PHYSICALITY 2006

First International Workshop on Physicality, Lancaster University, UK, 6-7 February 200

British HCI Group
www.bcs.org.uk/hci

EQUATOR

Position Papers

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PREFACE

First Steps in Physicality

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ABSTRACT
This preface to the Proceedings of Physicality 2006 describes some of the work at Lancaster and in the Equator project that were the initial inspiration for this workshop. We wish to understand physicality both because it is interesting in its own right and also because the understanding can help us design novel digital and hybrid digital–physical artefacts. Our own existing work is used to propose some initial properties and issues of physicality including rules of 'natural' interaction, issues of 'it-ness' and continuity in time and space, the physicality and instrumentation of the human body and issues of embodiment and spatiality.

Author Keywords
Physicality, spatiality, user-interface design, tangible computing, physiological sensing

LOCAL ORIGINS
This workshop stemmed from a growing recognition that issues of the nature of physicality were emerging in several aspects of our research work here at Lancaster and also as part of the inter-disciplinary, multi-site Equator project.

This theme, in different aspects, is very clear in the work of the organisers. Eva Hornecker has worked alongside and studied people in several institutions who are deeply involved in the design of tangible interaction, where the importance of physicality is explicit, even if its precise nature is seldom articulated [9]. Devina Ramduny and I have studied the importance of physical artefacts in work environments (evident in virtually all ethnographic accounts), and more particularly the computational role of those artefacts in socio-technical systems and how studying artefacts and their disposition in the office ecology exposes tacit and often hidden work processes [10]. In Masitah Ghazali's work, perhaps even more explicitly, the precise nature of physicality has been critical in making sense of the way in which the fine details of physical design in day-to-day consumer products enables fluid interaction [6].

In addition, Nicolas Villar et al's work on Pin and Play emphasises the role of spatial arrangement and this is beginning to be teased out in more theoretical accounts of the role of spatiality [13]. Jennifer Sheridan's studies of technological interventions in artistic performance, with myself and colleagues at Nottingham, has again surfaced critical aspects of 'normal' physicality and how these have been systematically broken or bent over many years, for example the way in which limelight creates visual asymmetry between audience and player [1].

The papers in the workshop touch on some of the themes emerging above, but also other aspects such as the physicality of the body and the importance of physicality within the design process.

DEEPER UNDERSTANDING
The workshop brought together a multi-disciplinary group of researchers and designers, whose work, in various ways, relates to physicality. However, the primary goal of the workshop was to start to dig more deeply into the nature of physicality itself. What is it about physical things that we take for granted but perhaps makes them easy to grasp mentally and hence becomes problematic in digital environments? What aspects of physicality by being broken or bent in digital environments are thus surfaced, problematised and become things we can consider and reflect upon?

Put more operationally: what can understanding physicality do to help digital design and what about digital design can help our understanding of physicality?

The first of these questions is clearly moot for many involved in this workshop. The second is perhaps more philosophical, and not one we would expect to answer in two days! Indeed, over the years, when discussing with philosophers the issue of "it-ness" (what it is about a thing that makes it an 'it' before 'it' is a something), I have found it interesting that they repeatedly refer back to the singular spatial and temporal nature of objects, qualities that are not necessarily essential to computational artefacts.

So, to seed discussion, here are a few properties of physicality to be challenged, enriched, rejected or added to.

THREE RULES TO BE BROKEN

Some years ago, in teaching a software engineering course, I tried to characterise what it was that made software engineering more difficult than many areas of more physical engineering. I listed three properties of 'ordinary' physical things – that is inanimate, non-mechanical, 'natural' things like rocks.

directness of effort You push a little, things move a little, you push a lot, things move a lot.

locality of effort Things happen here and now. If you push something it moves at the moment you push it, not earlier or later. If you push in space, not touching an object, it does not move!

visibility of state Whilst the more static appearance of an object may be complex, its dynamic state is defined largely by immediately apparent properties such as location, orientation, and (albeit harder to apprehend) speed and direction of movement and rotation.

These properties are systematically violated by computational artefacts. Take a mobile phone:

directness of effort – violated You press a single digit wrong, and end up dialling Brisbane rather than Blackburn.

locality of effort – violated Looking at spatial directness – the whole purpose of the phone is to talk to someone far away! Temporally as well: voice mail, alarms, waiting for a connection – all are non-local.

visibility of state – violated Hidden within the phone you have a large address book, old text messages and personal settings. Moreover the phone appears to be the repository of distant information and is influenced by invisible, almost magical, electromagnetic fields as you waft the phone near a window seeking signal.

The mention of magic in the last of these is not inconsequential; the violation of these principles often leads to magical explanations, either explicitly or implicitly, in people's understanding of phenomena. Imagine you put a glass down near the edge of a table, then as you turn your back the glass topples and crashes to the floor; it is hard to shake off that momentary chill down the spine even when you realise it has simply overbalanced.

Understanding these properties helps us realise why the design of software (or for that matter complex chemical plants, telecoms networks, and clockwork mice) is difficult. And from understanding comes better design. Many years ago, Harold Thimbleby included proportionality of effort among his GUEPS (generative usability design principles) [12], and in Masitah Ghazali's work the 'three properties', and others derived from and related to them, have been central.

Pinning down these properties is itself difficult; however even more problematically Masitah and others have been trying to experimentally 'test' the effects of some of them in interfaces – but we find it is quite hard to violate single properties without breaking many. Interestingly, we found similar difficulties 'testing' GUEPS back in the 1980s!

IT-NESS AND CONTINUITY OF IDENTITY

As noted, I have often found that philosophers refer back to the singularity of location in space at a given time in their explanations of the most fundamental aspects of thing-ness. Whilst the previous three properties were explicitly about inanimate things (kick a dog now and it may bite you in 5 seconds time), the more fundamental continuity in time and space is true also of animate things. In magical worlds this may not be the same. Hermione is able to study so many subjects at Hogwarts because she travels back and forth in time and is able to be in two places simultaneously [11]. The Frog Prince is continuous in time and space, but fundamentally changes what it/he is as frog becomes prince.

Digital objects (whilst usually not enabling time travel) also violate this fundamental spatio-temporal continuity. When I copy the file containing this paper I suddenly have two copies of 'the same' document. And whilst these are arguably different due to their different file names, the same could not be said for information stored redundantly on a RAID disk. Variables continually change their values. of course, but this could be argued to be like me changing the smile on my face; however, in the Smalltalk programming environment you can say that an object, like the Frog Prince, 'becomes' another of a completely different kind and type.

Even more strangely, the UNIX operating system allows you to write to parts of a file at arbitrary character locations. You can create a new file and then write a single 'X' at character location 1,000,000,000,000,000, but nothing else. If you look at

the directory listing, the file appears to be a peta-byte in extent – far bigger than your hard disk drive. In fact the intermediate data is not explicitly stored anywhere as it is 'known' to be zero (the initialised value) and is only 'called into existence' if you subsequently attempt to read the file. (This is a sure way to frighten your system administrator!)

THE BODY

From earlier more 'inside-to-outside' Cartesian conceptions of cognition, there has developed, over a number of years, an increasing acceptance of the importance of physical embodiment for cognition and even selfhood. This is explicit in frameworks such as distributed cognition [8], where the role of physical artefacts and multiple actors is seen as essential for 'cognition' to occur – thinking as transactional with and within the world, as opposed to disembodied then acted out – imposed upon the world. This has also been central to the conceptions of the computational role of artefacts that Devina, Julie Wilkinson and I developed in the "socio-organisational Church–Turing hypothesis" [4].

Looking more fundamentally at 'the body' itself, Damasio locates consciousness effectively in our brain's self-image of our physical body [3]. Personally I have tended to look slightly more broadly to self-consciousness emerging as an 'accident' of third-order model of mind. In order to understand you I 'construct' a model of your intentions. Because I do this, I may either directly apply the same process to myself (as an 'other'), or more indirectly construct myself as an intentional being in order to understand myself in your eyes … the first party 'I' developing from the third party 'me'. Others place consciousness in a neurological short-cut between mouth and ear, a silent narrative about oneself to oneself [2].

All of these are deeply embodied views where internal self-hood is intimately derived from or tied to external body-hood.

At a physiological level our bodies have an odd role of being both our own and yet also to some extent 'other': 'my' stomach does not always digest at 'my' will. One of the roles that physiological computing has played is in exposing aspects of users' bodily and mental functioning and making these explicit and apparent to 'their' mind. Alternatively, we may keep these 'secret' from the user, creating systems that respond to unconscious (but not necessarily unfelt) signs and signals. For example, Kiel Gilleade and others have worked on physiological sensing to influence computer game play – the body becomes sucked into the digital environment [7].

Strangely, the physical world does not always match our 'natural' understandings of physicality. The early twentieth century saw a series of discoveries, in particular quantum mechanics and relativity, that fundamentally challenged our understandings of the world and led to paradigm shifts of science, and to some extent broader public conceptions.

Perhaps even more strangely, our bodies also exhibit this relativity as nerve signals take a short but appreciable time to travel from eye to brain to hand … not massively different to the fastest Internet packets travelling from end to end of the earth. In computing terms our body is a distributed system; the 'now' we experience is spread over approximately a second and the apparent continuity of movement as we trace our finger across a frosty window pane is, Zeno-like, composed of a series of more discrete commands from central control and observations from field units at a leisurely 5–10 Hz pace.

EMBODIED COMPUTATION AND SPATIALITY

It is a truism (but also a potential fallacy) that computation and information are always physical: electrons speeding along copper tracks and through silicon junctions, magnetic regions polarising, even ink on paper.

Just as the embodiedness of the human body is critical to understanding cognition, physical embodiment reminds us of crucial features of computation; for example, that you can only perform finite computation in finite time and space and that memory 'space' consumes physical space (a peta-byte is currently the size of a collection of large filing cabinets!). The simple Turing Machine, whilst being a conceptual computation engine, apparently moves a tape through itself, or possibly, as a real 'touring' machine, drives along the tape, finding memory externally represented outside of the core (and finite) engine itself.

