functional, semantic, kinaesthetic* aspects outlined earlier.

**Movement Analysis**
Labanotation [4], a form of dance notation, was used to transcribe the movements produced through interaction with the two EYETOY™ games.

The notation led to a distinction between *functional* and *performed* movement in the interaction. For a given game action, the *functional* movement was taken to be the essential properties or the general form of the movement required for effective operation of the interface. *Performed* movement describes the actual, distinctive movements produced by particular bodies. Labanotation can describe general forms of movement e.g. *right arm reaches to forward high* (with a ‘gliding’ quality) or very specific and detailed body parts moving e.g. *using fingers to tap the virtual button in the game*. However this may result in a design representation that is unwieldy and obscures the relevant aspects of the interaction to be modelled. Relevance is of course dictated by the particular application under design.

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**MECHANICS OR MEANING?**
Only Labanotation, of the frameworks considered in our analysis, considers and describes the actual movements in the interaction, as such these descriptions could be labelled *anatomical*. Labanotation is written from the actor’s perspective rather than the observer’s, and so has built-in assumptions of agency. On the other hand, it could be argued that Labanotation reduces action to positions or a sequence of positions similar to photographs, sketches and or diagrams.

Belotti et al. [1] deal with sensor perception, while Benford et al. [2] deal with the meaning of the actors’ movements, however only implicitly. Descriptions produced using these frameworks would be of a *functional* or a *functional-semantic* nature. The analysis inspired by Suchman [10] was valuable in that it enabled us to describe the movement as *meaningful* actions occurring in context.

The sensemaking, interaction and movement analysis carry information of either:

- *functional* and *anatomical* nature, there is low or non-existent description of bodily awareness, the body is an object for others to observe; or
- *semantic* nature, where the emphasis is on the action performed, not on the anatomical or kinaesthetic nature of the movement.

Descriptions giving prominence to awareness of the body itself are not captured by either of these frameworks.

One obvious reason for this is the fact that we on the one hand have descriptions of movement of *observable criteria* while on the other we are trying to capture *experiencing*. This, we will try to show, takes us back to the issue of perspective.

Others can observe *what* I am experiencing, but not my *experiencing* per se. Having an experience while performing a movement does not necessarily determine what the action I am trying to perform is. It is not that the experience determines the action, but that the context of occurrence determines not only the character of the action but also the character of experience. Raising my arm would not amount to an action in Eyetoy™ [9] or the experience of it without the context of the game. Hence to focus solely the *experiencing* as that which explains the character of an action is not adequate either. *Experiencing* can not be regarded as distinct from what is *experienced*.

Farnell expresses this distinction as [4, p. 941]:

- *talk about* the body - the biomechanical perspective;
- *talk of* the body - the phenomenological experience of moving;
- *talk from* the body – enactment of the body in the agentive production of meaning.
What could be said about observable criteria vs experiencing is that that which the holds the least importance to the mover, in a certain situation, contains the most significance to the observer.

IMPLICATIONS FOR HCI
How then can this be applied to HCI? How can we integrate these diverse perspectives so that human movement can be described in its lived context for the study and subsequent design of movement-based interaction with technology. The nature of current and future interactions between humans and technology are such that technology still requires descriptions of human movement at the physical and functional level.

To see the human body as a system of weights and levers for producing forces operating within the physical universe and thus subjected to the same universal forces as any other system of weights and levers seems far removed from the experience of bodily movement in real life. In a Cartesian universe the body is seen as mindless matter moving around in a deterministic world in which there is no room for concepts like intentions, experience, meaning and value, concepts that play important part in an understanding of bodily movement as lived, and practical experience. Movement descriptions in HCI must be capable of writing all anatomically possible bodily action in ways that will preserve the identity of the movement and make possible accurate reproduction of it and maintain its semantic content.

The important thing seems to be to ensure that descriptions are generated within the context in which they have meaning and can retain their links to real human behaviour through the design process. One of the challenges is to explore the tension between simplicity and specificity for describing movement as input for interaction without unnecessarily constraining the possibilities for individual action and performance. The simpler the description, the more open it is to interpretation in performance. Conversely, the more specific the description, the less interpretation or leeway in performing the movement.

When people interact with other people, physical, digital or hybrid environments, human movement is manifested as purposeful actions reliant on the “essential corporeality of human cognition” [8, p.122]. This embodied nature of cognition shapes the way we can think about movement as input for interaction. For example, by learning to use a stylus we incorporate the stylus into our bodily space for the task of inputting. In contrast, when using movement as input for interaction we do not have to learn to use a new device, but we are reliant on the potential for action that the technology creates for us. This is to be taken in the sense that the technology poses certain constraints on and/or opportunities for our actions as natural movement, but also in the sense that what an action means depends on the intentions of the user [11]. In our approach this means that the technology will have to be designed to provide spaces within which people can perform movements that are meaningful.

In this paper we have attempted to illustrate that human movement can be described from many perspectives, of which we have only named a few; the mechanics of the moving body in space and time; the expressive qualities of movement; the moving body involved in acts of perception and movement as part of human action and activity. Further, we attempted to integrate these varied perspectives so that human movement can be described in its lived context for the design of movement-based interaction with technology. Just as importantly will be considerations of appropriate levels of translations, transformations and interpretations of human movement by the technology when the moving body becomes the enabler of interaction.

REFERENCES
ABSTRACT
This paper describes the development of movement-oriented personas and scenarios for representing multiple users of an interactive, immersive environment, designed as an artistic work for a public space. Personas and scenarios were integrated into a user interaction script and linked to a set of movement schemas using Labanotation for group choreography. Enactment of the script within a prototype environment allowed the designers to experience the aesthetic and kinaesthetic qualities of the work, as well as the social interactional aspects of the user experience. This ensured that the experience of those visiting the exhibition was always central to the design process.

Keywords
enactment, Labanotation, mobility, movement, persona, scenario, social interaction

INTRODUCTION
The development of novel technologies for public use in public spaces signals the shift from work-oriented technology to that where the user experience becomes primary to the design of such systems. This is of particular relevance to artistic works that are now utilising available technologies and expanding the aesthetics of user engagement to include aspects of interactivity and immersion involving the active and moving body. The design of interactive, immersive spaces intended for public consumption requires re-examination of the accepted user-and use-oriented technology design practices. We undertook this investigation during our involvement with an established collaboration of artists in the design of a multi-user, immersive, interactive environment called “The Bystander Field”.

This paper describes the use of movement-oriented personas and scenarios for representing multiple users of an interactive, immersive environment. These new forms of interactive spaces, such as the Bystander Field, utilise the presence and motion of people as input for interaction. We extended the traditional user-centred design tools of personas and scenarios to explicitly address human movement characteristics that are embedded in social interaction. A major concern was to make visible the effects of multiple users on the behaviour of the room, and on each other’s experience of it. Personas and scenarios were one means of ensuring that this could be explicitly addressed and kept active during the Bystander Field’s design and development.

BACKGROUND
The Bystander Field is the latest work in a suite of multimedia artworks created since 1999 by Ross Gibson and Kate Richards, based on a collection of several thousand black and white photographs of crime scenes taken by forensic detectives. The Bystander Field is designed as a space for living, moving and active bodies to be in, that responds to their presence, movement and stillness, as they actively make sense of the different images and texts that are displayed to them.

The audience sees a flock of white particles that is present in the room with them. The activities of the flock are represented by changes in size, density, detail, position, sound and motion that respond to the presence and activity of the room’s current and shifting inhabitants, disturbed by intrusion and inappropriate, ‘disrespectful’ activities, calmed by stillness and solitude. As the flock moves around, it reveals sets of images and texts. The relationship between the revealed media is more coherent and more narrative when the flock is calm, less coherent and more associative when the flock is disturbed. This changing relationship has been modelled in the design by a series of states.

Understanding movement and social interaction
The Bystander Field does not use the gestural aspect of human movement as input because gestural interaction was ultimately seen as detracting from a satisfying user experience of the exhibited work. Our understanding of the relevant kinds of human movement was thus directed to patterns of mobility, general body movement and locomotion. Recent studies of human movement by anthropologists indicate a shift from “an observationist view of behaviour to a conception of body movement as dynamically embodied action” in semantically rich spaces [2]. Conceptions of movement range from movement as
physical behaviour and motor activity to movement as situated, meaningful and embodied action. Even though we can more productively think of the moving body involved in acts such as walking, conversing and dancing in a particular place/space/time, when movement is input into technical systems, we still require descriptions of human movement at the physical and functional level. The important thing is to ensure that these descriptions are generated within the context in which they have meaning and can retain their links to real human behaviour throughout the design process.

An important source of understanding how people move and conduct themselves in museums and galleries comes from researchers in interaction and conversation analysis. They have shown that people’s experience and perception of an exhibit is fundamentally shaped by and through social interaction with others in the same space [3, 9]. Aspects of social interaction that were particularly salient to this work included: how visitors collaborate and coordinate activity; have sensitivity to others’ presence and orientation; encourage or discourage participation; continually monitor the environment; and maintain peripheral awareness of, and align their activities to, the conduct and performance of others, be they companions or strangers.

Thus the kinds of movement that we wished to describe in our scenarios are the patterns and forms of movement and the spatial trajectories as people move through the space and interact or engage with the exhibited material. These patterns and trajectories include aspects of timing, position and orientation that are influenced by social interaction and social protocol, people’s aesthetic and emotional engagement with the exhibited work, as well as their response to physical properties of the space. Apart from textual descriptions of the patterns and forms of movement, we wanted a way of representing these visually to support the reflective design practices of the project team. We examined existing movement notations for this purpose.

Labanotation for group choreography

Various notations exist for documenting human movement. Most have arisen for use in documenting dance choreography and include Labanotation, Benesh and Eshkol-Wachmann [4]. Benesh was devised for recording ballet scores, and Eshkol-Wachmann is a system that is not specifically tailored to the human body, whereas Labanotation is suited to describing all forms of human movement. It is a system of analysing and recording movement, originally devised by Rudolf Laban in the 1920’s. There are three essential forms of description - Motif, Effort-Shape and Structural - which focus on the movement characteristics of an individual body. Earlier research by [6] investigated the suitability of the individual descriptive forms of Labanotation for analysing and describing movement when used as input for interaction with technology. Preliminary findings suggested that the power of Labanotation as a design tool in movement-based interaction lies in the provision of a system for recording and representing human movement that has the body as a central focus. The representation of movements used as input for interaction can be visually linked to the point of interaction with the interface, thus facilitating exploration of the possible input design options.

In this paper we describe how the symbolic notation intended for group choreography has proved to be extremely useful in the design of the Bystander Field for representing the social and contextual aspects of interaction that influence how and where people move and locate themselves in the space in relation to others. Spatial trajectories can be mapped onto floor plans indicating the position, orientation, direction and path taken through space and time of individual and multiple people.

DEVELOPING MOVEMENT-ORIENTED PERSONAS AND SCENARIOS

Very early in the project we developed a number of personas, related use scenarios and a preliminary script of scenarios over time to represent the expected museum audience and their activities in the room. At this stage no formal user studies had been done and these initial personas and scenarios were developed from interviews with the artists about their impressions of those who visited their own and similar exhibitions in the past. The intention was to provide some use-focused tools for the design team “to think with” [8] that would make the potential visitor’s possible experience of the room a driver of the design from the very beginning. These early personas and scenarios made a major contribution to the then newly formed project team in developing a shared understanding of the initial concepts of the project. They were then put aside until user research could ground and guide their redevelopment.

Two separate studies of audience behaviour in immersive spaces were done. The aim of the studies was to provide the design team with a working understanding of potential audience behaviours that could be mapped to whatever behaviour was to be available to the flock of images and texts within the room. There were two strands of investigation. The first was what actually happened in these spaces: who the audience were, how people were inhabiting the exhibition space and what kinds of activities they were doing. The second was the patterns of mobility and motor activity of the visitors to the exhibits. Six main audience behaviours were identified: 1. Poke head in and retreat; 2. Walk in, stand for a while and then go out; 3. Skimming; 4. Try and make something happen; 5. Serious, quiet and contemplative engagement; and 6. Kids (running round!). For more detail see [5].