However, this truism of embodiment is also misleading, as there is a difference between computation and computer, between word and page. Whilst the representatum[†] is physical the idea of the information is not. As highlighted by the word and page, this is not a new thing but has been a feature of literary works, and, before that, ideas and classes from times when silicon was still simply sand. Indeed the ontological status of ideas has been a difficult and contested topic within philosophy from at least Plato onwards.

[†] Here I am using 'representatum' very nattowly to mean the *material* on or with which the information is represented (e.g. paper, ink). Some semioticians use the word effectively as a synonym for 'sign', which encompasses both the material and the form of representation on it (e.g. a black ink 'x' on paper).

So far I have only mentioned space briefly in passing, but clearly spatiality is a crucial aspect of physicality. In my previous writing about the development of ideas, expressed most recently in a keynote and chapter for the 2004 Space and Spatiality workshop at Napier, the relationship between spatial thinking and words and that of ideas and concepts has been central [5]. In particular, in the understanding of issues such as transarticulation – the way words form meanings – there are strong parallels between our partially imposed and partially determined namings and understandings of the physical landscape and the parallel namings and understandings of the intellectual landscape.

The physicality of representata, whether paper, silicon or neuron, does not determine but does shape the information, computation, and ideas that flow over and through them: linear narrative, planar graphs and patterns of thinking influenced by our physical existence.

ACKNOWLEDGEMENTS

This paper is drawing on the work of my fellow workshop co-organisers: Masitah Ghazali, Eva Hornecker and Devina Ramduny-Ellis as well as other colleagues at Lancaster and in Equator.

In addition, the Equator project (www.equator.ac.uk) sponsored this workshop and has supported my own work and much of the work referenced here.

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Making the Digital Palpable

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INTRODUCTION

Physicality is not just a property of matter and bodies. It is also, importantly, an effect of interaction. People perceive physical attributes (e.g. temperature, smell), physical processes, behaviours, and affordance as they engage with environments, materials, other people, and technologies. In their interactions with matter neither the range of sensory stimuli nor the range of responses are fixed. Many sociological studies with scientists show how matter can be made to 'speak' in many different ways [9] and how people can learn to register and interpret stimuli previously unknown or perceived as noise (see, for example, Genevieve Teil's study of trainee perfumists learning to distinguish a large array of smells, summarised in [9]).

People employ a 'documentary method of interpretation', by treating actual appearances 'as "the document of," as "pointing to," as "standing on behalf of" a presupposed underlying pattern' (Mannheim, quoted in [7]) and tap into this stream of agency through 'experimental interactivity' [11].

Digitality is not the opposite of physicality. Digital processes are material: Transistors are rapidly switched on or off, fans cool processors, electrical currents activate display photons, etc.. But it is difficult for people to sense many important aspects of this materiality. With many phenomena and processes in the sciences, digital phenomena and processes share the characteristic that their material 'documentation' requires long chains of amplification or translation.

While software developers are very good at devising and deciphering such chains, most users of digital technologies are not. They cannot easily make digital matter 'speak' in a way they can understand or train their perceptual system to register and interpret sensory information and translations they may encounter. This seriously hampers the appropriation and of digital services and devices.

THE PRACTICAL ACHIEVEMENT OF PALPABILITY

How can designers make digitality and its affordances more palpable, that is, more available to people's senses? If palpabiltiy is not a property of an object but the outcome of interactions between human actors and material actants, digital technologies should seek to better support human-matter interaction. But to do so, designers need to know more about how this interaction is practically organised, and a series of further questions arises:

- What exactly does a documentary method of interpreting material activity involve? How do people and matter engage in 'experimental interactivity'?
- How do people (learn to) make matter 'speak' in ways they can understand? How do they (learn to) register and interpret new sensory stimuli?
- How much understanding and what kind of an understanding of internal structures and processes is necessary to be able to generate palpability in interaction with material actants?

In order to explore some of these questions I carry out video based ethnographic studies in a range of different settings, focusing on work, play, software development and use.

Work: a number of professionals are routinely concerned with making complex, very subtle, or hidden material processes palpable for themselves and others, for analysis, diagnosis or evaluation, to communicate with others about them and to enable a decision making process. For example:

- landscape architects engage in the assessment of proposed new developments (e.g. windfarms) and their effect on the experience of landscapes [3]
- ultrasound scanning nurses and parents-to-be are concerned with pre-natal care, including the assessment of the risks of physiological or genetic irregularities [4]
- physicians, parents and nurses who care for prematurely born babies must carry out, and perceive the effects of, treatment meant to facilitate the development of the foetus/child
- emergency response personnel learn to 'read' and react quickly to the ways in which bodies exhibit the consequences of injuries and the ways in which material agents can cause danger [5]

Play: A series of small pilot studies capturing how people play with things (sugar-sachets, unfamiliar prototypes, mechanical things) apparently absent mindedly, with no purpose, unconsciously interacting and learning about material ways of 'speaking', and training their sensitivities, extending Heidegger's notions of ready-to-hand and present-to-hand, with more playful, less purpose-oriented ways of engaging with material qualities and processes.

Development and use: I am a member of a team engaged in the participatory design of an open architecture that

supports palpable computing (PalCom [10]). As part of this work, my colleagues and I develop prototypes for use in the different work settings described above. I have collected video records of numerous occasions where developers or users actively make digital processes (or a lack of such processes) palpable, when engaging with these prototypes. A range of characteristics of the architecture are utilised, a range of methods, tools and tactics can be distinguished [2].

TOWARDS MORE PALPABLE COMPUTING

My empirical studies and insights from current sociological thinking about human-matter relations inform the design of palpable computing, which builds upon reflective or declarative methods to make digital processes more palpable [1, 4, 6, 8, 12).

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Noncommand-Based Interaction in Tangible Virtual Environments

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ABSTRACT
Over the past decade, Virtual Reality (VR) systems have become more and more important in industry, medicine and entertainment. The visual quality of these systems is impressive, but their interactive features are usually artificial. Users within Virtual Environments (VE) are often bound to complicated interaction devices (e.g. data gloves or force-feedback arms) and have to learn special interaction techniques in order to manipulate virtual objects.

Conceptual errors, introduced from the WIMP world could be a cause of the difficulties of today's VR interaction techniques. As Tangible Interaction changed the human-computer interaction, it might also change VR interaction techniques. In Tangible VR, the computer interface is distributed on discrete, directly manipulatable physical objects which the user can manipulate without having to consider interaction-syntax.

Author Keywords
Tangible Tools, Hybrid Objects, Tangible Interfaces, Tangible Virtual Environments, Tangible VR, Noncommand-Based Interaction, Interaction Syntax, Paperless Office.

NONCOMMAND-BASED INTERACTION
In 1993, Jakob Nielsen defined twelve dimensions[1] for future, noncommand-based user interfaces [6]. There has been progress in some of the dimensions (e.g. software packaging), but nothing has changed within the dimension s*yntax*.

According to Nielsen, command-based interfaces typically require specification of objects and functions (commands) in noun-verb or verb-noun syntax. This structure dominates both command languages (e.g. MS-DOS) and graphical user interfaces (GUIs), even if they rely on direct manipulation. In GUIs, commands are placed in menus and objects are represented by icons. Also most VR interaction techniques require sequential object selection and object manipulation actions [3], thus they do not meet the requirements for syntax- and command-free user interfaces.

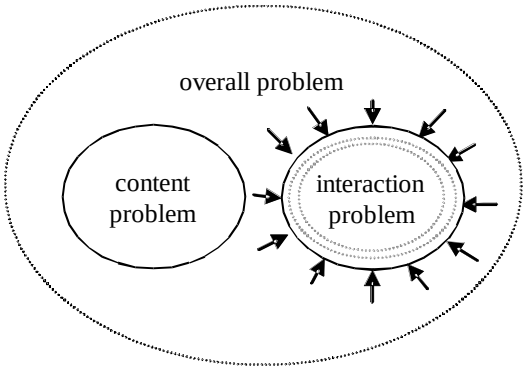

Figure 1a. WIMP: All content problems must be solved with same interaction techniques. The interaction problem can be adapted only marginally to the content problem.

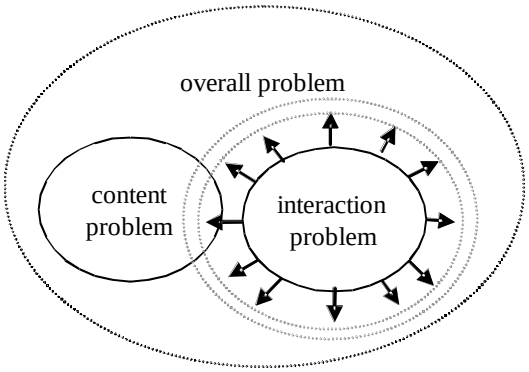

Figure 1b. Rich Interaction: To solve the content problem the user can use various suitable interaction techniques. The interaction problem can be adapted flexibly to the content problem in order to ease the solution of the content problem.

Reflecting on future user interfaces, Nielsen wrote: "such interfaces will to some degree be syntax free (...) the specification of both action and object are unified into a single token rather than requiring the composition of a stream of user input" [6, p. 86]. This corresponds to human grasping. Reaching for an object and moving the thumb, fingers and hand to positions on the object surface

[1] user focus, computer's role, interface control, syntax, object visibility, interaction stream, bandwidth, tracking feedback, turn-tacking, interface locus, user programming, software packaging

appropriate for object-manipulation is an integrated movement [11].

THE INTERACTION PROBLEM

Working with computers can be defined as interactive problem solving of the *content problem* and *interaction problem* [12]. The content problem relates to the actual problem itself, the interaction problem arises from solving the content problem with the help of a computer (e.g. positioning problem). In today's WIMP interfaces, designers try to reduce the interaction problem by providing the same, well-known interaction primitives Windows, Icons, Menus and Pointing Devices [6] for all content problems (Figure 1a).

Humans have a rich repertoire of object manipulation abilities. For example leafing through a book is a highly complex procedure which reveals the book contents and meta information such as age, usage and volume. Instead of reducing the interaction problem to a few limited interaction techniques, humans should be able to use their highly efficient sensomotor skills for the manipulation of virtual objects. They should be able to use different interaction techniques for different content problems, thus extending and diversifying the interaction problem instead of reducing it (Figure 1b).

PAPERLESS OFFICE

In the vision of the *paperless office*, as few physical objects as possible should be involved in the working process. Preferably all documents should be digital and all tangible, physical documents and tools should disappear from the desk in favour of uniform Personal Computers [2]. But despite the efforts, the use of paper is still increasing; paperless offices will not work for a long time yet [9]. From this follows that tangible documents and objects are still important to fulfill our work and to organize information.

UBIQUITOUS COMPUTING, AUGMENTED REALITY

Ubiquitous Computing and (Tangible) Augmented Reality (AR) are two approaches which try to integrate real and digital workspace, whereas the digital is basically an overlay on top of the physical environment. Interacting with those systems is usually simple and requires little learning. But if the computer is everywhere, the user loses the means to specify if actions are intended only for the physical or also for the digital workspace, which might lead to ambiguity and additional interaction problems. Ubiquitous Computing even tries to make the computer interface invisible. Dourish appropriately comments: "You can not be engaged with something that essentially isn't there. Invisibility is not engaging; invisibility does not communicate (…) the relationship between the user, the interface, and the entities that the interface controls or represents is continual shifting. The focus of attention and action is subject to continual and ongoing negotiation." [4, p. 202].

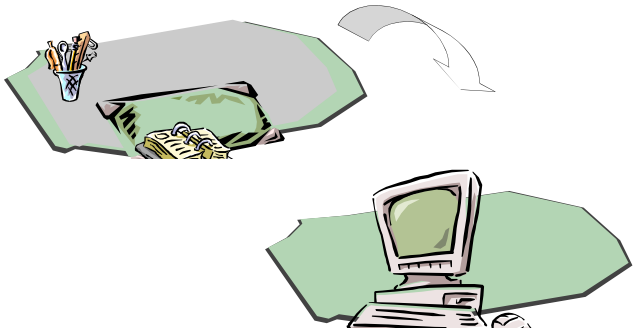

Figure 2. Vision of the paperless office: tangible, physical objects disappear in favour of uniform Personal Computers.

TANGIBLE VR

Just as the mouse as a dedicated *pointing* device is not suitable to be used as a general purpose interaction device within WIMP Interfaces, current VR interaction techniques are not suitable for all interaction problems which may arise within Virtual Environments. Most of the interaction techniques are based on complicated selection-manipulation-deselection sequences [7, 3], provide no haptic feedback or require heavy and expensive equipment.

Tangible Interfaces (TUI) are physical objects which are linked to digital functions or objects [5]. In order to provide successful physical / digital mappings and to ease the interaction problem, TUIs should contain successful spatial mappings, unify input and output space and enable trial-and-error activity [10].

TUIs are directly manipulatable and perceptible by their physical presence within the workspace. Users can make direct use of tangible objects without having to specify input focus and manipulation technique separately. In the definition of Nielsen such a manipulation can be called a *single token of interaction* (Table 1).

WIMP	VR	TUI
• position mouse pointer • select object (attach focus) • manipulate (position) • deselect (release focus)	• position glove / device (point) • select object (attach focus) • manipulate object (position, rotate) • deselect object (release focus)	• grasp / manipulate / release object (single interaction token)

Table 1. Interaction sequences required for direct object manipulation.

In order to integrate Tangible Interface into Virtual Environments and to detect collisions with virtual objects, the VR system must be aware of the objects' positions and geometries (e.g. by optical tracking). The digital functionality of tangible objects can be integrated into the VR system's software. For various ergonomic reasons and to facilitate the integration of real and virtual workspace, non-immersive environments (e.g. Holobench) should be preferred to immersive environments (e.g. HMD, Cave).

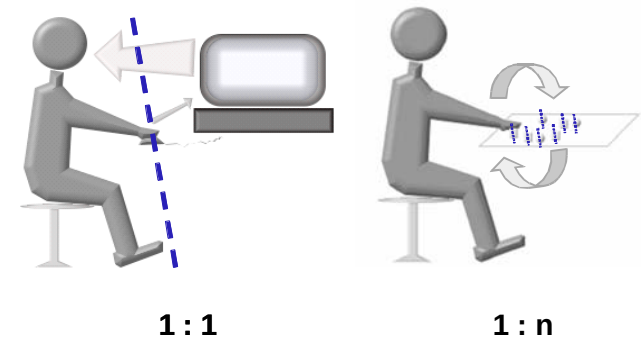

Figure 3. Tangible Virtual Environments: The 1:1 human-computer interface shifts towards a 1:n human-object interface.

By integrating Tangible Interfaces into Virtual Environments, the 1:1 human-computer interface shifts towards a 1:n human-object interface. Furthermore, if the system facilitates simultaneous interaction with multiple objects, two handed interaction comes naturally.

TANGIBLE TOOLS AND HYBRID OBJECTS

The advantage of Tangible Interfaces, their physical presence, is also their biggest disadvantage, because they are very inflexible in changing their shape and usually suitable for only one application [10]. There are two approaches to this problem: *tangible tools* and *hybrid objects*.

Tangible Tools are general purpose tangible interfaces, which can be used for different tasks and in different contexts. They are similar to physical tools in that they are *ready to hand* (zuhanden), as Heidegger calls it [4, p. 109]. After having learned how to use it, the user acts through the tool and the tool itself is not in the users attention anymore. An exemplary tangible tool is the MIT's I/O brush [8]. Tangible Tools can also be hybrid.

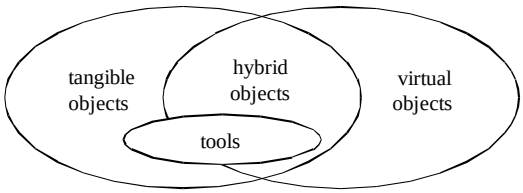

Figure 4. Objects (present-at-hand) and tools (ready-to-hand) in Tangible VR.

Hybrid objects consist of tangible, physical and virtual, visible, but not tangible parts. They are bridges between the digital and physical world, the interface runs directly through the objects. Usability tests will show to what extent users perceive these objects as units and transfer their manipulation abilities to the digital object. (Hybrid) objects within the user's attention can be called *present at hand* (vorhanden) as per Heidegger [4, p. 109].

SUMMARY AND OUTLOOK

Just as Tangible Interfaces changed our concepts of human-computer interaction, they might also change our concepts of interaction within Virtual Environments. What has begun

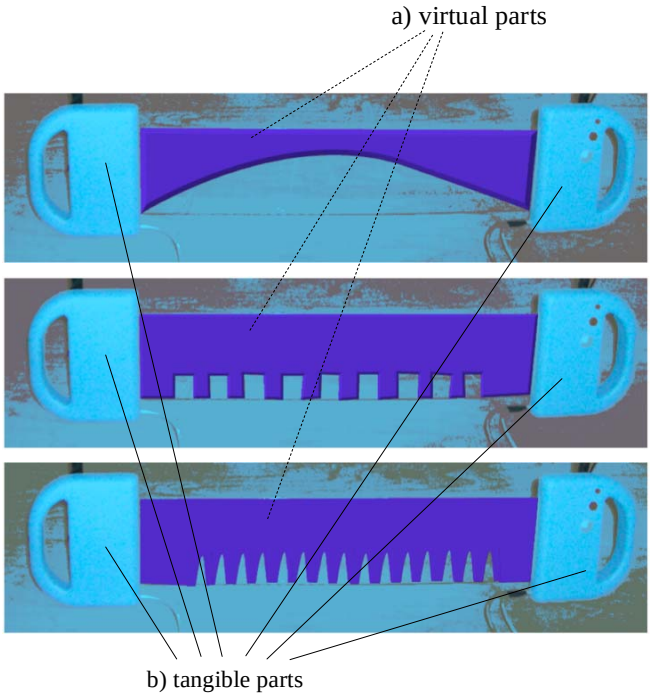

Figure 5. Hybrid tangible tool for Virtual Clay Modeling [1].
a) virtual, variable but not tangible parts
b) physical, tangible but invariable parts

with Tangible Augmented Reality should be continued with Tangible VR and might finally lead to the smart VR Systems we have been waiting for for the last ten years.

In a next step, usability studies on hybrid objects have to be conducted and prototypes have to be developed which make active use of hybrid objects and tools.

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Building Bowls for Miscellaneous Media

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INTRODUCTION

In this paper, we describe an early design sketch of an augmented bowl. The sketch illustrates how a bowl's physical properties might be used to enable a simple, lightweight method for casually displaying and containing the media held on devices like digital cameras (still and video), mobile phones, music players, etc.

The features we present of the augmented bowl have been designed to exploit our commonsense understandings and everyday uses of container-like objects. As we'll explain, in choosing the features, we've attempted to build on the ways in which physical content can be casually added to or retrieved from a bowl with little to no thought. We've also tried to capture the way bowls loosely contain their physical content, so as to enable an informal and to-hand solution for managing digital media.

The underlying motivation for this work has been to explore innovative methods for displaying and handling digital media, something we feel to be timely given the nascent proliferation of capture and playback devices. Given this proliferation, our intention has been to move beyond the constraints of the personal computer (PC) and consider the possibilities that might exist for using alternative display technologies and physical methods of interaction [see 3].