Evolving personas

A series of personas was developed from the user studies and the early interviews with the artists to represent the
range of visitors to the spaces considered. Unlike Cooper’s [1] recommendation of having 3 to 8 different personas for task-related scenarios of use in a work context, we found we needed to develop multiple examples of basic personas to allow us to populate the Bystander Field prototype over time so that different combinations and effects of public use could be investigated. A range of individual ‘characters’ was created for each persona. Note that these characters were not a return to individual users but were designed to carry the characteristics of the personas through multiple instances within the testing environment.

These persona descriptions evolved from traditional descriptions of user history, skills and goals to include two distinct characteristics specific to the kind of interactive, immersive environment under design: 1) a motivation for why that persona might be interested in the exhibit, either alone or with others; and 2) the movement characteristics that reflected the persona’s unique bodily expression and movement styles, and the kinds of movement that this person might perform in a specific situation encountered within this particular setting.

**Scenarios and the user interaction script**

Scenarios of each character’s movement and activity inside the Bystander Field were developed and then joined together to form a user interaction script that could structure the exploration and evaluations of various models and prototypes over time. The basic script was produced during a design session that involved developing and simulating various scenarios of audience activity and behaviour that were grounded by the observations made during the user studies. A scaled-down model of the room was constructed out of foamboard and cardboard cutouts were made of different characters to make multiple instances of each of the personas. Care was taken to ensure that the full range of audience behaviours we had observed was captured in the script, as well as different configurations of people in the room so that full functional testing of the system could be done with particular regard to state definitions, boundary cases and transitions between states.

The script was structured so that the audience activity was listed on one side of a table along with what was available to them to sense in the room at the time. On the other side, we defined whatever was actually available for the room to sense and its corresponding behaviour. This approach was directly inspired by the analytic framework Suchman used to identify available conversational resources in her classic study of photocopy use [7]. The matching of audience and system behaviour and perception allowed for the mapping of action and response, where appropriate, from both the user and the system perspectives, as well as making the perceptual asymmetry between the two available. Audience activity was described in terms of position, orientation, direction of movement, degree of movement, spatial paths and configurations within specific scenarios of use.

A 3 minute excerpt (see Table 1 and Table 2) from the 40 minute user interaction script illustrates two scenarios. We have presented it here in two separate tables purely for formatting reasons. In practice it is a single table in landscape format, with the User Perception and Machine Perception columns side-by-side. The Time column connects the two tables. Table 1 contains the audience or user perspective and Table 2 contains the room or machine perspective.

The first scenario involves Betty and her friend, Val, entering the space. They represent visitors who are slow-moving and contemplative. When they first enter, they stand just inside the entrance, looking around to watch the flock revealing images and text on the wall opposite. At this point in time, the system should detect two figures and transition to state one, where the flock changes in some way but still coherently presents images and text. The second scenario involves a young teenager attempting to enter the room.

<table>
<thead>
<tr>
<th>Schema</th>
<th>Time (M:S)</th>
<th>Scenario</th>
<th>Activity</th>
<th>Movement/Stillness</th>
<th>User Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>01:00</td>
<td>Slow-moving, contemplative visitors. Betty and Val about to enter.</td>
<td>Betty and Val enter room together and stand fairly still looking around with heads turning.</td>
<td>See flock revealing on wall, w2.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>01:30</td>
<td>Head-poker. Young teenager enters, blocked by Betty and Val, so leaves. (see Figure 1)</td>
<td>Young teenager enters room, then exits.</td>
<td>What they see depends on whether or not the room perceives the head poker</td>
<td></td>
</tr>
<tr>
<td></td>
<td>02:00</td>
<td>Betty and Val decide to stay and watch more.</td>
<td>Betty and Val walk towards centre.</td>
<td>See flock moving, some images and text unfold.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>02:30 - 04:00</td>
<td>They watch the flock.</td>
<td>Slowly turning to watch flock, taking 1 or 2 steps each way.</td>
<td>See flock moving, more images and text unfold.</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Room Perspective - User Interaction Script

<table>
<thead>
<tr>
<th>Time (M:S)</th>
<th>Machine Perception</th>
<th>Room State</th>
<th>Flock/Sound behaviour</th>
<th>Design Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:00</td>
<td>Detection of 2 figures, some motion.</td>
<td>State 1.</td>
<td>Flock coherent presentation on wall, w2.</td>
<td>What is considered ‘still’? Standing still may realistically translate to slow, peaceful, gentle body movements and locomotion within a very small area.</td>
</tr>
<tr>
<td>01:30</td>
<td>Ingress of 1 figure.</td>
<td>Flock coherent presentation.</td>
<td></td>
<td>Has this person been detected? May want dead zone at entry.</td>
</tr>
<tr>
<td>02:00</td>
<td>Detection of 2 figures moving towards centre.</td>
<td>State change?</td>
<td>Does it change?</td>
<td>Is this sufficient movement to trigger a state shift to state 2?</td>
</tr>
<tr>
<td>02:30 - 04:00</td>
<td>Detection of 1-2 figures at centre.</td>
<td>Flock behaviour depends on answers to design questions.</td>
<td></td>
<td>Does position matter to the room?</td>
</tr>
</tbody>
</table>

But the entrance is blocked by Betty and Val, so the teenager leaves. The question arises, for the designers, as to whether the young teenager (persona - a "head-poker") is detected and registered by the system as a presence that will affect the subsequent behaviour of the system. Then Betty and Val walk towards the centre of the room and remain there for a couple of minutes, slowly surveying the exhibited material, turning and moving around occasionally. The system remains in state one, with the flock moving dynamically around the five walls of the space and coherently revealing images and text. The description of the characters’ movement in space and time is represented visually in movement schema 2 (see Figure 1).

The format of the script clearly allowed the designers to recognise the extent of the perceptual asymmetry between the audience or users and the room or ‘machine’ [7]. The users act in the space within a social, situated and interactive context and hence their perception is shaped by and through their action and interaction with others, and the nature of the interactive work. In contrast, the machine’s perception of the action is limited to detecting what the designers chose to make available to it. Presenting the design questions regarding the mapping of audience input to system response within the analytic framework of the user interaction script meant that they could be continually addressed and evaluated as the design evolved.

Movement schemas
At the same time as the script was developed, an augmented set of Labanotation designed for group choreography was used to describe a set of movement schemas. Figure 1 and Figure 2 are examples of such a schema. These were developed to illustrate the changing spatial configurations and trajectories of the users during the scenarios. They provided an easily learnt, at-a-glance view of the overall activity in the room in terms of the path, position, orientation and movement of multiple users in space and time. By matching these schemas to the script it was possible to map the movements of individual characters both within the Bystander Field and in relation to other characters participating in the experience with them. This enabled us to ensure that the interaction with others that has been identified as defining of user experience of interactive art works, e.g., [3,9], was represented within this design tool. Most importantly it provided us with a way to represent findings from the user studies so these could be used to drive the enactment and evaluation of the developing Bystander Field.

![Figure 1. Movement schema 2](image)

We needed to augment the standard Labanotation symbols with a few of our own to enable us to represent, for example, undifferentiated body movement or ‘motion’ within a bounded area (see the dashed circle in Figure 1). This was important because the authors of the Bystander Field wanted audience presence and stillness to encourage revelation of the content, whereas activity and motion would result in less coherent and more turbulent presentation of the content. Body movements (be they gestures, postural shifts or locomotion, etc.) were treated as motion in the room: a source of disturbance. This raised the question of what constitutes ‘stillness’ in interactive spaces as people are rarely ever completely still in these
environments. User studies also found that stillness can sometimes be associated with a lack of engagement, when for example, people are ignoring the exhibited work to talk together about something else. We needed an understanding of stillness that was defined in relation to people's experience of the content and behaviour of the room.

**DISCUSSION**

The interaction script and its accompanying movement schemas were intended to enable the design team to experience aspects of the work that had not been possible until team members could immerse themselves in the piece. Prior to enactment of the script, much of the design conversation about the nature of the interaction between different members of the audience and between the audience and the room had been speculative and ungrounded. The first scenario enactment provided the design team with an extraordinarily strong sense of the physical and social aspects of the audience experience. The influence of other people's presence and activity in the room on an individual audience member's experience and perception of the work was made evident [9]. It was clear that for an individual to experience all aspects of the work, it might not be possible without the presence of several other people [3]. For example, it may only be possible for a quiet and attentive couple to witness the full extent of the work when a group of hyperactive children enter. This meant that audience understandings about how the interactivity of the room 'worked' could be only loosely tied to the experience of participating in whatever the current behaviour of the room actually was. It also meant that we needed to think about a range of 'satisfying' experiences for various configurations of people in the room.

During the script enactment, different people had quite different experiences regarding how and where they wanted to move or position themselves in the space. There was a tension between moving into the centre and moving to the periphery or corners. This pattern of movement was influenced by several factors such as moving to a position to gain a wider field of view; moving backwards to keep the visuals in front; following the flock by moving or watching; the sense of scale and physical shape of the room; the presence, position and behaviour of other people in the space and corresponding accommodation or sensitivity; the social interaction between companions and strangers; and actively engaging with the images and text. Later versions of the user interaction script were developed to support the design team's understandings of other aspects of the design such as movements in response to different experiences of the aesthetic content of the room.

**CONCLUSION**

The use of scenarios, personas, immersion and enactment revealed crucial aspects of the emerging design in ways that enabled them to be reflected on and used to build robust shared understandings among the designers. They functioned as “tools to think with” [8] to enable the design team to test, reflect and refocus their decisions throughout the design process. Most importantly, the use of personas and scenarios as design tools ensured that the experience of those visiting the exhibition was always central to the design process and that design decisions were always accountable, in a range of ways, to user experience of still emerging and novel technologies.

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**REFERENCES**

Some grammatical remarks on movement as interaction design material

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ABSTRACT
Human movement is rightly seen as a rich and under-explored resource for the design of novel interaction modalities for new technology. In this paper, I would like to briefly explore some of the difficulties inherent to harnessing what seems to be the limitless potential of human movements as a means of interacting with technology. In particular, I will treat these difficulties as a symptom of the fact that movement (generally conceived), unlike language, does not have a grammar. I will focus on sketching out some of the implications of this for the promise of human movement as interaction design material.

Keywords
Movement, interaction design, grammar, embodiment

INTRODUCTION
Anyone who has played ‘charades’ (where one has to silently act out words or phrases e.g. movie titles or figures of speech, to an audience who guesses what is being acted out) is familiar with the vast variety of interpretations that can be ascribed to human movements. Indeed, it is exactly that variety that makes possible the fun (and/or frustration, novelty, surprise, ridiculousness, humiliation, discovery) of the game. But this example alone reveals some of the difficulties inherent to the adoption of movement as a resource for interaction designers. If, for instance, movement is so ambiguous even to human interpreters with common frames of reference, how can it be harnessable as an input modality for interactive technologies?

In this short paper, I want to discuss some difficulties inherent to the utilisation of movement as an interaction modality. This will be argued through a discussion of the necessity of grammar (i.e. standards of correct use) to forms of intelligible communication. From this excursion, it will be possible to speculate on some fruitful possibilities for making use of movement, and to delimit their bounds of application.

This paper is structured as follows: The centrality of grammar to shared forms of communication is briefly introduced, forming a contrast to the inherent ambiguity of movement. Some preliminary options that have been available to designers interested in making use of movement are then surveyed. This leads to a discussion which critically treats the hope that movement-based interaction might lead to ‘better’ ‘more natural’ or ‘more embodied’ systems. The paper concludes with five directions that this critical exploration recommends to designers and researchers interested in human movement as design material.