Beyond the PC

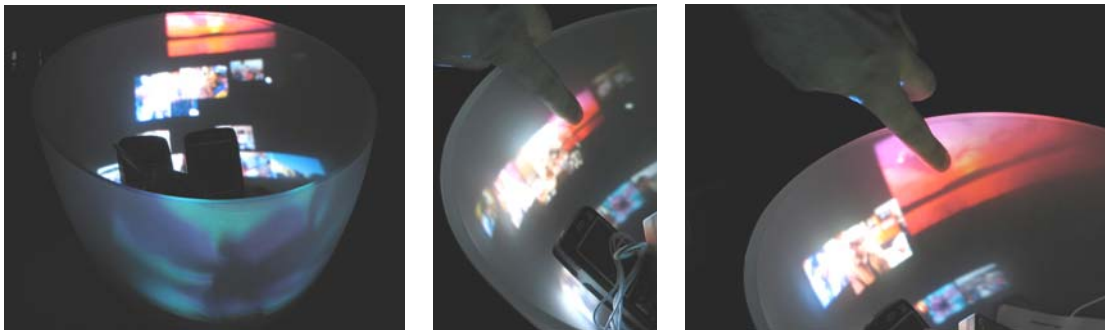
Our ideas for the augmented bowl, as one possible avenue for this research, arose from our ongoing empirical investigations into home life. One possibly unsurprising discovery we've made in this work is that household members, in their day-to-day routines, often devise simple, easy-to-use techniques for managing their physical 'stuff' [1, 5, 6]. Our bills and correspondence are loosely collected into piles, piles distributed around the home. Bowls and drawers become to-hand containers for bits and pieces that have yet to be sorted or that aren't quite ready to be thrown out. Indeed, we might argue that such ordinary practices are an essential feature of homes and what we do to make them special—transforming the mundane or possibly profane to sacred [2]. Thus, at times, it would seem that in our daily dealings with stuff we simply want easy-to-hand places to put things that casually and informally organize. A key feature to these places is that they require minimal effort to use—they're not about engagement, but rather disengagement. Thus we find these piles, bowls, drawers and so on situated around the home, purposed, as it were, for us to make use of them.

What has become the established PC-centric model of handling digital media contrasts with these types of minimal effort practices and casual forms of storage. The PC's ability to perform a range of activities related to storage, organization *and* manipulation demands a level of complexity that makes it unwieldy and thus difficult to incorporate into everyday routines. The convergence of features into a single 'solution' makes what should be straightforward operations complicated to perform. Because of this complexity, there exists no casual way to simply contain or store digital media—no parallel to the way in which an object is simply placed in a bowl or drawer and minimally organized by dint of its size and when it was placed there. There is an in-built formality to both containing (or 'uploading') content and organizing it that is manifestly not the case with physical containers. Because of this, the PC is more suited to the more formal storage and organization of content that requires highly focused interaction or engagement, the sorts of activities that are often put off in the home for more time-bounded and infrequent occasions.

Digital media containers

Our sketch of the augmented bowl has been undertaken in an effort to contemplate this apparent problem and consider the practical design issues. Broadly, the aim here has been to support the casual and informal organization of digital media by providing lightweight methods of interaction that are highly intelligible to the user. Our focus thus far has been on augmenting physical bowls, building on the particular functions they afford.

The current design 'sketch' is based around a semi-transparent bowl capable of holding digital and physical content. As devices such as cell phones and digital cameras are placed into the bowl, the digital content stored on them is copied and displayed. Using two data projectors, the content is displayed on the sides of the bowl's semi-transparent surfaces. As more content is added, so existing items fall deeper to the bottom. The bowl therefore becomes a place into which digital content can be easily copied, previewed or deleted, in a casual or informal manner.



(a) (b) (c)

Figure 1. Augmented bowl.

AN AUGMENTED BOWL

The current manifestation of our bowl is shown in Figure 1a. By no means a finished article and yet to be touch-enabled, this early mockup is intended to inspire our future design work, in particular allowing us to rethink how media can be managed in easier and more lightweight ways. In the following we discuss some of the specific interactions that such a bowl might support, how these can provide utility in the digital domain, and how we believe these link back to our established practices in the physical world.

Containment

In conceiving of a digital media container, we have chosen to preserve the physical properties of a bowl in order to exploit the visual cues that bowls exhibit. A bowl's shaped surface—its *sidedness*—indicates that it will bring together objects; that it will *contain*. The bowl's visible form affords its use in this respect. Using our envisaged system, the containment of digital media is achieved by placing a digital device in the bowl. The media associated with a device is projected around it, on the bowl's glass surface. Digital containment is thus achieved by further utilizing the physical properties of the bowl; it is accomplished through the simple act of placing a device in the bowl.

Layering

Using the described bowl, we're aware that some of the media displayed may get obscured as more physical and digital items are added. We consider this, however, to be an intelligible feature because of the well-established understandings we have of physical bowls. With a conventional bowl, as items are placed in it, other content is obscured. To view lower lying items, we know that the top layers must be sifted through, moved apart or removed. Indeed, we exploit this principle of layering when we wish to let objects lie hidden and out of sight. Thus, our intention is that this interactional feature should hold true for the augmented bowl.

Detaching content

Our proposed method for detaching media from its associated device has also been chosen in an effort to maintain the principle of layering. We envisage content being 'peeled' away from its device and left on the top 'digital' layer until obscured by other content. To detach the media, a device's thumbnails or icons are held down in the bowl with a finger as the device is pulled away (Fig. 1b). Providing visual feedback, media is temporarily stretched to imitate a peeling-like action. This action duplicates the media in the bowl, leaving the original content on the device.

Signaling attention

In apparent conflict with their limited display capabilities, we find that bowls are sometimes used to draw attention to their content. Apparent here is that a bowl is *not* being utilized for its ability to display its content. Rather, we attract attention to content by the way we place it in relation to the bowl; by putting something out of kilter in a bowl, it stands as a reminder of something to take with you, put away, or otherwise act upon because it has been placed, figuratively speaking, to trip over. The mechanism builds on the at-a-glance quality that physical bowls can have when they are situated in the home, on hallway sideboards or kitchen counters, for instance.

Our augmented bowl supports this idea of signaling attention by allowing media to be dragged up and against the bowl's side. Using this feature, chosen media can be visually distinguished from low-lying contents. For example, a picture or possibly an address from a mobile phone can be moved up to one of the sides of the bowl to mark it out for a passer-by to see. We have attempted to further develop this feature by building on the specific properties of the bowl. If media is dragged to the topside of the bowl (Fig. 1c), the increase in size of a thumbnail or icon is more pronounced. Thus, given the orientation of the bowl's topside (facing outwards), media left there is made visible from a distance. We have also made media placed in this section visibly brighter, adding to its visual prominence.

Surface ecologies

Arguably, other augmented surfaces, such as tabletops and walls, offer a technically more feasible solution to the problem of digital media containment and storage. The difficulty involved in projecting onto and detecting

interactions with tabletops and walls has been subject to extensive research. Indeed, a number of systems have been presented in the research literature that provide possible solutions to containment and viable techniques for interacting with digital content [eg 7]. At issue here, however, are the distinctive properties of surfaces and the different interactions they afford in settings like the home. What is evident from our observations is that tables and walls do not lend themselves to the same types of containment and storage functions afforded by bowls and other container-like objects.

This point is best illustrated by example. Consider how horizontal surfaces such as tables play into the patterns of home life. As we and others have observed [1], tables are ideally suited to the display and organization of materials, sometimes in shared environments. The physical nature of the table, for example, lends itself to having content spread over it and people arranged around it for the purposes of sorting, organizing, viewing, playing, eating and so on. Usage is thus driven by bounded activities, something that appears all the more pertinent in the home where table-use is regulated by a household's daily rhythms and negotiated by its members. Any containment afforded by tables is consequently constrained by who and what has overall rights to the table. The table has a social as well as physical character in the home that means any storage is time limited and bound by an established social order.

A sensitivity to the actions and activities afforded by tabletops, walls, containers, etc. gives an indication of how bowls might operate within the larger environment. In essence, bowls can be seen to be part of a wider ecology of surfaces in the home. This notion of surface ecologies [also see 3]—of different surfaces working together and sometimes competing—stands in contrast to the multi-purpose solution of the PC, where an effort is focused on centralizing virtually all operations. Instead, we offer the basis for a solution that should be used only under certain conditions, with a constrained range of operations working in concert with the physical and social surroundings.

Our main assertion here is that an augmented bowl should retain its specialized containment and storage functionalities. The casual ways in which items can be literally tossed into bowls and the loose organization that results from the physical form of the bowl should be preserved because this appears to be one of the reasons why it is so compelling as a storage container. The design space then becomes one of considering how the bowl works in coordination with the surfaces around it. We propose, for example, that to organize its content more thoroughly, a bowl's media might be 'poured' onto and spread over an interactive tabletop. Similarly, media items might be virtually 'stuck' or 'thrown' from bowl to wall displays to view content collaboratively.

CONCLUSION

The augmented bowl concept we have presented in this paper is designed to support the need that we sometimes have to effortlessly handle things. As a design sketch, it hopefully provides an idea of how computational resources might be exploited to build on our intimate familiarity with the physical, and done so with a sensitivity to the ways in which our social arrangements imbricate with material surroundings. As opposed to an all-encompassing solution for managing digital media, the bowl is envisaged to be one of several resources that operates within a larger ecology of purpose-built solutions.

As intended, the presented work has raised a host of questions about digital media containment and possible solutions that address real-world practices in homes. For instance, the mapping of physical 'stuff' onto digital media is clearly not a direct one. Further, thought needs to be given to the sorts of digital media that might take on physical-like qualities and consequently what media should and should not be displayed in containers like the augmented bowl we describe. Questions are also raised about the literalness of our interpretations in designing the augmented bowl. Is such a literal translation of physical containers necessary? Also, do such tangible interfaces merely limit our potential, while failing to introduce novel and possibly more appealing methods of engaging with our everyday experiences? Why too should our interactions with digital media be constrained by the properties of the physical world when clearly they do not have to?

As we develop this work and progress towards a fully functioning prototype of the augmented bowl, we hope to address these questions as well as the more technical problems. The position we take, here, is that detailed studies of established, real-world practices provide a powerful resource in incremental design. This approach is best complimented, however, with *in situ* prototyping where people's everyday interactions with a solution can be used to help develop potentially more novel, but still grounded design ideas.

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Physicality from the Sidelines: Potential Hurdles and Solutions in the Development of Novel Interaction Styles

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ABSTRACT
This paper provides a pragmatic argument on how best interaction designers and researchers can influence and perhaps even guide the interaction design process of the ever accelerating digital revolution. This is done through important lessons learnt through the development of a set of design tools for a major consumer manufacturer. Principally, idiosyncratic organisational factors need to taken into account when introducing a new design approach or methodology.

Author Keywords
Interaction design, design tools, interactive technology

INTRODUCTION
The promise of pervasive computing, augmented interfaces and ubiquitous smart devices has now been with us for many years. Many papers addressing the future of computing often begin by providing examples of existing consumer products such as mobile phones, PDAs, in-car navigational systems, MP3 players and interactive TV to substantiate how 'digital' we are becoming. Furthermore, researchers and designers then often go on to make claims about experiencing and using digital technology that is less intrusive, more ubiquitous and will naturally blend with common everyday physical objects.

FACTORS AFFECTING THE IMPLEMENTATION OF INTERACTION DESIGN TOOLS
There is very little doubt that digital technology will relentlessly progress and evolve. This position paper, however, offers a pragmatic argument on how best interaction designers and researchers can influence and perhaps even guide this accelerating digital evolution. This approach has been shaped by my experiences of managing a research project about 10 years ago. There were three factors beyond the initial remit of the study that prevented our design tools being successfully implemented in the design of future digital products.

Organisational acceptance of design tools to support innovation
Firstly, although the design tools were received with high approval by the designers, organisational acceptance was more difficult. The aim of the research was to provide industrial designers with 'ergonomics based information' to support the design of usable product interfaces using emerging digital technologies. This research preceded the now recognised discipline of 'interaction design'. These design tools were developed to help support consumer product interfaces, where generic design rules from computer interfaces could not be used because product interfaces had different forms of technology, usage behaviour, functionality, and used 'physical' control and display technologies.

We placed a heavy emphasis on developing *appropriate* delivery mechanisms for industrial designers to ensure their acceptance. The tools were underpinned by HCI research and cognitive theory. Very briefly, the first design tool developed was a user requirements capturing tool which used 'card sorting' techniques involving the collaboration of anticipated user groups and designers. The second design tool, 'scenario design', refined this proposal at a more detailed level with users interacting with crude paper based prototypes within the context of a real scenario. The third design tool was an 'inspection' based evaluation tool that assessed the selected or preferred conceptual design solutions from the previous tool. Iterations between these design tools took place until a detailed interface specification was complete. The design tools were tested in two large consumer manufacturing organisations. Although the design tools were found to be 'successful' in terms of affecting design decisions, they were not successful in terms of organizational acceptance.

We found that both design groups used in the study were continually competing against other related sub-groups with their respective organisations. This meant the design tools had to quickly suggest their capability in terms of problem solving, usability, adaptability, robustness (against scrutiny from other sectors within each host organisation), and

provide organisationally relevant outcomes to be successful. The design tools needed to provide support beyond their immediate functional purposes and support other auxiliary needs. For example, outcomes from design tools had to map easily to organisational reporting structures to improve their viability and competitiveness against other 'rival' information that was used for product development decision making.

Research community's perception of how to provide design knowledge

Second, we placed a heavy emphasis on developing *appropriate* delivery mechanisms for industrial designers to ensure their acceptance. The tools were underpinned by HCI research and cognitive theory and over a period of three years these tools were developed with strong involvement from the designers who were going to use them. This is in contradiction with the common assumption within the HCI research community that design methods development and implementation are separate research endeavours. For example, Sutcliffe and Carroll (1999 p 216) while commenting on 'reusable claims' - contextually sensitive design statements that suggest potential ways in which usability problems can be resolved, they state, *'The users of claims are intended to be software engineers, so another motivation for this research is to spread HCI knowledge beyond the community of human factors specialists; however, effective delivery of design knowledge is a research topic in its own right...'*. We would argue that the 'delivery of design knowledge' must be an implicit part of producing the design methods and can not be separated.

Venturing beyond conventional products and interaction styles requires commercial collaboration

Thirdly, during this study and through other related work carried out at the time, it became apparent that these new digital technologies, products and services do not inhabit a particular manufacturing or service domain. Very often these predicted or potential digital products cut across consumer product manufacturers, network providers, media and service providers. These are high risk ventures that require major capital expenditure and huge network infrastructures to provide the products and services product designers and researchers are developing.

A WAY FORWARD

At present we are currently in the process of developing a research studio at Huddersfield University. The primary purpose of this studio is to develop and evaluate future consumer products and interaction styles. Physicality will certainly play a part in our thinking. However, based on the lessons learnt from the work carried out before, it is intended that our approach will learn from the findings of my previous research. Work has already begun on developing an organisational consortium where each organisation has a vested interest in exploiting digital technologies in creative and potentially financially rewarding ways. We hope this will include some unusual partners – furniture manufacturers for example where aspects of physicality are obvious.

We also intend to focus our research in developing 'bespoke' design methods. Experience from the previous studies strongly suggests that generic design tools simply do not work. Design tools have to be specifically tailored to meet organisational demands and this has to be part of the design tool development process.

Finally, we hope to develop conceptual product development ideas that are based on high quality empirical evidence but also grounded in the commercial constraints and demands of the research consortium. In this way we hope that we can contribute tangibly to future innovative digital products that also have commercial credibility.

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Physicality, Spatial Configuration and Computational Objects

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ABSTRACT

This paper addresses physicality and the spatial configurational character of interactive technologies that are prevalent within HCI research. The primary issue being presented here is the inextricable link between the fundamental qualities of physicality and the spatial configuration of objects. Firstly, the question of what is meant by 'physicality' is discussed in terms of 'computational' and 'non-computational' objects, in which the importance of physicality's relationship with spatial configurations is described. Secondly, the impact interactive technologies can have upon spatial configuration—and thus physicality—is explored. Finally, the implications for design and HCI are very briefly considered.

Author Keywords
Spatial configuration, sensor technology.

PHYSICALITY AND SPATIAL CONFIGURATION

What is physicality? We can start with a simple definition: the physicality of an object is shaped by the physical properties of that object.[2] Tactile and visual senses primarily inform this; in the case of a mug, the shape and material form the essence of the immediate sensory experience. Somewhere above these immediate, low-level senses of the object lie concepts such as Norman's "perceived affordances" [6], which attempt to capture the nature of medium-level reasoning about an object's physical nature. Such notions consider all the perceived actionable properties of an object, such as how a thing is used as in the possibilities afforded by a mug's handle or a pen's clicker. There also is higher-level, non-sensory information that helps shape physicality, such as attributed or historical meanings and the aesthetic qualities of an object. For example, affordances and sensory data alone cannot inform someone how an object may be commonly used (e.g., musical instruments, religious objects, etc.), and as such one's historical experience or education about an object as well as a common sense, "what anyone knows" body of knowledge associated with an object both in turn further shape the experience of physicality. It is worth noting that this perspective on physicality is admittedly reductionist and abstracted and in that sense is most useful *as a metaphorical way of thinking* about physicality.

Why is it useful to understand what physicality is? Within the field of human-computer interaction, the physicality of objects that drive computation (namely, the physical manifestation of the computer, from the traditional mouse and keyboard to tangibles, handheld computers and mobile phones) differs from the physicality of everyday, non-computational objects. Computational objects have properties in addition to their sensable qualities, affordances and associated meanings and aesthetics. Some of these properties 'break' commonsense understandings of physicality. Computational objects have internal states that may change the resulting use of that object (the computational 'black box'), as well as interactive possibilities that are outside of the bounds of 'normal,' non-technological physicality (e.g., mobile phones and other objects that create action at-a-distance). (See [3] for a description of these properties.)

The physicality of computational and non-computational objects is, as has been hinted at already, intimately related to the spatial configuration of those objects in an environment and the spatial relations that exist between them. Here a couple of examples will be briefly turned to. Firstly we can consider the way in which knives and forks each have an individual physicality (e.g., the shape of them, their use in cutting or holding food, the historical use of knives and forks, etc.), and yet they also have a collected spatial configuration. There is a 'pairedness' and close proximity that is typically 'maintained' between knives and forks, such as in a draw or on a table. Knives and forks also have a particular relationship to other objects like the draw or the table. Umbrellas provide an instructive second example. They may reside indoors (on a stand) or outdoors, and have a configurational relationship with these outdoor and indoor spaces (i.e., the environment). It is of note that opening umbrellas indoors is traditionally thought of as 'unlucky' and thus it could be said that their use has

[2] By 'object' is meant things created by humans, rather than every possible object in the surrounding environment including plant matter, minerals and animals. Furthermore, in considering the properties of physical objects, a 'macro-level,' Newtonian sense of physicality as humans directly experience every day is assumed.

different meanings according to the different configurations they operate in spatially.

Leading on from these examples, spatial configurations can be thought about in similar terms to the way that we have thought about physicality. Configurations have an immediate sensory impact (e.g., visual, tactile). They also have particular spatial affordances or actionable properties, such as how a particular arrangement of objects may afford certain movement/navigation or uses of a space (such as thoroughfare). Finally, these configurations can have associated meanings and aesthetics, such as the configurational meaning of objects in a church (for example, the cross and easterly orientation of a typical cathedral, or the open-plan or cubicle layout of a place of work). Since spatial configurations are configurations of physicalities, the sense, affordances and meanings of both are deeply tied together.

Figure 1 attempts to schematize the various different aspects discussed here.