But to begin with, a clarification: when talking about movement it is important to remember that with the arguable exception of speech interfaces and passive input devices (e.g. body heat or skin conductivity sensors), all interaction with technology makes use of human movement, whether we talk of the keyboard-mouse interface, eye-tracking interfaces, tablet PCs, virtual reality, or the buttons and displays found on most handheld devices. When speaking of making effective use of human movement as a way to interact with systems, I am thinking primarily of the movement being the interaction with the system, rather than moving the system in order to interact with it. Admittedly, this is a somewhat arbitrary distinction. Sony’s Eyetoy™ Play¹ is a fair example of the first kind: ‘movement-as-interaction’. Many bodily interactions with technology take the latter form, however, where larger human movements are required to interact with physically larger interfaces. However, if the promise of the notion of embodiment as a resource for design consists in taking advantage of our ordinary, bodily, lived experience of and in the world [6, pp.17-18], it is clearly the first kind of interaction (i.e. movement-as-interaction) that is of greater interest. But it is also this promise that will be subjected to scrutiny in the present discussion.

GRAMMAR
Agreements with respect to our uses of words are what enable us to make intersubjective sense with language. These agreements constitute the grammar of our language—what words can be employed in which ways. This is not limited to the rules of grammar learned in

¹ Eyetoy™ Play is a Playstation™ game that uses a video mirror. The game works by superimposing digital characters onto the (mirror) image of the player. Thus, the player can interact (i.e. make ‘virtual’ contact) with those characters, and play the game.
school (e.g. conjugation of verbs, plural forms etc.) but is more encompassing than that, including the standards for what, within language, it can possibly make sense to say. A principal point is that while we can, in principal, say anything we like with language, we cannot mean anything we like. A string of words such as “Impressing open dubious if” has no meaning. While we can stipulate a meaning for it, (i.e. “When I say ‘impressing open dubious if’ I mean ‘quietly keep working’”), that meaning must be expressed in other, intelligible, terms. Grammar determines the bounds of sense [see 1, 3, 11].

While it is commonplace that there are ambiguities in linguistic forms of communication, there is not, as some might suppose, an inexhaustibility of interpretations of a sentence [4]. Were that to be the case, intelligibility, communication and coordination of action would be a far more remarkable achievement than it already is. But when we move to consider movement as a form of interaction with technology, we encounter a different set of difficulties inherent to the ambiguity of movement as a form of communication. Since movement of itself does not have a grammar [but see 9, 10], designers seeking to make use of interaction with movement seem to be presented with a limited set of choices. For example, should designers specify how systems should interpret human movement as input (thereby stipulating what movements to recognise), or can they make use of a more direct translation of human movement (e.g. where users’ physical movement in a space corresponds to the movement of a perspective in a virtual space)?

The challenges of taking full advantage of movement as input modality hinge on designers’ decisions in this regard. Thus it is worth a brief look at some of the options available to designers.

**DESIGN OPTIONS?**

When we recognise the centrality of grammar to intelligible communication, several aspects of the potential of movement for interaction design come into focus. The following is by no means an exhaustive set of options; it is only intended to sketch out some of the ways in which movement has been appropriated for interaction design. By presenting these four options as a continuum, this is intended to provide a (contestable) framework around which discussion can take place.

When the goal is for technology to respond to human movement as communication with the system, (e.g. issuing commands) then designers will be compelled to specify a grammar for movement. Failing this, users will be led inexorably into playing charades with a machine that does not share any of their forms of life. Clearly, this is a situation that does not maximise the ‘embodied’ potential of movement for interaction design, particularly as it would require users to learn another (bodily) language to interact with the system. However, this situation may still have benefits, of course; currently, too little attention is paid to systems that may be difficult to learn but rewarding to use, particularly for their potential to build physical skills through practiced use. But importantly, this is a conceptually distinct employment of human movement for system design; one that takes advantage only of our capacity for movement and skill building, and not our embodied familiarity with the physical world.

Alternatively, designers can make use of movement as an *open-ended* means of interaction, by fitting what we might call a ‘loose’ grammar onto physical actions. One example could be to imagine devices with ‘hotspots’, where it doesn’t matter how the user gets there, only that he or she is there. Sony’s Eyetoy™ Play may be illustrative again—one can see in such a system that it does not matter how one plays, only that one finds a way to play that the system can respond to. Within the game there can be innumerable styles of play, as the system does not script how to act, only where (by use of a video mirror) action will be recognised.

Another possibility is where systems treat movement as *the end, not the means* of interaction. Here the point of the system may be to facilitate certain kinds of human movements, but not as something that the system ‘reads’ or responds to. Systems of this kind might be those that are designed to assist physical rehabilitation or to build (perhaps through imitation or instruction) specific skills or qualities of movement (e.g. dance, embroidery) in users.

Movement can also be appropriated for design in a more ‘direct’ sense, where systems treat movement as movement. Consider a case where physical/spatial movement is mapped to movement through a virtual space. In many ways, this seems to offer the greatest potential to make use of our ordinary familiarity with the physical world. Such systems are those that attempt to couple perception and action; frequently they are immersive, virtual or augmented environments. Furthermore, they appear to bypass (or at least forestall) the difficulties raised about assigning grammar to movement. Here, although movement is monitored by and is interaction with the system, it doesn’t mean anything (other than being movement). Physical movement is only translated into a system-sensible correlate. This, of course, is imagined to enable people to act within the system as they would the world; to ascribe meaning to and possibilities for interaction with objects that they ordinarily would (e.g. coffee cups, files, books, corridors, doors etc.). However, when we press the metaphor, we expose the chimera. As soon as we attempt to significantly trade on the virtuality of the environment (e.g. by permitting the manipulation of the digital properties of an object), we find ourselves suddenly back in a realm where we must spell out a grammar for movement. And the moment we specify a grammar for movement, we again (as in the first case) require users to learn a language of movement to interact. Once more, we are no longer making use of our ordinary familiarity with
the physical world, but only on our capacity for versatile actions. These actions are ones to which a (new) meaning (i.e. instruction or action) must be ascribed and understood. Of course, as I hope I have demonstrated, my point is not to argue that movement grammars are evil, but only that they, in many cases, appear to offer us the possibility to trade on our embodied, pre-conceptual familiarity with the physical world, but do not fulfil that promise in actuality.

DISCUSSION

Of course, the reason for this is that ‘virtual’ or information environments are what they are, and are not identical with (nor should/can they be) our ordinary world of practical, social, physical affairs. In ‘the world’ of which we have embodied familiarity, there is no decoupling of movement and action, nor is there disjunction between the means and ends of interaction. The fundamental question remains: how can systems facilitate such interaction without specifying a grammar for it? If having to learn a ‘language’ to interact prevents us from relying on our embodied knowledge (as I have argued here), then there is no straightforward solution to our problem.

Direct mapping (as in the penultimate design option above) will inevitably lead us towards metaphorical interpretations (of e.g. objects and possibilities for action) that will (as with the ubiquitous ‘desktop’ metaphor) fall down in certain places. This is by virtue of the fact that we possess nearly unlimited modes of interaction with the physical world. My coffee cup is not only a receptacle for a hot beverage, but, variously, a paperweight, a welcome relief from work, a hand-warmer, an informal timer (is the coffee cold yet?) etc. As has been demonstrated with respect to language many times before [2, 7, 8, 16] meaning is inherently indexical. It draws much of its significance from context and the uses to which it (the language) is employed. And this is true of a form of expression that has a grammar. The point to be stressed by repeating this truism is that the uses of things (not only language) are contingent upon the practical circumstances of the actor, and are no less varied. To use a tired example, we often open (physical) documents not to read or annotate them, but to see how they are typeset and laid out, how many images they contain, or to peruse their bibliographical details. With electronic documents, ‘viewer’ applications are often the same as ‘editor’ applications, and to open a document is to do much more with a system than simply opening a document (i.e. it also launches an application). This isn’t necessarily a problem, but again, we very quickly come to the point where we must rely on our familiarity with the ways we encounter and have experienced computers, rather than the ways we encounter physical documents.

What can I actually do with a coffee cup in a virtual office? The range of my possible actions within a system is the real point at issue. It is, and will necessarily be, limited to a degree that will, at some point, deny me the possibility of unreflectively trading on my embodied experience of the world (of, for example, coffee cups).

Worldly experience is not thus limited. Interaction with a virtual coffee cup will, however, be able to allow me to experience the system, with which I may become familiar with practiced use. But in these circumstances, we must begin to question what the system metaphor (the representation imbedded in the interface) is actually achieving, because it is not offering us anything like ‘the same’ possibilities for action for its designers might have been hoping for.

The contrast between the way we encounter the world and the way systems are designed to be encountered is still an invaluable distinction. (Suchman’s seminal analysis of the alien intelligibility of expert systems [14] is no less trenchant a critique today.) But this should not be conflated with the distinction between the way we encounter the world and the way we encounter technological systems, as though the former kind of encounter is natural and embodied, and the latter disembodied and disjoint. We encounter systems as no less a meaningful part of the world we inhabit than any other artefact, and such encounters need not be demeaned as any ‘less’ embodied, for there are no encounters of any other kind. The point is, again, that systems need to be designed to be experienced, and not necessarily designed to be experienced as ‘the world’ is experienced. As long as systems are systems, and are based on a logic different to that from which the social order is constructed and sustained, they are likely to remain tragically poor imitators of the world of everyday experience anyway.

IMPLICATIONS?

I will now try to briefly explore some of the implications for design and research that this excursion can recommend. I have sketched out five directions that seem to be corollaries of the argument that has been introduced.

First of all, let us conceive of a system that makes obvious and available the ways in which systems are unlike the world. What is being suggested is not to create a system that people will encounter as something other than a system (a system that people will encounter as they do ‘the world’, for instance). Rather, it is to embrace the fact that computational systems are powerful for the ways they are notably different from other artefacts. Let people build and develop a familiarity with systems for the ways that systems are systems.

Alternatively, we can look to those who wish to invent new architectures upon which novel kinds of systems can be developed, e.g. [15]. The attraction of these systems lies in the hope that they could enable different kinds of operations, and that they would be experienced, appropriated and enabling in new and different ways. The way one trains a neural net to recognise and respond to a user’s action is very different from the way one writes a macro. The quality of the experience of interacting with the system is what becomes important.

Another option is to explore the interaction ‘middle ground’ implied earlier, in our discussion of designers’ options in making use of movement. Somewhere between specifying a grammar for movement and employing a direct translation of physical movement to a virtual correlate, we find systems that have the potential to build physical skills (and/or styles of interaction) in use, or that exist for the sake of movement instead of

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3 Grammar accounts for the sense that can be made with language, but does not pre-determine the uses to which language can be put [see 1, essay 2].
existing to be controlled by movement inputs. This is a largely unexplored region of interaction design (but see [5] for some interesting directions).

With respect to research opportunities, each of these in some way highlights the need to understand how technology-in-use is appropriated. This would suggest research addresses the ‘system encounter’—how systems are experienced, both in the moment and over time, with a view to seeing how they can be designed e.g. to engage users, develop skills, build familiarity etc.

Furthermore, it recommends that research return to focus on designers themselves. If we can better understand designers’ conceptions of the world (i.e. about use, users, and their expectations etc.) [12, 13] we will be better able to diagnose (and, when necessary, treat) the foundational assumptions on which systems are based.

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ABSTRACT
Embodied movement-based interaction is still in its early phase and the area lacks basic foundations to guide the design and development of technology that supports this kind of interaction. In this paper we propose to use the performing art of modern dance as approach to increase our understanding of human movement and thus search for foundations for what we call kinaesthetic movement interaction. We explicitly point out seven aspects of modern dance that we find interesting in relation to human movement and movement-based interaction design. The results are based on theoretical as well as empirical studies including a design-oriented prototype development.

Keywords
Human movement, modern dance, aesthetics, kinaesthetic movement interaction, design foundations, first-person perspective.

INTRODUCTION
Embodied movement-based interaction is still in its early phase and the area lacks basic foundations to guide the design and development of technology that supports this kind of interaction. The work referred to in this paper aims at searching for basic design foundations for movement-based interaction in general and what we call kinaesthetic movement interaction in particular. The starting point is taken in modern dance and methodologies for movement exploration found within this field.

By kinaesthetic movement interaction we mean interaction that makes use of movement as main interaction modality, both for input and output. Kinaesthetic also refers to the kinaesthetic part (as different from tactile) of the human haptic system. Finally, making use of modern dance implies that we strive towards an interaction design that even takes into account the aesthetic in kinaesthetic.

We aim at, through emphasizing the kinaesthetic aspects, focusing on the movement interaction of the body in relation to itself, as different from the body’s movement in relation to the physical space.

First, we will briefly present the empirical study and design-oriented prototype development that was used in searching for design foundations. Second, we will present seven topics related to theoretical and empirical results that could be used for discussing the contribution from dance in order to increase our understanding of human movement and thus search for basic design foundations for movement-based interaction.

SEARCHING FOR FOUNDATIONS – A CASE
In order to gain more knowledge of human movement interaction and how people experience this, we have carried out an ethnographically inspired empirical study of people exploring movement [3] that was followed by a prototype development [5].

Exploring Human Movement Through Dance
The method used for the movement exploration study was based in methodologies found within the art form modern and contemporary dance (in a European/North-American tradition). Similar approaches have been used to inform interaction design for artistic installations [6] as well as within industrial design [4].

The aim of the study was to gain knowledge of how people, mainly non-schooled in relation to artistic dance in general and modern dance in particular, experienced human movement and physical expression. The informants attended a 13-week dance course called Physical Expression. During the course they took part in different kinds of movement exercises, e.g. movement improvisation; expressing text, pictures, and notions by means of movement individually as well as in groups; creating and performing a solo piece. The course also included two design workshops.

Data were collected through multiple interviews with each participant before, during and after the course was completed. After each class the participants were asked to answer in written text, one or two reflective questions similar to the cards described in [6]. They also got two written home assignments. All dance classes and the two design workshops were observed and videotaped.
BodyBug – A KinAesthetic Interaction Concept
Based on and inspired by findings from the empirical study, a kinaesthetic movement interaction concept called BodyBug was designed and developed (see Figure 1). The main aim of developing the prototype was to gestalt and to make concrete our questions and concerns regarding kinaesthetic movement interaction, but also to let it function as starting point for further discussion. Additionally, BodyBug could be looked upon as a kinaesthetic movement interaction prototype or artefact within the area of what we might call “functional artefacts without functionalities”.

The focus when developing BodyBug was to concentrate on the interaction form, i.e. bodily movements, and to design the interaction before the application, which also implies focusing on the aesthetics of use, as different from the visual appearance. This was in line with the intention of the project, i.e. to apply a people based first-person perspective of human movement, rather than taking the starting point in technology or a specific application or work context.

Some of the design implications that came out of the empirical dance study and which we wanted to incorporate in the interaction design of BodyBug, were: to use the body as a haptic display for movement input and output, to work with movement impulses, to utilize the physical interaction space immediately surrounding oneself, to take into account the individual differences of people’s movement patterns, and to design for the mere pleasure of motion.

Our main aim when designing the interaction concept was that it should encourage and trigger movements and thus provide a possibility to sense and experience one’s (kinaesthetic) body. But it should also open up for “user defined” movement, and thus a personal and individual movement expression and impression. As the bodily movement required for the interaction was not specified, it also gave room for creating “new” movements, i.e. make the person move in new or unusual ways, however, still using his or her own personal movement vocabulary.

BodyBug consists of a case running on a plastic covered wire that has attachments made of Velcro at each end in order to hang BodyBug onto your body. All technology and mechanics, e.g. accelerometers, micro controller, battery and motor, are placed inside the case. When the case is moved in space, depending on how it is programmed regarding input/output, it will move for a set time and direction along the wire. The electronics can be switched on and off, which makes it possible to decide yourself when it can start to move.

Experiencing Movement Interaction
The prototype BodyBug has been exhibited and demonstrated at three different events and conferences, which has given us the opportunity to make informal qualitative observations of people interacting with BodyBug in real settings.

![Figure 1: Experiencing BodyBug](Photo: Peter Knutson)

Our main experience concerning the interaction form was how differently people moved. We observed a variety in movement from big, violent movements taking up large physical spaces, to people standing still and just moved one body part. A typical observation however, was that people engaged their whole body in the interaction, even when the focus was on moving one specific body part. There was also a difference in whether people had their focus towards BodyBug, mainly the case and if or how it moved, or if the focus was turned towards themselves, their body and how they moved.

Another experience was that people very easily adjusted their interaction to how they believed the technology worked. Some people thought that the sensors were placed inside the Velcro attachments, others’ thought that the wire was an electric cord and in some way had effect on the case’s movement. In some cases it was obvious that people were interacting after the principle: the more input – the more expected output. Others’ were moving without experiencing any output or had wished more output in other modalities. However, the movement output seemed for some to be surprising even when they had been told that the case was going to move when they moved.
DANCE AND HUMAN MOVEMENT – 7 ISSUES
In dance, human movement is the material on which everything is based. This is the main reason for why we have chosen dance as approach to understand human movement and how people experience movement. Through applying a phenomenological perspective on dance and human movement, we get access to philosophies and theories of human movement from a first-person perspective, based on experiences obtained through the lived body, meaning that we are a body in contrast to have a body.

In this section we point at seven different aspects of dance and human movement that we have found interesting in relation to design of movement interaction. These perspectives have arisen from reviews of dance science literature [e.g. 1, 2, 7], as well as empirical data from the dance course already mentioned, and the development and experiences of BodyBug. However, these issues (i1-i7) do not intend to be exhaustive or final in any fashion, but could be used as starting point for further discussions on how and where we can search for design foundations for movement-based interaction and how this is related to technology use and development.

1-Movement for the sake of Movement
Dance makes use of human movement for the sake of movement itself, i.e. movement is not used as means for obtaining something else. The main aim of dance is not to test physical limits, like in some sports, being useful, or produce anything. Further, dance does not aim at being illustrative or mimic, like in pantomime. Neither does it aim at being relaxing, calming, or meditation, like in tai chi or yoga.

2-Movement as Embodied, Aesthetic Experience
Dance has aesthetic aims and intends to move people emotionally. Dance is also embodied actions of human movement and becomes art only when it is intended for someone else, a viewer or “the other”. The audience, who also are embodied persons, will always experience the movement (dance) in relation to their own bodies and embodied experiences, and thus their personal aesthetics of movement.

3-Design of Movement
Dance is design of movement as the choreographer makes use of movement in order to design, create or compose a certain expression and thus experience. It is the choreographer that is the designer, human movement the material and the dancer (as an embodied person) the means of communication.

4-Movement as Material
Dance makes use of human movement as the design material. It is the body (and natural forces as gravity), no additional artefacts as texts or instruments that create the expression. Dance makes it possible to objectify the movement and even the human body. But the dancer’s body is not considered as “just a body”, rather as means to express the movement, the dance.

5-Individually Accommodated Movement
The reason why a dancer’s dance could look so easy or as having no physical limits is because the dancer only do and perform movement he or she manages. The dancer projects his or her abilities in movement and not the limitations.

6-Experiencing Other People’s Movement
Dance provides a possibility to experience and understand other people through their movement. Trying to perform movement originating in and made by other peoples’ bodies give us an embodied experience of how they move and expresses themselves.

7-Movement as Socio-Cultural Expression
Human movement and dance are rooted in social and cultural traditions. Different dance styles and techniques schools bodies into a specific movement pattern according to that style’s aesthetics. In similar ways our everyday movement and body language is appropriated to the social and physical context or space, in which we act.

REFLECTIONS AND FURTHER WORK
Human bodily movement is closely related to each individual as reflected in the dance course and observations of BodyBug. In dance and related areas this comes to expression through different kinds of body-mind practices, dance techniques, body aesthetics, etc. These practises are often a result of individuals’ personal preferences of movement patterns, but also a result of their own experiences of their bodies, physical abilities and disabilities (i5).

Even if dance provides a possibility to objectify the human body and human movement (i3, i4), it is strongly connected to the person performing the movement. As movements are embodied actions they can never be separated from the person acting. But what that person expresses is not necessary his or her private or inner feelings. A dancer is trained to be able to express any feeling or emotion through movement, as if it really was hers. In order to emotionally move the audience this expression have to look like it is personal, as emotions are connected to persons, and not something that could be expressed objectively (i3). Again, even if dance is able to objectify human movement, the human body is always expressive, also when interacting with technology (i2).

Movement-based interaction provides possibilities to create embodied, aesthetic and richer user experiences (i2), and especially when the movement could be defined by the person interacting and related to how she or he prefer to move (i5). However, human movement is not always appropriate as interaction modality. This might be related to both aspects of efficiency and to the social and physical context (i7). Thus, when designing movement-based
interaction it is important to have an idea about why the specific interaction modality is used. How we design and develop technology also influence people’s movement pattern and habits in a longer perspective and thus contributes to the social schooling of our bodies. In this aspect it is important to know the “properties” of human movement, i.e. to know the design material.

Further development of BodyBug as the case presented here, could Thus focus on varying the different movement qualities of interaction (i1, i4), e.g. the speed of the case’s movement along the wire, the time it moves, the amount of movement you have to create in order to make it move, etc. In many devices today, the output provided aims at focusing the attention towards the device or a specific event through sound, light, etc. This is not the case with BodyBug as it requires another kind of bodily awareness in order to take part of the output. The movement output provided might be described as subtle and small. To some extend this could easily be changed by programming the input/output relation differently.

Another way to influence how the interaction is experienced is to change the motor and the length of the wire as well as the length of the Velcro attachment, as they effect how BodyBug could be worn (e.g. around the waist). It could also be possible to make BodyBug autonomous in the way that it learns the movement pattern of its wearer, and adjust its movement according to that. This also creates and opportunity to try out other people’s movement pattern (i6) when sharing BodyBug between people.

These aspects of further development are in line with focusing on the interaction modality of movement and aesthetics of use, rather than the visual (aesthetic) appearance in order to personalize devices or when making different version of the prototype.

Technologically, one big challenge of BodyBug is the lifetime of the batteries used. This is a common problem when concerning wearable and mobile devices. As the freshness of the batteries effect how fast or powerful the motor will turn and thus the output, this is a crucial issue for how the interaction is experienced. We do also believe that the interaction concept might be better developed and experienced using more advanced technology. However, keeping to a certain time and economic frame, we chose to make use of inexpensive and easy-accessible technology that was suitable to demonstrate the interaction concept.

As earlier stated, we do need frameworks and foundations for movement-based human computer interaction. One big challenge is how we can design movement-based interaction without loosing the aspects of individual preferences and differences in movement, but also how to preserve the spontaneity in human movement. Taking the approach described has been one attempt to increase the understanding of human movement. The seven issues presented might help to put the focus towards how people move and experience movement. The consequence should be that we design for embodied people that move, rather than people having a body by which they make movements. Or as expressed by Selma Jeanne Cohen [1, p. 12]:

“While movement expressiveness is not an equally unique virtue of dance, it is nevertheless one of its natural properties because its instrument is a person who not only moves but feels. If we want to deal only with design of moving shapes, we have no need for human performers. Animated drawings can do the job as well and better, for the graphic artist is not limited to using only those shapes that the human body is capable of assuming. If dance, then, is to realize the full potential of its nature, it will draw on its resources of interest both in meaning and design.”

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Cognitive aspects of movement

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ABSTRACT
A closer understanding of the cognitive aspects of movement may help us to approach movement-based interaction in a more informed way. Far too often movement is simply addressed as a self-explanatory concept that is self-evident – movement is movement. However, movement is fused into the very basic aspects of human cognition, and a closer understanding of these aspects could yield more informed approaches to movement-based interaction than ordinary case-studies and trial & error.