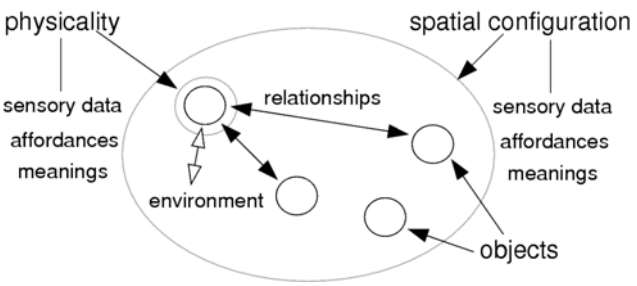

Figure 0. Physicality and spatial configuration

COMPUTATIONAL OBJECTS AND INTERACTIVE TECHNOLOGY

It is primarily the fundamental link between the spatial configuration of *technological* objects and the resulting impact upon physicality that is of interest in this paper. In order to understand how this change features for computational objects, we must consider technologies that have some link to the physical environment (i.e., the qualities of input and output).[3] This kind of interactive computational object is increasingly being included in mobile applications (such as games and tourist guides (e.g., [4,1]), museum and gallery interactives (e.g., [7,5]), and performances that are augmented or integrated with technology in some way (for many examples, see [9]). Technologies such as GPS, Wifi, ultrasonics, computer vision and RFID often feature in these examples. Such devices may have components embedded with physical units (e.g., PDAs or wearables) as well as those found in the environment (e.g., video cameras, GPS satellites, tag readers). These technologies often involve some form of instrumentation or sensing (e.g., sensing RFID tags, sensing the position of a fiducial marker, or sensing wireless network access points), and the appropriate interpretation of this data is typically vital to the function of the application it is driving. It is precisely when technology like this is placed in everyday environments ("in the wild") that their complex relationship with the environment and other computational and non-computational objects is exposed. These generated relationships are then essentially autochthonous in character and as such can only be studied within the setting in which they were intended for, designed for, or actually used in. The point here is that HCI can potentially be informed by the broad study of these environments and thus in turn come to be informed about the nature of computational physicality and configuration as it shapes our everyday experience of technology.

There are many examples of this changed configurational and physical character, such as the way in which GPS coverage varies over both time and space. Certain objects in a space (such as buildings in a city) create 'shadows' that obscure a GPS unit from a satellite, rendering the unit's position information unreliable or unusable. This spatial character of the signal reception as experienced via the GPS unit also changes over time as the movement of satellites affect the shadows' sizes and orientations [8]. Another everyday example would be a television remote. The sensors and emitters (i.e., infrared) for such a system require that the remote maintains a particular spatial configuration with the television, namely close enough to it for the beam to be detected (a 'pairedness'). Having a remote in a hallway when the television is in your living room does not make sense for its use; the remote might be said to be "in the wrong place," and thus its physical meaning is shaped by its spatial configuration with reference to other objects. There are further examples from the technologies previously mentioned, such as: patchy and irregular coverage for Wifi access points; sonic interference in ultrasonic positioning systems (e.g., jingling keys or coins); and computer vision suffering from occluded or noisy images, resulting in problems, say, detecting fiducial markers.

In understanding the impact of introducing such instrumented or sensor-based technologies into real world spaces, it is perhaps useful for designers and technologists to consider the 'superimposed' character generated by the interaction of spatial configuration between objects and the environment, as well as the changed sense of physicality of the objects. Use of these technologies particularly in ubiquitous computing contexts is creating wholly new spaces. Returning to our examples, the television remote's technology transforms it into a useful object and yet at the same time restricts its physical meaning by establishing a relationship with television itself, just as the GPS unit's meaning and usefulness is bound by its technological components, i.e., by its relation to satellites via

[3] Whilst a computer with no input (e.g., keyboard) or output (e.g., display) is still a computational object, it is not of interest here.

electromagnetic waves. So, whilst non-computational objects usually have their own configurational and physical meanings—such as an umbrella's relationship to the environment, or the pairedness of knives and forks—computational objects, or at least interactive technologies, have physicalities and configurations that can be deeply affected and shaped by their integral computational features.

DESIGN FOR PHYSICALITIES AND CONFIGURATIONS

How can we design for the changing spaces and physicalities presented by areas such as ubiquitous computing? What the previous discussion has suggested is that designers can employ a few strategies when dealing with configurations and physicalities in order to shape interaction. Considering, for example, the spaces and configurations of those spaces in which interaction is 'safe' or 'unsafe' may be particularly useful when working with sensor technology. The designer of interactive systems involving computer vision, GPS or ultrasonics for example, may wish to guide users around or away from spaces in which coverage is poor, or interference with sensors is possible. Alternatively the nature and structure of this 'safe' and 'unsafe' configuration and physicality could be exposed to users in a legible and reasonable way, instead of treating these as 'bugs' or 'glitches' to be avoided. This can be seen as being a 'seamful' form of design [2].

A challenge for the HCI community currently, then, is to further explore and document the real-world implications of physicality and spatial configuration upon the increasing use of interactive technology in performance scenarios, museums, galleries and other public spaces.

CONCLUSION

This paper has proposed that physicality and spatial configuration for arbitrary objects is intimately linked. Computational objects, particularly interactive technologies, change the nature of this physicality and spatial configuration. Primarily this paper has attempted to assert that design for physicality should also be about design for spatial configurations.

ACKNOWLEDGEMENTS

This paper was written with the help of Alan Dix and Holger Schnädelbach, and was inspired by work on the Journey into Space event, the details of which are located on: `http://www.mrl.nott.ac.uk/~str`

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Work Practice between the Real and the Really Made Up

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ABSTRACT
This paper can be read as a motivation to do further research in relation to the physical aspects of work practice. A brief survey of contemporary conceptual frameworks is carried out with a focus on how these frameworks grasp the question of materiality in relation to work practice. In conclusion, it is suggested that in regard to further research, it could be fruitful to employ a concept of practice that builds on the notion that we live between the real and the really made up.

Author Keywords
Physicality, materiality, artifacts and computer supported cooperative work.

INTRODUCTION
The description and analysis of work practice has long been a central research focus within CSCW, with its aim to forge computer support for cooperative work.

In regard to work practices, Schmidt and Wagner [42] describe them as historically specific practices, grounded in the use of material artifacts. However, for years mainstream CSCW have implicitly been preoccupied with face-to-face interaction and taken conversation as the arch model of human interaction, all other forms of interaction have been accounted for as improvised. The prime motivation behind this preoccupation has been the desire to forge technologies that can support cooperative work over distance modelled on the conversation paradigm [42]. The focus on the conversation paradigm we could suggest can be traced through out the last decade in the interest for "media spaces" (e.g. [17, 36]), "collaborative virtual environments" (e.g. [3, 6]), "Virtual work spaces" (e.g. [13]), "instant messaging" (e.g. [39]), etc.

Conversations over the telephone, in emails, in the meeting room, etc. are of course parts of cooperative work. However, in a number of cases cooperative work is coordinated and interactions takes place through artifacts rather that by direct face-to-face interaction or by other forms of verbal interaction [15, 41]. For example signs left or modifications made by individuals on artifacts, may feedback on themselves or others, and trigger new actions on the artifacts, that in turn may feedback: activities are (partly) recorded in artifacts, and this record is used to coordinate collaborative work. This is just one example of how cooperative work could be coordinated through artifacts.

If we divorce our selves from the preoccupation with "conversation" as the model of interaction in cooperative work, we can suggest that material artifacts play an important role in the contemporary cooperative work setting. It is the question of how to conceptualise this role that is at the heart of this paper. Perhaps at this point it would be timely to explicitly state the research interest of this paper: How can we conceptualise the simultaneously material and non-material (mental, psychological, cognitive) nature of work practice?

Of course this paper is far from the first attempt to address the material and non-material nature of artifact based practices in cooperative work in particular, or in human practice in general. A number of studies have been published over the years, as we shall see below. In the following we shall attempt to survey this research.

CONCEPTUAL FRAMEWORKS
In the resent years researchers within the research fields of CSCW and sociology of technology, have come to realize that material artifacts have a crucial role to play in the framing of human practice [1, 32, 41].

To begin with, ethnomethodologically informed studies demonstrated that material artifacts are key to the understanding of coordinative practices, they demonstrated the strong impact of material artifacts on human practice (e.g. [20, 21, 22]). Other ethnomethodologically informed studies pointed out how actors skilfully employ the affordances of the material work setting in order to articulate their cooperative efforts [24, 25, 44, 45].

More recently a variety of conceptual frameworks have been employed in order to account for the material and non-material nature of artifact based work practices. There has been a shift of conceptual framework, which can be observed in the increasing use of a number of theories such as 'activity theory' (see [29, 30, 38]), 'distributed cognition' (see [27, 28]), Gibson's concept of 'affordances' [18], 'actor-network theory' (see [8, 33]) and research inspired by phenomenology (see [12, 14, 40]). These theories are not only seen as providing a framework for CSCW and sociology of technology studies, they are also seen as bringing focus to the relationship of actors and material artifacts. The immediate question to be considered

below is: do these theoretical approaches capture the non-material relations (mental, psychological, cognitive) as well as the material (facts like diamonds are harder than wood) entangled in artifacts, at the same time, without putting one in a black box left unexplored?

Activity theory, as contemporary advocates of the framework understands it, does pay attention to the materiality of the context of human action. Take for example Bonnie Nardi, in the book "Context and Consciousness – Activity Theory and Human-Computer Interaction":

> "Activity theory (…) extend the concept of consciousness past an idealistic, mentalistic construct in which only cognitive resources and attention "inside the head" are at issue, to a situated phenomenon in which one's material and social context is crucial" [38, p.13].

Activity theory (as well as distributed cognition) diverges from other cognitive theories by incorporating the context of cognition [19, p.4], but does that include the materiality of the context, as Nardi [38] claims? In order to pursue this question, we shall have a look at the roots of activity theory and distributed cognition.

Contemporary activity theory and the subsequent theory of distributed cognition builds on L.S. Vygotsky a Russian psychologist and his successors Leont'ev and Luria's work initiated in the 1920s and 1930s. Vygotsky had an ambition to ground his theory in historically evolving and culturally specific material practices, inspired by Marxist theory [41, p2]. His ambition was undermined, however, by his concept of "psychological tools":

> "In the behaviour of man we encounter quite a number of artificial devices for mastering his own mental processes. By analogy with technical devices these devices can justifiably and conventionally be called psychological tools […].3. Psychological tools are artificial formations. [..] They are directed toward the mastery of [mental] processes – one's own or someone else's – just as a technical device is directed toward the mastery of processes of nature. 4. The following may serve as examples of psychological tools and their complex systems: language, different forms of numeration and counting […], writing, diagrams, maps, blueprints, all sorts of conventional signs, etc" [49].