Keywords
Movement, motor actions, operations, signs, gestures, discrete, continuous, fluency, core knowledge

INTRODUCTION
There is no lack of creativity and innovation when it comes to movement-based interaction. A wealth of new approaches, ideas and implementations are constantly presented. What seems to lack, though, is an informed and theoretical guided approach to what movement basically is. Two key issues are here explored in relation to movement-based systems: first, motor activity needs to be de-intellectualised and human dexterity preserved in the system. Second, motor activity is intimately related to basic cognitive skills, such as orientation, and careful consideration needs to be paid to the dynamics of them and systems constrained correspondingly, otherwise these skills will not be accessible.

THE NATURE OF MOTOR ACTIVITY
The first topic I wish to reflect upon is how to take conscious cognition out of movement-based interaction and create systems where we can focus consciously on our goal and interact seamlessly at an unconscious motor level.

Motor activity is not a centrally guided and controlled process. Rather the brain acts as the overall coordinator of the activity, whereas the detail operational aspects are carried out in a dynamical relationship with the physical environment [9]. In this way movement is unfolded over time and space in close concordance with the environment properties. In other words, humans and animals do not simply act blindly in the world by means of prescribed motor programs. An example with eyesight illustrates this: it is impossible to perform a smooth trailing movement with the eyes. Such a movement can only be achieved when tracking an object that moves in such a way; say a car or cyclist. Walking biped robots have for a long time pursued movement with reference to a central control processing unit. Although a lot of research has been carried out, the results so far are no way near the abilities of human walking. The Honda Asimo robot is the best example so far, but it takes an enormous processing power for it perform even the most rudimentary movements. Complex movement, such as kicking a ball, is next to impossible for it to achieve in a manner that resembles human dexterity. In a way Asimo is oblivious to the environment, it only seeks to negotiate and overcome it. Asimo would probably function just as good on the moon as on earth. Compared to human movement it seems that something fundamental is wrong with this approach towards walking.
A qualitative different approach was recently unveiled by a research team at the Cornell University [10]. Their robot walks by means of stiff limbs that are connected in joints with springs and tethers. The Cornell robot actively incorporates the dynamical features of the ground and gravity, instead of negotiating them. As a consequence, it uses much less energy, and walks much like a human.

With movement-based interaction we can pursue solutions along either paths. One, were there is a loose coupling between the user and the system, with the user effectively sampling the environment and based on conscious analysis conveying chunks of commands back to the system. The other approach would be to make a closer coupling between the user and the system. In order to do so the system must be populated with regularities and dynamics that have some basic correspondence with the users motor abilities. Today many movement-based interactive solutions are often, either implicitly or explicitly, developed with reference to movement considered as a centrally controlled activity. While such systems might work in research and demonstration settings, they force human motor activity into a format that is at odds with our natural motor behaviour. As a result the full potential of human motor activity is not utilized.

MOTOR ACTIVITY AS CONTINUOUS
Computer systems are by their very nature discrete, in that work on principles of discrete states based on 0 and 1, on versus off. States, modes, input, commands etc. are all either in one state or the other, one mode or the other etc. The human physical world, in contrast, is continuous. Although cultural artefacts such as language and numbers have discrete properties the physical world they relate to is still continuous. Differentiation is a nice mathematical example of how discrete chunks are approximated to a continuous waveform. Motor activity is also continuous, with no absolute starting point, no thresholds, and states etc. It makes no sense to parse human activity, such as handling objects, into discrete chunks. Only analytically can we do so.

In the meeting between the human continuous and discrete system world, system developers must be very careful not to force the discrete nature of the system upon the user. It is important to strike a careful balance between the two. If successful, the unique human capabilities can be taken into full consideration and implemented into the dynamics of the system. I believe an example is called for! Consider how the mouse pointer moves around on the computer screen in concordance with your movement of the mouse. Compare that to how the same mouse movement would be obtained with the arrow keys. It simply cannot! Although the cursor might be moved from A to B, the continuous movement style with aggressive gross macro movements and detail fine motor movements is lost. In other words the interaction becomes discrete. Movement-based interaction often tends to break down the traditional human–interface barrier, and sometime even immerse humans in the virtual systems. In such cases it becomes particularly important not to force human behaviour into a discrete paradigm.

Two examples illustrate either end of this extreme rather well. The examples are not target of any critique, since they are themselves only test-cases and mock-ups; they only serve to exemplify my points. The first example, called eMote 3D [11], is a virtual globe build up by a number of discrete boxes that each corresponds to a folder or a container with information content. At any moment only one box is highlighted and its information content presented next to the globe. The globe can be rotated along its x and y axis in order to bring the other boxes into focus and thus access them. Navigation is achieved by holding a physical stick. The stick has build in accelerometers, that translates flips either up and down or left and right into movement along the x and y axis.

Figure 2: eMote 3D [11]

Although one can perform a number of rich motor movements with the stick, the system can only recognize stepwise commands. With box no 1 in focus it will thus take 20 flips with the stick to access box no. 21. The discrete nature of the globe content is propagated all the way to the user interaction.

The other example is a camera based device called Mixed Interaction Space [1] that translates optical flow information picked up by a camera into device input. In the case study (ibid), navigation in a map application takes the form of a keyhole into a virtual world. The map is
manipulated by moving device and thus generating optical flow in relation to a figure. The crucial aspect is the one-to-one relation between continuous movement of the device and navigation on the map surface in the application.

Figure 3: Mixed Interaction Spaces [1]

Again compare how navigation would have been discrete steps by means of arrow keys for example. The one-to-one relationship creates a close coupling between the user’s motor activity and how the system responds. Many of the dynamical features of the user’s movements are preserved in the system.

The challenge is to preserve human dexterity, which requires systems that are equally dexterous. A pitfall is here to promote human motor activity from an unconscious operational level to a conscious gesture based sign level. Mouse gestures in the Windows operating system is such a case. A circular motion with the mouse can have a certain meaning attached to it. When a circular motion is made with the mouse, the computer might for example be programmed to shut down. The gesture has no intrinsic meaning - it is arbitrary. The mouse, as such, is also arbitrary; a webcam might have done just as well and picked up the circular gesture of the hand in mid air. The point is that we are not truly engaged in movement-based interaction but a kind of speech.

BASIC COGNITIVE SKILLS

The next topic I will reflect upon is paradoxically how to reinstall cognition into movement-based interaction; although cognition at a very sub-conscious level.

Humans are endowed with a range of very basic, evolutionary old cognitive skills, which are shared with a number of other mammals [4], [5], [8]. A group of these mechanisms relate to spatial orientation and how we navigate in the world. For a comprehensive presentation of these knowledge domains see [3]. To adult people spatial orientation is enmeshed in cultural artefacts such as maps and road signs. Here I will present a subset of two more subtle navigation mechanisms, cue and response learning, that all mammals, including humans, possess. Even though these navigational capabilities permeate most of our daily activities they are tacit in nature and thus not subject to immediate conscious introspection.

Cue learning

Research in cognitive psychology has found that humans navigate in uniform undifferentiated layouts by the help of spatial categories [2]. A spatial category is a kind of template that segments an area into smaller units or places. Many have experienced first hand the workings of spatial categories when we have a strong feeling of where we have read something in a book that we want to find again. The spatial category is, depending of the size of the book, typically segmented into four areas. These are the right or left page, top and bottom of the pages. Sometimes, we can also pinpoint whether it was on the middle of the page segmenting the book layout into six pieces. Cue learning does not specify a specific target as such but a smaller region of a layout where the target is located [2].

Response learning

Response learning is an orientation mechanism where a pattern of muscular movements are associated with a target [2]. The position of a specific target is thus coded in relation to the dynamics of the sensory motor activities associated with a previous encounter the target. Response learning can thus be considered as a kind of bodily tacit knowledge. Response learning is at work when we reach for something out of sight that we know is there; for example the coffee cup next to us we put away moments earlier when we last took a sip.

In order for such faculties to come into play we must take their unique mechanisms and dependencies into consideration. Movement-based interaction provides unique possibilities to get these systems into work compared to traditional screen based interfaces. Only we have to make sure that we do not obstruct some key aspects. These key aspects are those regularities of the physical world they rest upon. In windows based operating system environments the ability to resize a window is quite nice. Unfortunately the content in the window is rearranged accordingly – for example from thee to two columns. The relative position of an individual element to the other elements, the frame of the window and other landmarks is thus changed. Our most basic orienting skills are thus made obsolete and we have to resort to other more demanding cognitive search strategies. In similar vain, response learning is put offline whenever the environment we navigate in is fluid, changing and dynamic with relation to physical properties. System developers, that seek to exploit human based movement, thus need to concern themselves with the basic laws of the physical worlds that such skills developed in concordance with.

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Movement and Space – Exploring the Space in Movement based Interaction

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ABSTRACT
In this paper we explore the space in which movement based interaction takes place. We have in several projects explored how fixed and mobile cameras can be used in movement-based interaction and will shortly describe these projects. Based on our experience with working with movement-based interaction we will briefly introduce and discuss how learning, mapping and multi-user interaction are important when designing movement based interaction.

Keywords
Mixed Interaction Space, camera tracking, movement-based interaction, interaction design, ubiquitous computing

INTRODUCTION
Another way of phrasing the shift from desktop computing to ubiquitous, pervasive computing is to notice that computing has gone from sitting to standing or moving. The best places to notice the shift is to search for everyday and work situations where we could benefit from a computer, but where we do not sit down, but move around.

Numerous such situations exist e.g. when visiting a museum, on the way to work, being a tourist in a new city, visiting a library or working in a hospital. We have for some time worked with the last two situations and found that even though these situations are characterised by people moving around and looking and working with physical material traditional sit down computers have been applied. This approach creates a gap between e.g. looking for a book and using the computer or treating a patient and accessing the patient data through a computer.

In several project we have worked with how to bridge this divide between playing and working in the physical world and using computers. We have especially focused on how to actually use mobility and movement as an enabling factor for new interaction technique.

INTERACTION TECHNIQUES AND SPACES
The projects we will present in this paper all use video tracking to capture movement. One of the properties of using a video camera to track an object is that the camera is only able to track the object as long as the object is within sight, but instead of seeing this as a limitation we explore the space that arise and is bounded by the cameras ability to see the object being tracked.

The space has the shape of an inverse pyramid. Close to the object the space is small and the space expands the further away from the object the camera get until it blurs out when an object gets to far away from the camera.

We call this space a Mixed Interaction Space because it is both a physical space you can move around in, but at the same time the movement in the space can be mapped to the digital domain and can therefore be seen as a mixed space.

We have worked with two different kinds of Mixed Interaction Spaces. A Fixed Mixed Interaction Space is a space where the camera is mounted and the space is static. In the projects iFloor and StorySurfer briefly described below we use this kind of space for the interaction.

Dynamic Mixed Interaction Space is the second type of space and describes spaces that are dynamic due to the camera being mobile. A further subdivision can be made between what is being tracked. Is the camera moving and tracking a fixed-point or is both the tracked object and the camera dynamic? We have in the Mixis Fixed Point (fixed-point) and Mixis Face Tracking (dynamic camera and object) projects used this type of dynamic spaces. Table 1 shows an overview over the techniques and the projects.

<table>
<thead>
<tr>
<th>Fixed Interaction Space</th>
<th>Mixed Interaction Space</th>
<th>Dynamic Mixed Interaction Space</th>
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<tbody>
<tr>
<td></td>
<td>Static tracking object</td>
<td>Dynamic tracking object</td>
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<tr>
<td>iFloor &amp; StorySurfer</td>
<td>MIXIS-Fixed point tracking</td>
<td>MIXIS-Face tracking</td>
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Table 1: Fixed and dynamic mixed interaction spaces.
MOVEMENT-BASED INTERACTION PROJECTS

We will briefly introduce the four projects we have worked with that uses movement-based interaction.

iFloor

iFloor can be characterized as a chat-floor. The idea behind the prototype is to facilitate the exchange of information between users at the library, as well as to bring some of the QA services that the library offers on the Internet into the physical library.

The questions and answers on the interactive floor are navigated and highlighted by moving your body along the edges of the display. A video tracking system will record the movements and size of the people present and on the basis of this single persons or groups of people will attract a magnifier highlighting the different questions and answers displayed on the floor. The magnifier is a cursor shared between all the people participating, so navigating it is dependent on collaboration between the people present around the floor [6]. Figure 1 and 2 show the iFloor prototype and the tracked movements.

StorySurfer floor

StorySurfer is a prototype that facilitates children in browsing a library collection of books by displaying projected covers on an interactive floor surface. The covers of the books are evoked by stepping on buttons on the rim of the floor. Each button is associated with keyword. Hitting a keyword button will evoke a cloud-like shape on the floor containing materials associated to the word. Stepping on to the floor enables one to examine the displayed covers. Each person entering is provided with a cursor in the shape of a "magnifying lens"; the "lens" is controlled by your bodily movements. Holding the lens still over a projected book cover causes it to enlarge for better inspection and maintaining the position even a bit longer will cause the image to move across the floor to the interactive table top also being a part of the prototype [9]. Figure 3 and 4 show the StorySurfer prototype and the tracked movements.
MIXIS – fixed point
The concept behind the Mixes project is that instead of limiting the interaction with mobile devices to the device we use the space around the mobile device as input and we are thereby able to create mixed reality applications where the space is used to interact with programs running on the mobile device or on a nearby PC.

The Mixis interaction technique uses the mobile device’s camera to track a fixed-point and use the distance and rotation of the device from this fixed-point as input vector to a set of different applications. Depending on how the different movements of the device are mapped to the applications the device can be a 1-4 D input device. In Mixis – fixed point we tracked a circle symbol that could be printed out or drawn by hand.

Based on the Mixis mobile tracking technique we have built a set of applications e.g. the ImageZoomViewer, an application where the user could pan and zoom on a map or image by moving the device in the interaction space. DrawME is an application where the user could call a person by drawing a symbol on a piece of paper and associate this symbol with a phone number or BlueMix where several users could use their own mobile device to interact with shared displays by each having their own fixed-point and connecting the phones to the display over Bluetooth. The Mixis concept and some other applications are further described in [4, 5]. Figure 5 and 6 show MIXIS – fixed point.

MIXIS – face tracking
In a newer version of Mixis we track the users face instead of a circle. We use a mobile phone with a camera facing towards the user as our platform and have a new situation where both the camera and the tracked object are mobile. Figure 8 shows the concept and the different degrees of freedom we are able to use as input to our applications. Besides moving the phone in the space the phone can also be tilted to move the entire interaction space and achieve similar results as moving the phone just with smaller less fatiguing movements. We have re-implemented several of the applications from the original Mixis with the face tracking technique and designed some novel applications. The Mixis face tracking project is further described in [3]. Figure 7 and 8 show MIXIS face tracking.

DISCUSSION
In the following discussion we will outline a set of common issues relating to movement-based interaction we have worked with in the four projects.

Learning novel interaction techniques
Since movement and sensor based interface differ a lot from traditional user interfaces [Sensor], a challenge for movement and other sensor based interaction techniques is to tell the user how to use this new interaction technique and how it maps to the different applications. A keyboard and a mouse seems intuitive to use, but watching a new computer user try to figure out how to use the mouse or getting access to some of the special characters on a
keyboard, points to some of the tacit knowledge that is required for using a computer.

Playful interfaces, Frustration and Social Interaction
Some of the interfaces we have worked with are easy to learn, but not self-explanatory. E.g. first time a user saw the iFloor it was not clear that you could interact with it by just walking up to it. However, as soon as one user got hold of the concept it was easy for this person to tell other users how they should use the interface and help him or her cooperate in the interaction. One way to learn a new interface is by having someone around to tell you how to do it and use social interaction to learn about novel interfaces.

Another way of exploring the possibilities of a new interface is through play. Letting the user play with the interface and learn what kinds of possibilities the interface has to offer. However, there is a thin line between learning by playing and being frustrated and abandon the interface. E.g. having a problem finding the sensor that turns on the water tap in a public bathroom is normally a frustrating experience and the hidden interface is not considered a playful and exploratory interface.

Constraints
Another approach to learnability in sensor based interfaces is to build constraints into the interface. An example is tangible user interfaces. The tangible objects can be shaped in forms that only allow them to be manipulated in a certain way and constraint some unwanted interaction. E.g. a tangible object can be designed as a block in a tray to allow sliding in one dimension, but not free movement in 2D. Ulmer’s paper about constraints explores tangible object and constraints in details [10].

However, when using cameras and especially dynamic cameras it is really hard to constrain the interaction and prevent people or objects from moving away from the camera’s field of sight. Another option is therefore to visualize the interaction space for the user.

Visualizing the space
Visualization becomes important with sensor interfaces as pointed out by Bellotti et al. [2] in their discussion on sensor interfaces. Visualization is highly important when working mixed interaction spaces since the boundary of the space, and thereby the interaction, depend on what the camera sees and not what the user sees.

With fixed mixed interaction spaces we can use the architecture to visualize the space. In the iFloor and StorySurfer we use a white mat to show where the interaction space starts and ends.

With dynamic mixed interaction spaces we cannot use the architecture to signal the presence of a mixed interaction space and we therefore use digital feedback. In Mixis projects we use the display to overlay information about the position of the device in the space. E.g. in the ImageZoomViewer we draw a thin line from the center to the position of the face or circle in the interaction space on top of the map to help the user in determining where in the interaction space the device is. We found that finding good ways of visualizing the interaction space was crucial for a smooth and easy interaction with the application we build.

Mapping
Mapping is a term that refers to how the data captured by the camera or sensor is mapped to the different applications that relies on the technique. We have worked with a set of different mapping approaches in the four projects.

In applications with tight couplings between the physical movement and the movement in the application natural mapping is accomplished, which is a term suggested by Norman [7]. Natural mapping uses physical analogies or cultural meanings to bring about immediate understanding of the relationship between the physical and digital movement. An example of this is the application for map navigation with MIXIS on a mobile device, where moving the device to the left, right, up, or down pans an image, and moving the device closer or further away from a fix point zooms in and out. With StorySurfer moving the body to the right moves the cursor to the right. This resembles Norman’s example of natural mapping in which turning a steering wheel to the right make a car turn right [7].

However, we also explored some more advanced types of mapping e.g. in the StorySurfer, where the position of several users determined how the applications behaved and the mapping was a form of collaborative mapping.

Multi user interaction and public space interaction
The fundamental design of the computer with a single keyboard and a single mouse has been the general standard since the early 1970’s. Most applications involving more than one user are based on collaboration from the distance over network.

In research today there is a struggle to develop technologies where several people can interact simultaneously and as natural as possible. New hardware developments such as multi-user touch-sensitive tabletop surfaces offer new possibilities, which often mean a complicated and expensive setup such as the MERL DiamondTouch [8] and other similar systems that requires specialized hardware.

Social interaction is also a fundamental part of our public life and multi-user interfaces can also be seen to facilitate novel applications for use in public spaces. The following table 2 summarizes some issues we have identified to be relevant and important with movement based, public, multi-user interfaces.

Public Spaces: Interacting in public space adds new challenges to the input devices used on public displays. As the traditional computer does not support simultaneous colocated multi-user use, the technology in use today lacks functionality for interaction with large public displays as listed by Ballagas and Rohs in [1].
Identity: PDAs and mobile phones can be used to implement simultaneous inputs, but even more interesting is the capability of tracking and distinguishing users which allows the application to associate actions to a specific user. Using MIXIS the portability in public space increases since the user is able to connect to a range of different displays. With a personal ID the user is able to transfer data from the display to the personal device whereas the floor interaction is not attached to the actual user.

Serendipity: MIXIS and floor interaction has a high degree of serendipity, offering the user to spontaneously interact with a large display by connecting its Bluetooth unit to the system or by stepping out on the floor. Thereby, MIXIS supports intentional interaction initiation, the user has to initiate and accept the application, while floor interaction does not.

Portability: MIXIS has a high degree of portability even though the interaction device is not a part of or on the body, but since the mobile device is personal and ubiquitous. The portability in floor interaction is very high, since the interaction device is the body of the user, and is therefore very suited for public interaction.

Sanitation & Social Acceptability: Since the mobile phone is personal, the sanitation aspect with MIXIS and floor interaction is very high; the user never touches any common controls. The physical security is therefore high, and the input controls to the system are not a problem for vandalism, so no maintenance is needed for the input controls. MIXIS and floor interaction has a high degree of social acceptability since it is a very discrete interaction technique with no embarrassing or disturbing noise, light or gestures

Dexterity: With MIXIS there is only one hand required for operation of the device, and none with floor interaction so the degree of dexterity is very low.

Security and privacy: With MIXIS the information security and privacy is tried maintained by transmitting data only to the public display and only transmitting input and not personal data. The cursor does not display the identity of the user and no participant or by-pass can identify which cursor belongs to what user, and the privacy is therefore secured. With iFloor the cursor is shared and not user specific, meaning there is no ID for the user. In Story Surfer each user has its own cursor and the privacy around user identity is very low.

Multi User: MIXIS and floor interaction are both multi-user interaction techniques that support a large number of simultaneous co-located users. E.g. with iFloor the cursor behaves differently depending on the number of user, whereas with Story Surfer the cursor is individual, and does therefore not affect the other user at all.

Table 2: Public space and multi user issues

CONCLUSION

In this paper we have presented the concept of Mixed Interaction Spaces as a room for movement based interaction. We have described four projects we have worked with that all uses movement based interaction. And based on the project we have highlighted three issues we find important when designing movement based interaction systems based on cameras. We have presented our initial reflection on how you learn to use novel movement based interfaces, how you map between movements in the physical world and the digital realm and listed a set of issues relating to movement based interaction with multiple users both for private and public spaces.

REFERENCES

ABSTRACT
This paper suggests an approach to designing tangible interaction devices by focusing on the movement within interactions. This is done to make objects based on computer technology, and traditional objects that we are used to interact with, more alike.

Two ways to this are proposed, first, using 'movement thinking' as a way to create new forms of objects based on the way they are used, rather than upon the computational technology that they are based on. And secondly, by using 'movement paths' as a way to fine-tune or recreate interactive devices based on the movement pattern that their functions and therefore their form proposes.

Keywords
Movement thinking, tangible interaction, interaction design

INTRODUCTION
Where objects earlier have been static we have now a greater possibility to add movement into objects and artefacts used by humans, with the aid of computer technology. Objects can be programmed to physically move, indicators to be visible when a state is changing in an application, and interactions may occur when a user twist or turn an object.

Traditionally object form was almost always dependent on how the technology behind it was built, the turn of a lever, mechanically flipped and started up a process. With computational technology, the ‘inside’ has no longer the same impact on the physical form [1, 5], this has in numerous cases resulted in interactive objects that do not take into account that users have bodies and lives in a physical world. Instead of limiting humans, computational technology has the power to make people fulfil tasks in their every-day lives with grace and satisfaction, if products are designed appropriate. I am in this paper arguing for the importance of seeing the users of designs as humans with bodies, by incorporating movement-based interactions, for approving functionality and at the same time aesthetics. The concept of ‘movement thinking’ is being introduced for inspiration when designing new computational gadgets and systems, and the concept of ‘movement paths’ for how to work with an ambition of making aesthetically pleasing interaction within interactive objects.

The true force in computational technology today lies not in the ability to hide away choices, or automate our everyday, but the ability to make things change state, and by doing so, to generate actions. First now we have the possibility to design in time and in space simultaneously. Combining changes over time with changes in space creates movements. Movements are the very potential in interactive systems, may they be periphery or petite, but interaction is movement and it is there we have to start think when we are designing interactive systems.