The concept of psychological tool is fundamentally problematic in that it suggests that skilful action is somehow determined by stable or concrete mental structures (psychological tools), the concept downplays the dynamic and temporal nature of human mental processes and denies materiality a part to play [41, p3.]. This de-materialised and all encompassing definition of the concept of artifact has continued in the tradition of activity theory. Kuutti [31] to take one, list instruments, signs, procedures, machines, methods, laws, form of work organisation and even activity theory as examples of artifacts. Kuuti [31], in the tradition of Vygotsky, fails to make explicit the importance of materiality, especially in connection to the concept of artifact. A critique that applies to activity theory in general as it is advocated by Nardi [38], Kuutti [31] and Kaptelinin [30]. Distributed cognition does no better.

Distributed cognition uses the framework of classical cognitive science, slightly modified, in order to be applied to a unit of analysis that is larger than a person. Cognition, within the distributed cognition framework, is viewed as being distributed across a system of actors and artifacts localized in a historical and social context [26]. This framework, as contemporary advocates understands it, does pay attention to the material world. Take for example Hutchins [27]:

> "The examination of the role of the material media in which representations are embodied, and in the physical processes that propagate representations across media. Applying the cognitive science approach to a larger unit of analysis requires attention to the details of these processes as they are enacted in the activities of real persons interacting with real material media" [27, p.266].

Hutchins draws attention to the "details of these processes as they are enacted in the activities of real persons interacting with real material media", but on closer inspection material media or artifacts merely serve as vehicles of representations. That materiality plays a part is noted, but it is never explicitly and systematically explored. As Hutchinson describes the phenomena in connection with his and Klausens analysis of cooperative work in an airline cockpit:

> "We can see that the information moved through the system as a sequence of representational states in representational media. From speech channel to internal memories, back to speech channels, to the physical setting of a device" [28, p.27].

Further more, information seems to migrate unchanged form mind to artifact to mind, maintaining unity and identity (Schmidt & Wagner 2002a, p.3) across materiality, minds and time. The practice of producing and reproducing meaning is neglected - order is presupposed. As Schmidt & Wagner (2002a) observe, by presuming the practice of producing and reproducing order, what is to be investigated and understood is taken for granted, in line with the idealistic precepts of cognitive science, and artifacts are treated as vehicles of stable units of information [41, p.4].

Both activity theory and distributed cognition are both first and foremost, theories about cognition [19, p.3], and does not include the notion of materiality in a strong sense as we have seen.

Turning to Gibson's research and his influential concept of affordances [18], he describes the concept in the following way:

> *"The affordances of the environment are what it offers to the animal, what is provides or furnishes, either for good or for ill. […] It implies the complementary of the animal and the environment". [18, p.127].*

An affordance, as mentioned, points two ways, to the environment and to the observer. Gibson's concept of affordances have been instrumental in bringing focus on the importance of materiality in the conceptualisation of the relationship of actors and material artifacts, and in the process of accentuating materiality (of things and the human body). However, Gibson have been criticised for not accounting for the role that culture and learned practice play in regard to establishing what an artifact affords (e.g. [12, 16]).

Considering Actor-network theory (ANT) it does not as much mediate between (materiality and humanity) as negate the difference [12, 48]. The theory argues that it is analytically fruitful to reject any a priori distinction between elements in an actor network [2, 8], including the distinction between humans and non-humans.[4] The method employed in ANT analysis is to project a micro history of an actor network (of a technology rather than a society) that reveals the social character of changes in the material world and adds to this the material character of the physical components in the network (see [4, 7]).

If there is no trace of the human body in ANT (no distinction between humans and non-humans), it is at the centre of attention in the phenomenological tradition. In the phenomenological tradition the difference between humans and artifacts are explicit in terms of the notion of embodiment [40]. They embodied perspective emphasize that we do not observe the world in front of us, like a picture. We are in it [37]. However well the embodied perspective provides us with a lived through the body perspective, it is a perspective that seems centred on the individual; perhaps it does not provide any concepts that can fully account for interconnectedness of human practice [5, 47].

CONCLUSION

Summing up on the theoretical review above, we have proposed that Activity Theory and Distributed Coqnition leans towards a non-material account of the relationship of artefacts in humans practice, that Gibson leans towards de-culturising the relationship in his concept of affordances, and actor network theory negates the distinction of artefacts and humans, while lastly phenomenology lacks strong concepts that can account for any structural context that the actors acts in relation to. On this basis we could suggest that none of the conceptual frameworks considered above tells the whole story, in the sense that none of the frameworks seem to explicitly account for the entanglement of materiality and non-materiality in relation to work practice. Rather we could suggest that what they let us see and conceive of is patchy and incoherent, in the sense that there is no systematic and integrated approach to the simultaneously material and non-material nature of artifact based practice.[5] Consequently, by virtue of their partial character, the various frameworks treat as separate what is interconnected in practice; no rigorous system architecture can be built on this as a basis. We could suggest that this state of affairs is unsatisfactory and needs to be addressed. There is a need for an approach that leaves room for the material side of being in the world as well as the non-material (mental, psychological, cognitive) side of being in the world. This approach must build on an ontology that includes both. I will, following Taussig [46], claim that:

> "We live between the real and the really made up" [46, p.xvii].

Adopting such an ontology leads us beyond purely mentalist or purely materialist perspectives and includes the material side of being in the world as well as the non-material (mental, psychological, cognitive) side of being in the world. It does so in the sense that it employs on the one hand a "real" reality (physical facts like: paper is easily bend, stone is not) and on the other hand makes use of "the really made up", social and mental constructs that structure our lives (in a very "real" way) such as plans or work ethics. Neither the mental side of being in the world nor the material side of being in the world is given precedence at the expense of the other. The truly interesting part, for our purpose, is of course how these two "realities" interplay in human practices, such as shaping and using artifacts in cooperative work[6]. In the investigation of these questions, it could perhaps be fruitful to employ a concept of practice that builds on the notion that we live between the real and the really made up.

ACKNOWLEDGMENTS

The opinions of Kjeld Schmidt are gratefully acknowledged as well as the critical comments given by Lucy Suchman, Manuela Jungmann and Eva Hornecker. Further more I would like to thank the organisers of the Physicality 2006 Workshop for a job well done.

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[4] This quest for symmetry has created a lot of controversy around ANT (see Collins and Yearly, 1992; Callon and Latour, 1992).

[5] Please do not read this as an attempt to belittle the importance of the research mentioned above.

[6] Writing for instance, evolved in close connection with the development of writing materials (Harris 1995), the "real" the material side of reality and the "real made up" interplayed in the development of a practice of writing.

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Physicality in Tangible Interaction: Bodies and the World

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ABSTRACT
What is the role of physicality in the type of interfaces and/or interaction styles that is being referred to as 'tangible interaction'? It refers to the physicality of the user's body and the physical world. This position paper gives a short introduction into 'tangible interaction', denoting systems relying on embodied interaction, tangible manipulation, physical representation of data, and embeddedness in real space. It then introduces a framework that contributes to understanding the (social) user experience of tangible interaction (as well as to designing these), proposing four themes and a set of related concepts, and discusses the roles of physicality in this framework.

Author Keywords
Tangible interaction, physicality, body, embodied interaction, physical world, framework, design, analysis.

INTRODUCTION
Tangible User Interfaces (TUIs) and Tangible Interaction are terms increasingly gaining currency in HCI. Through embedding computing in the everyday environment and supporting intuitive use these approaches [5, 7, 9, 28] share goals with other novel approaches to HCI. Design here requires not just designing the digital but also the physical, as well as designing new types of interaction. There is still a need for conceptual frameworks, that unpack why 'tangible interaction' works so well for users [8], unpacking user experience aspects, and offering principled approaches for research and design of these new hybrid environments.

Over the last two years I have developed a framework, contributing to filling this gap [15, 16, 17]. It offers four 'themes' or perspectives on tangible interaction, highlighting different aspects of the user experience and interaction. These build upon results from numerous studies (researched from the literature) on human interaction within physical environments and with physical objects, underpinned with theoretic (or philosophic) argumentation lines from e.g. phenomenology, distributed cognition etc. Themes are explicated with 'concepts', which summarize single aspects or arguments. At a more detailed level, which is still in development, concepts are translated into design guidelines (or rather: inspiring and thought-provoking suggestions – they are meant to be selected as adequate and interpreted). The framework focuses on how tangible interaction supports social interaction, but also addresses the overall interaction experience. The question I'll focus on in this position paper (which has gotten a rather quick sketch in need to be outlined in more detail and care…) is:

What is the role of physicality in the type of interfaces and/or interaction styles that is being referred to as 'tangible interaction'?

The position I'm taking here is that it refers to the physicality of the user's body and the physical world. As written earlier, my framework contributes to the larger research agenda of Embodied Interaction [8, 22, 28]. With his book on Embodied Interaction, Dourish [8] gave the most notable push towards a theory of tangible interaction and of its interaction experience. Yet when he emphasizes how social action is embedded in settings, he focuses on social construction of meaning. Physicality is a central aspect of Embodied Interaction, although often ignored. Even when Dourish talks about embodied interaction, it seldom becomes clear what it means to be embodied – the human body is strangely missing, as well as the materiality of the world we interact with and live in.