Tangible interaction
The thoughts and ideas presented in this paper apply to physical and tangible interaction, which may be referred to as a part of the authors’ style in interaction design [1]. Albeit, the theoretical base that the discussions are being based on was first developed around software and expressions in programs. The use of time and movement within screen-based design was in this previous study the major subject [9]. In this paper the theory is linked to physical computing projects and examples performed by the author, in first hand technology-based tangible devices.

PRACTICAL INTERACTION FOR END-USER PRODUCTS
I will start by defining interaction in this context. One might include wearing a sweater as interacting with what you wear, as you do feel the sweater and the sweater gets impact in its form by you, and it is most certainly a physical sensation when the material touches your body. This will though not be enough for interaction in this context. I would like to define interaction like this: to
intentionally manipulating a state by physically performing an action.

This is not meant to be a general definition but to serve for the purpose of this text. What’s important is the intention. This may exclude parts that are generally included in the field of interaction design, like invisibility and pro-activity, but are here left out as they are not to me ideal forms of interaction. Further you may note the ‘physical’ part in the statement above and this very much includes actual touching and feeling an object, rather than using gesture-based interaction. So why is it important to make movement-based interaction tangible? This is very much the way we have experience in manipulating objects, and as we are living in a world based on gravity and other physical laws, we have some pre-stored knowledge about how things works in space that is unnecessary to neglect.

MOVEMENTS IN INTERACTION
A movement in an artefact, as referred to in this paper, may be anything that attracts attention to an object, but it may also include any movement occurring from an intention of a user. Everything from state-changes i.e. a LED changing from active to passive state, to someone approaching and actual touching an interface. This includes actions triggered either by the user or by the machine.

Movement-interaction can be looked upon in many different ways. Artefacts can create movements of the user in the use, movements can be an integrated part of the interaction and movement may also be a response to something the user just did, as some form of output. The effect of how you incorporate movements into an artefact may not shift dramatically depending on which form of movement you are using, but is a good idea to be thinking of which form of movement that fits best into your system.

In movement thinking tangible artefacts the internal movements or state changes and the users movements are never really far away, and are therefore not necessary to always treat separately.

Examples
The interactive artefacts BodyBug [6] and BeatCatch [8] (figure 1), both use simultaneous output and input as a way of improving the perception of the interaction. BeatCatch is a haptic, force-feedback, drum machine that uses movement to express rhythm. BodyBug is a man-climbing gadget that uses movement as its sole communication modality. These are examples of movement used for improving the experience of the object, and simultaneously the aesthetics of the interaction. Movements are an integrated part of the objects and is used both as a part of the functionality, and for descriptive and expressive purposes. The movements shows direction as well as makes the object crawl in BodyBug, and gives the pace as well as expresses the energy in the musical outcome in BeatCatch.

These are ‘active’ objects that produce physical movements themselves. The discussion on how to use ‘movement thinking’ and ‘movement paths’ in the design incorporates design of passive interactive objects as well.

Figure 1. Movement interaction - bodybug and beatcatch

Composition
What you are dealing with when designing physical interactions is design in and of time. Each interaction occasion is a piece of more or less directed composition. You have an enter to the interaction, getting started time, working time, perhaps a peak, and a finishing and leaving the object or system. Within this interaction time it is the movements that sets the pace, the flow, and the overall feel to the interaction.

MOVEMENT THINKING AS INSPIRATION FOR INNOVATION
I will propose how we might gain from thinking in movement interaction within design of almost any physical interaction. All interactive things have some inbuilt states. They can be active or passive, and usually deals with some kind of input and output. In and within these stages, and in the process of altering them, there is always a certain amount of movement involved. And in these states changes we can adjust the collected amount of movement built within the object. We may also when designing the stage changing interactions, explore new ways to look upon the object, how to interact with it and at the same time also what it is. In this way, innovations can be based
not merely on new technologies, but by rethinking use and thereby coming up with new and interesting applications, based on use rather than on technology.

**Deriving form from interactions**

Movement thinking is a way to form an existing concept or idea into a physical manifestation. This can be based on an idea to an interaction, or an idea of some form of utility. You take start in a form of action that are in line with your idea and exploit it and adopt it for your situation of use, by sketching or with your own favourite design technique. The key is to let movement be the main component in the design. Movements can simplify designs and scale down details that otherwise will make more complex products [2].

By basing the design on preferred actions, ideas are concretised entirely from their interactions. Once the interactions are specified the object is taking form, and discussions upon what you have in front of you are possible. As these artefacts are based on the appearance and feel of an action, the base of what the thing is pretty much rests on these built expressions, and not adapted expressions carved from stiff technological platforms. Letting go of platform specific thinking will simplify computer-based objects.

Using movement thinking is simply to think about how to perform actions, rather than to start to think on the functions level, or about what you are building. When we know what we want to achieve we try to envision this by thinking about the movements that will solve this for us. We then have a set of possible interactions, instead of a set of functions to design. Starting with the movements will naturally give focus to the interactions rather then to the technology or prefixed ideas about what a thing is. Designing the interactions, designs the form of the object, defines what the object is, and how it is being looked upon.

Physical interaction gives room for more individual interpretation on how to use the objects, and greater possibility for personal expressions is being provided. As physical movements can be adapted to the users own needs, they can become more personal and therefore more natural for the user when being performed. Actions that are mastered give the user a wider room for personal expression.

**Example**

Mustardman (figure 2) is an artefact fully designed based on thoughts about movement in interaction. Here the interaction itself was focused upon, rather than the utility. The object has the characteristics of a megaphone, but was conceptually first designed as a listening device. Mustardman is built with a microphone in one end, a bendable arm in the middle, and an amplifier and speaker in the other end. In the experiment, the interaction and its form were designed, rather than the utility. The object was not formally tested, but playing around with it suggested a couple of new use scenarios: for communication, amplifying sounds, and for sound creation. Experimenting with ‘movement paths’ (see below) could further develop it into even new things.

[Figure 2. ‘Movement thinking’ while designing Mustardman: sketches, outcome, and exploration of use.]

Though this is a very simple example, providing only basic interaction possibilities, it explores expressive issues when applying ‘movement thinking’ into a design. Designed interaction forms, like this one, may be further used and explored in numerous new application areas (see also for example [6] and [10]).

**REARRANGING FUNCTIONALITY**

Designing movements is designing in time and when you start to think about timely aspects of an user interface you will have to raise your eyes from the details and look at the whole system, this often leads to more fundamental and structural changes of an artefact, rather than just improving performance on the function level.

**Movement paths**

By using and thinking about ‘Movement paths’ I would like to come closer to an ‘applied aesthetics’ for computational based interactive systems. Theories within the subject of aesthetic interaction [7] are giving a solid ground, but are not outlining any particular path or methodology to follow to come closer to these aesthetic ideals. Using ‘movement paths’ applied for anything you can use with your hands, which has ‘functions’ that may be altered, is a way to enter the core of interaction design, i.e. the physical actions.

Using an interactive artefact or device with your hands will generate a physical movement. When functionality is altered in one way or another the hands are moved to a new place with a gesture, creating a point-to-point path. This can be used as a base for how to construct interactions in new appliances. The possible interactions and how to
perform them, combined with their correlation, creates the overall movement scheme that creates the aesthetics of the use and the interaction. Finding these paths is done by trying out different possible combinations and trying out which versions that give flow in the interaction. This can be done actively by acting-out the interactions [4], or by sketching different possible solutions (figure 3). Of course, there are always hundreds of reasons to add a function in a specific place, because of the technology it is based on, or according to visual aesthetical preferences etc. The path that feels most satisfying to perform would though contribute to the aesthetical experience of using the object, and the aesthetics of the interaction of the object.

Functions or active parts in a system are not just represented by their correlations. Size and shape and structure of where and how these interaction points are put together are all together also the form of the very object. In this way you build systems based on interactions and not the other way around. In the example below physical movements, but also attention, is marked out as movement paths. On-screen interfaces (left) are giving less expressive interaction (movements are limited to mouse movements, keyboard strikes and eye movements), but you have a greater freedom in changing the programs entire structure. In physical artefacts (right) interactions are more rigid but the expressions gained when designing them are more powerful when being performed, due to more lively interpretations of the object.

**Figure 3.** Marked out movement paths for an on-line lottery and for a ‘one-armed bandit’ slot machine

Experimenting with movement paths may first look as an add-on technique - not taking respect to the initial interaction concept, but combined with ‘movement thinking’ while creating the concept of your interactive program or thing, may be what alters the aspects of your project that makes it striking and a true interactive experience in the use.

**Flow**

Using ‘natural’ movements that feel good performing is a good starting point when finding movement paths. Basing the aesthetics on the flow in the interactions, gives interactions grounded in both functionality and perception - an awkwardly designed application or function would not give satisfaction in its use. The concept of flow should thought not be mixed up with lack of friction or intrigue, as good flow usually is experienced while being concentrated and devoted to a task, which often includes overcoming challenges and the feeling of being able to master and control the situation [3].

**DISCUSSION**

The paper proposes an approach to tangible interaction design, by focusing on the physical actions performed when using an artefact. By focusing on the core in every interaction – the movements within the actions - we might get a hint on how to focus on and approach aesthetic interaction in any system, from spectacular to mundane.

Design always also involves contexts and personal intent. The focus of this approach is on the aesthetics of the physical action within interaction design, while at the same time not underestimating these forces. You cannot exclude context, but you can also never exclude the fact that actions are being carried out, adding to the expression, no matter what context. More vivid ‘movement thinking’ concepts and designs may further trigger new forms of use not typically foreseen by the designer, but still within the realm of the designed physical capabilities of the object.

When adding interaction design principles and Movement thinking into a traditional production area, the importance of incorporating new computer technology may be a lesser part of the transformation. Coming up with new interactions using ‘movement thinking’, further improved by adjusting the ‘movement paths’, may gain new interesting solutions even without adding new and advanced technology. This is a way to open up for new forms of uses, and through this more fully making use of computer technology today. Working as a tool for innovation by interaction, opposed to innovation by technology.

**CONCLUSION**

This approach claims:

- To narrow down object interactions, making objects more focused than when based on underlying technologies.

- To open up for new solutions by basing the form of the objects on how they later are handled.

- To give more flow in the interaction and therefore more expressive artefacts.

- To make objects based on computer technology more easy to master, while still being challenging, as objects built from traditional materials.

I have proposed using movement-based interaction as an approach to designing interactive artefacts. This is done to make movement-based interaction for physical objects not
just a peripheral field within Human-Computer Interaction, but an approach to designing interactive technology, focusing on aesthetics, usefulness and suitability as one joint force.

**ACKNOWLEDGEMENT**

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**REFERENCES**

ABSTRACT
In this paper we explore Ingold’s notion of growth and decay of movement, an approach of understanding the relationship between human and the environment. We presented two instances regarding human and machine movement from our exploration during a brief ethnographic study at a local pot warehouse. This is followed by further analysis of two video clips, where we explore the richness of human movement as a relationship between the actor and the environment; we then analyze how the task is done differently in the machine’s case. In the last part of this paper, we raise issues regarding the appropriation and implication of this notion of growth and decay of movement in the field of interaction design. We concluded with opening up a discussion arena for further works in this field to look at the appropriation of technology in relation to the importance of human’s freedom to move, express and experience.

Keywords
Growth and decay of movement, anthropology of movement, obviation approach, alongly integrated

INTRODUCTION
When it comes to interaction design, there are many approaches in understanding the relationships between human and the product contextually. In the field of designing tangible user interfaces, especially, significant amounts of study [1, 2] have looked closely at ways to observe and analyze human movements while interacting with products. However, it seems to be an importance to look further into the movements in the larger context, where sometimes they seem to be more intricate than just moving parts of a body. Do movements have meanings? How do we move? What are the relationships between movements, the actor, the artifacts and the environment?

TOWARDS AN UNDERSTANDING OF HUMAN MOVEMENT
What does it take to understand human movements? We realized that in the case of human, the notion of movement is far more complex than the straightforward definition found in a dictionary. There are significant relationships between movement and time, actor, meanings, and the environment. From an observation exercise with a video ethnography of a Dutch funeral, we found out that body movement is very much connected to the societal context in which it took place. By this we mean that movements could be seen as more than just a set of actions. From this brief video observation exercise, some movements can be performed and/or interpreted as complex as cultural or as subtle as emotional expressions. In these cases, movements have meanings and they are defined not only by the mind of the actor, but also influenced by the unfolding relationships of various experiences both from the past and present, the place, the evolving culture and tradition where these movements are expressed [6].

We also learned from exploring briefly upon the complexity of culture, the notion that it is both organized and natural, supports the idea that body movement, as a cultural expression doesn’t merely serve as a collection of actions in completing a task, but also as a reaction, or perhaps a conversation with the environment, objects and other body movements that exist in the context [3]. In a way movements are structured with some level of organization, where one action is followed by another, either molded by human biological conditions or by rules and restrictions in societal agreements such as laws and rituals. However, even to the level that they are ritualized such as prayers and dances, movements constitute the dynamic and reflexive flow of actions both internally and externally, involving the human mind and body being aware of the material, space, and time.

GROWTH AND DECAY OF MOVEMENT
According to Ingold, human movements as part of skilled practices are too often regarded as only an extension of one’s ability to physically manipulate objects [4]. The trail of these movements then can be seen as a line of “transport” [5]. It is destination oriented; the movement is focused on transporting from one point to the next (Figure 1). Here, human movements are presented as completion of a task after another. Here...
the notion of perception and action is isolated and solely oriented on the actor and object.

Figure 1: Transport: movement from point to point

Ingold argues that human movements are far more intricate than such simple transport. Movements should be seen as a string of actions that are thought out through one’s awareness and knowledge in interacting with the objects, space and other actors. In other words, one way to look at movement should not be in a way that we end up fragmenting the body-object-space-others interactions from one set of actions to the others. Instead, movements should be observed as a lively process where the actor is present both physically and mentally through a path. Ingold proposes to look at the path of the wayfarer. A wayfarer’s travel trail is different from the travel of a vehicle from one point to another. A wayfarer establishes his path in a rich process, where he relates to the environment and other humans: here the actors are actively part of the process or “alongly integrated” [5] (Figure 2). The movements can be seen not as dots along these paths. Rather movements are scattered through out the path, where they can be seen as growth, as they are about to be enacted, and decay, as the actor proceeds gradually to the next movement [5].

Figure 2: Wayfaring: alongly integrated path of movement

FIELD STUDY

In order to explore different types of skilled movements we performed an ethnographic study. We visited both industrial and crafts sites, ranging from a one-person therapeutic massage therapist to a large multi-national industrial component producer.

One site that took our attention the most was a local pot warehouse. The warehouse has over 16,000 m2 of stock under roof and around 8,000 m2 of outdoor stock. In their warehouse, we found pots from all the key major pottery regions of the world. The warehouse uses two different operations in wrapping a stack of pots: manual operation and automate operation. Manual handling or automatic handling is decided based upon visual input, e.g. the operator has to check the type of wood has been used for the pallet.

During the field studies we employ a large range of techniques, for example, interviews, observation and video analysis.

VIDEO ANALYSIS

Manual Operation

Fragmenting movement

Looking at it briefly, there are two main steps that are clearly carried out by the operator in order to completely wrap one stack of pots: 1) Put the plastic bag on (Figure 3a), and 2) seal the stack up by heating the bag with gas torch (Figure 3d). However, when looking at it more closely, each step is a result of movements each building on top of each other, leading towards the completion on a task. For example, if we describe what happens during the first main step, “putting on the bag” can be broken down into several sub-steps such as: 1) open the bag, 2) throw the bag in the air, 3) tip the bag over, 4) lower the bag down, 5) envelope the stack with the bag, and 6) pull the bag down.

But such description of movements leaves out other details such as the actual movement of the operator’s body. For one simple sub-step of opening of the bag, for example, what actually happened to the operator’s feet, head, shoulders, arms, biceps, wrist, and fingers? And what actually was the operator thinking then?

Looking at what’s in between

Instead of isolating the operator’s movements into the two main steps, we try to look at what happen during the transition from “putting on the plastic bag” to “sealing up the stack”. When focusing on one of the influencing factors, space, we realized that upon the transition from Step 1 to Step 2, the operator leaves and re-enters the space where the stack is located. When the operator finishes putting on the bag, he goes to grab the torch, located not too far from the stack (Figure 3b-c). He then goes back to the stack and starts to seal it up. We realize that the main task of bagging and sealing up the stack cannot be completed without movements that are in between.

Obviation approach, as Ingold proposes, is perhaps a better and more appropriate way to understand movements in relation to the nature of human beings [4].

Figure 3a-d: Manual Operation. The four sub-steps of packaging a stack of pots
Instead of looking at events or points when a task is completed, we should try to look at the progression of movements as *alongly* integrated process [5], where the operator is not simply transporting from one point of task to another, but actively present in his movements and interacts continuously with the environment.

Each movement that he makes is not a predefined action and isolated from the others. For example, when the operator is pulling the plastic bag down (Figure 3a), his movement is influenced by the previous one, when he throws the bag up in the air, as his feet balancing the act and thus locating him in the corner of the stack. Perhaps unconsciously he does this as what might feel right or logical to do. But in a way, he is also aware of the spatial conditions of the artifacts he is dealing with: the size of the stack, the stiffness and creases of the plastic bag, etc. But it seems that this awareness is not automatically executed either. The operator seems to continually adjusting his positions and actions, thus resulting in an intricate web of movements. All these seem to be part of the operator’s dexterity in completing the task. Each movement builds not necessarily on top of each other, but together simultaneously along a path.

*Socially influenced path*

What kind of path that the operator deals with? From our study, we found several artifacts that might partly constitute as a path such as manuals, signs, labels and lines painted on the floor and wall all around the warehouse. The warehouse is also set up in an order where three main rooms house three activities: stacking, packaging, and shipping. It seems that these artifacts constitute the orders and rules to be followed. Are these the only paths influencing the operator’s movement?

As mentioned before, the operator is present and aware of his movements. He is actively engaged in the deciding process, figuring where to go and what to do. But from our observation, though he is working individually during the manual packaging section of the warehouse, he is still a part of a greater social context, where he works together, alongly with the rest of the workers. His path of movements is comprised of both physical and social artifacts. The rooms, signs, manuals, labels, the stacks, the torch are the physical artifacts that shape the interactions in the warehouse, thus play an important role in shaping the movements of the operator (Figure 4). At the same time, the social artifacts might seem less visible, since it is influencing the operator’s movements implicitly through verbal communications and common understanding of each other’s work among workers in the warehouse.

*Automatic Operation*

In the case of automate operation in order to completely wrap one stack of pots the machine performs the following steps:

1. Frame opens up (Figure 5a)
2. Frame moves down (Figure 5b)
3. Stop. Torch turns on (Figure 5c)
4. Frame moves up (Figure 5d)

In the current growing field of automate service, machine plays a key role where in many cases machine and human share the same workspace and to some extent even have to work together. In the case of the local pot warehouse, we could not see if machine is a single entity in the packaging system or not. The fact that the operator moves around the machine for supervision, and that the high stack of pots could have been wrapped up by two operators lead us into some thoughts that the machine, serves as a supplemental tool.

Furthermore, while machine executes the pre-defined command, machine follows a rigid pattern to complete a task. The completion of task is a transport of one step to the next. This type of movement did not allow any other movement to take place, lacking the flow where movements integrated alongly a path of growth and decay.

With the current pace of technology, it becomes obvious that in many dynamic situations or complex control tasks, human rely on machine to extend their perceptual-motor capabilities. A more expressive interface would be needed to allow human interact with machine without being overpowered.

CONCLUDING DISCUSSIONS
In designing interactions (products, interface, system, etc), it seems to be the case that the focus of study leaves out the complexity of human movements. Approaches in product design for example have been able to thoroughly look at an array of dismantled movements: twisting, turning, pushing, tapping, etc. However, it is important to consider further the importance of the context (meaning, values, space, artifacts, environment) in which the movement is expressed and experienced.

Growth and decay of movement
From our field study, we found out that once we try to describe the movement of an operator during interacting with a product at a local pot warehouse, it is very easy to fragment his movements into steps. Perhaps it is easier to do so since, we are able to recognize (at least visually) the result of a task, or the artifacts that are used during the specific movement. Bagging the stack and sealing up the bag are two movements that can be identified directly by acknowledging the presence of the bag and the use of the torch. However, such description, truncates the flow of human movements that actually takes place in a very intricate way.

By looking at the strings of movements and how they influence each other, we were able to see that movements are very much influenced by both physical and social artifacts, such as (in our case) instructions, labels, signs, torch, stacks of pots, bags, discussions, etc. The operator moves in a path where we could find traces of his movements through such physical and social artifacts.

From the path we were able to recognize the growth and decay of movement, as influenced by these artifacts. For an example, around a stack of pots that is ready to be manually packaged, we found that the growth of movement is present as the operator picks up a plastic bag and continues through until the bag is enveloping the stack. The movement starts to lessen as he leaves the space and entering another space to pick up the torch. The short walk to the other space is the decay of the previous movement. It seems to be an importance to regard this process as a rest [5], a moment when the operator progresses from one movement to the other.

At the same time, the movements are not only influenced by the dynamics of these artifacts, but also influenced by the operator’s qualities of care, judgment and dexterity [5], where he as an active body and mind, continually interacting with other actors in the environment. This process evolves into the development of skills where the operator is able to continually adjust his movements and acquire knowledge of the tasks. This doesn’t predetermine a perfect, satisfying outcome, however. The completion of the task is still flexible to various changes that might take place, perhaps influenced by the culture or freedom of expressions.

Technology in the picture
It seems to be an importance to recognize that the design of machines appears to be inspired perhaps mostly by the knowledge of human movements in completing if not the same, similar task. In the case of bagging and sealing a stack of pot, we realized that the main steps the machine executes mimic the steps that are done manually by the operator. However, the movements are very different. Perhaps this is not a coincident, since machines are built to help or support our work. But how can we design machines that in a way that it doesn’t end up overpowering, but empowering the human ability to move, express, and experience?

In the case of the automatic packaging machine, we notice that the machine still needs the operator’s supervision and it doesn’t have the ability to adjust its movements. The machine is a closed mechanical system that is not able to be continuously influenced by the environment. However, the design of the machine leaves room for an interaction with some physical inputs from the outside, such as when an operator pushes the activation button or when a stack of pots activates the sensor to move the conveyor belt.

But, what does this interaction mean for the operator? One may see this as an opportunity for the operator to acquire new skills: operating and supervising the machine. Does this skill replace his previous skill of manually packaging the stack? This is a crucial question that needs be considered in design, whether or not such design allows or disallows the operator to carry out the task appropriately? The next question would then be, what is appropriate and how do we find out?

Anthropology of movements: a step ahead towards an understanding the complexity of interaction between humans, the artifact, and the environment
It is challenging to develop a design that supports and improves appropriate interactions for human and its environment. Human movements are influenced by both
the environment but are also adjusted by the body and mind in a very intricate and complex way.

From our experience in observing the operator and the packaging machine at a local warehouse, we learned that one single movement is very much connected to other movements. These movements are enacted not only as actions to complete a task, but also as a result of interacting with the physical and social environment. From this observation, it seems to be an importance to take this notion of growth and decay of movement as springboard to uncover the complexity of human movements in designing interactions.

The relationship between the user and the environment indeed will be different from case to case. This notion of growth and decay needs to be appropriated to the users, the environment and the meanings and values of interaction. This understanding then, would perhaps allow members of the design team to move forward and further in the next stages, developing not only the appropriate style, tangibility, or interactivity of a product, but also allowing user in their environment to move naturally and meaningfully.

REFERENCES