A BROAD VIEW ON TANGIBLE INTERACTION
Increasingly, computing is moving beyond the desktop and 'intelligent' devices spread into all fields of life and work. As argued in [16, 17], we chose to use 'tangible interaction' as an umbrella term, drawing together several fields of research and disciplinary communities. This deliberately broad view encompasses a broad scope of systems relying on embodied interaction, body movement as interaction means, tangible manipulation and physical embodiment of data, being embedded in real space and digitally augmenting physical space. It covers approaches from HCI, computing, product design and interactive arts. From the characterizations found in literature, we can distinguish three views:

- *Data-centered view:* [8, 14, 28] define 'tangible user interfaces' as utilizing physical representation and manipulation of digital data, offering interactive couplings of physical artifacts with "computationally mediated digital information" [14]. This characterization of TUIs is dominant in HCI publications. Conceptual research from HCI and computer science tends to explores types of coupling and representations [13, 28].
- *Expressive-Movement-centered view:* An emerging 'school' in product/industrial design aims to go beyond form and appearance and to design interaction. This

view emphasizes bodily interaction with objects, exploiting the "sensory richness and action potential of physical objects", so that "meaning is created in the interaction" [7]. Design takes account of embodied skills, focuses on expressive movement and 'rich' interaction with 'strong specific' products tailored to a domain [5, 18]. The design community prefers the term 'tangible interaction'.

- *Space-centered view:* Interactive arts and architecture increasingly talk about 'interactive spaces'. These rely on embedding systems physically in real spaces, combining real space and real objects with digital displays or sound installations, [4, 6, 24], integrating tangible devices to "trigger display of digital content or reactive behaviors" [6]. Full-body interaction and use of the body as interaction device or display are typical for this approach.

Tangible interaction, as we understand it, encompasses a broad scope of systems, building upon and synthesizing these approaches from different disciplinary backgrounds. This approach includes tangible appliances or remote control of the real world [18]. It focuses on designing the interaction itself (instead of the interface) and exploiting the richness of bodily movement [5]. Interaction with 'interactive spaces' by walking on sensorized floors or moving in space [4, 24] further extends our perspective, the body itself being used as input 'device'. Taking this broad view, we can address this larger design space, interpreting these views as emphasizing different facets

A FRAMEWORK ON TANGIBLE INTERACTION

Theme: Tangible Manipulation

Tangible Manipulation refers to the reliance on material representations with distinct tactile qualities that is typical for tangible interaction. Tangible Manipulation is bodily interaction with physical objects. These objects are coupled with computational resources [28] to control computation. The main concepts, colloquially phrased, are:

Haptic Direct Manipulation: Can users grab, feel and move 'the important elements'?

Lightweight Interaction: Can users proceed in small, experimental steps? Is there rapid feedback during interacting?

Isomorph Effects: How easy is it to understand the relation between actions and their effects? Does the system provide powerful representations that transform the problem?

Theme: Spatial Interaction

Spatial Interaction refers to the fact that tangible interaction is embedded in real space and interaction therefore occurring by movement in space. The interfaces take up space and they are situated in places. Interaction with spatial installations or interactive spaces can be interpreted as a form of tangible interaction that is not restricted to moving objects in space, but relies on moving one's body. The main concepts for Spatial Interaction are:

Inhabited Space: Do people and objects meet? Is it a meaningful place?

Configurable Materials: Does shifting stuff (or your own body) around have meaning? Can we configure the space at all and appropriate it by doing so?

Non-fragmented Visibility: Can everybody see what's happening and follow the visual references?

Full-Body Interaction: Can you use your whole body?

Performative Action: Can you communicate something through your body movement while doing what you do?

Theme: Embodied Facilitation

Embodied Facilitation highlights how the configuration of material objects and space affects and directs emerging group behavior. We literally move in physical space and metaphorically in software space. Tangible interaction embodies structure and thereby styles, methods and means of facilitation. We can learn from facilitation methods how to shape physical and procedural structure so as to support and subtly direct group processes (for details see [16]). The main concepts are:

Embodied Constraints: Does the physical set-up lead users to collaborate by subtly constraining their behavior?

Multiple Access Points: Can all users see what's going on and get their hands on the central objects of interest?

Tailored Representation: Does the representation build on users' experience? Does it connect with their experience and skills and invite them into interaction?

Theme: Expressive Representation

Expressive Representation focuses on the material and digital representations employed by tangible interaction systems, their expressiveness and legibility. Often hybrid representations combine material and digital elements, each with distinct representational qualities, In interaction we 'read' and interpret representations, act on and modify them. Here the main concepts are:

Representational significance: Are representations meaningful and have long-lasting importance? Are physical and digital representations of the same strength and salience?

Externalization: Can users think and talk with or through objects, using them as props to act with? Do they give discussions a focus and provide a record of decisions?

Perceived Coupling: Is there a clear link between what you do and what happens? Are physical and digital representations seemingly naturally coupled?

On the Framework

The themes and concepts summarize our experiences from system assessments and reflections on design, in combination with a literature review on the use of material artifacts in social situations, distilling a set of social affordances [15], synthesizing previous works of other researchers and concepts developed by us.

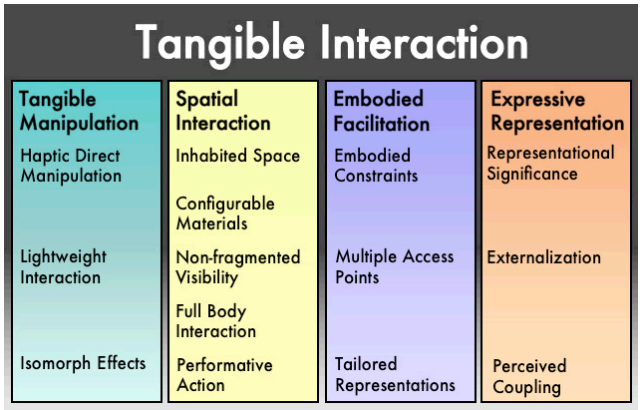

Figure 1. Tangible Interaction Framework with themes and concepts.

Tangible Manipulation is the most specific theme, relying on the use of material objects. It applies best to systems usually referred to as tangible interfaces [28] and tangible appliances. *Spatial Interaction* and *Embodied Facilitation* provide insights relevant for the broader research area of 'embodied interaction' [8], where movement in space and physical configuration of computing resources are central characteristic, e.g. mobile interaction and ubiquitous computing. *Expressive Representation*, insofar as it concerns tangible representations, is specific to tangible interaction, but can be generalized to mixed reality representations.

FINDING PHYSICALITY

Physicality turns up in all four themes, and usually concerns the interrelation of physical bodies (users) and objects respectively the physical world in general.

In *Tangible Manipulation* physical interaction is central. Our tactile sense is in fact multimodal, as on touching something a whole battery of sensors and nerves fires, feeling resistance, temperature, surface quality, softness, weight and more. The word tangibility itself refers to the specific double-side characteristic of the sense of touch, that one cannot touch something without being touched oneself, being active and passive at once [2, 19]. Touch is our only active sense, which is not purely receptive. The tendency of western philosophy to take vision as our primary or highest sense, has led to looking down at touch (similarly on smell) as a lower sense, claiming that it does not allow for abstraction and detachment. Yet perhaps: "Hands are underrated because they are poorly understood" [20] (see also the grandiose voyage into the anthropology, psychology, and mechanics of human hands from Wilson [30]).

From an anthropological viewpoint (or phenomenological) [2, 11, 19], the sense of touch reminds us that we are embodied beings and forms the permeable border between outside and inside, enabling our primary experience of the world. Touch reassures us of our existence – e.g. people who have lost their sense of touch feel like dissolving, and mental-cognitive development and health of children depends on human touch. But, because touching something always brings us in close (and potentially dangerous) encounter, it is deeply emotional – the aesthetics of touching something have immediate emotional responses.

With the theme of *Expressive Representation*, physicality is the least salient. Still, physicality can be considered as one means of expressiveness – materiality provides an endless array of properties for an object [25], such that e.g. the weight of a tangible object being used suddenly influences how it is used and interpreted (something very surprising for system developers 'grown up' with computers, who are used to think of objects as only referentially representational). The physical properties of external representations are read and reacted upon just like their symbolic ones.

How does *Spatial Interaction* relate to physicality? We may think of space as abstract and non-physical. Yet lived space in fact is physical. We cannot escape spatiality - we are spatial beings; we live and meet each other in space. The graspable objects of TUIs exist in this "real" space that we live in. "People and physical space are made of the same stuff, but people and virtual space are not", as Toni Roberson notes [23, p.308]. Physical objects are experienced as part of real space, which is not abstract, geometrical space, but a habitat filled with life [29]. Phenomenology talks of situated space, which receives orientation from an embodied HERE [21, 29]. Because we are spatial beings, our body is the central reference point for perception (defining e.g. what is HERE). Movement and perception are tightly coupled and we interpret spatial qualities (or e.g. the positioning of other objects) in relation to our own body. Spatial relations therefore have psychological meaning and effect our perception of a setting. Real space is always *inhabited* and situated, becoming *place* [6, 12]. By inhabiting space, we appropriate it, interpret it and give it meaning.

Physical company of people and objects makes their presence noticeable and vivid. We *encounter* objects and people in space. They have material/physical presence (demanding our attention) - we meet them face to face, feel their (potential) resistance to our actions. Some philosophers, in particularly those in phenomenology, talk of people emitting an atmosphere like an aura, making us resonate [3, 29]. Social effects of *sharing space* are intimacy, social nearness and a higher tendency to cooperate. When sharing physical space we enter a

reciprocal situation where seeing implies being seen [22, 23]. This creates both vulnerability and trust [29]. Visibility furthermore contributes to account-ability [22], because it implicitly requires vindication of public action.

One of the concepts explicating spatial interaction is performative action. In the foreground of performativity is the users' body as the means with which one represents oneself. Movement expressiveness [18] and unescapable individuality are relevant here. Our body is the thing we cannot escape from (or only partly, with avatars and face lifts). The physical world takes part in this performance, as the stage acted upon, in form of props that take a role in the performance, in setting the constraints for acting.

In *Embodied Facilitation*, again, physicality implicitly is central, by moderating the interaction of physical bodies in physical configurations of space and objects. With tangible interaction we act (or move) in physical space and in system space (software). Software defines virtual structure, determining interaction flow. Physical space prescribes physical structure. Both types of structure facilitate, prohibit and hinder some actions, allow, direct, and limit behavior, determining usage options and behavior patterns. E.g. the size of a table in combination with our bodily size moderate how much of the table we can reach and touch. The number of pens provided to a group determines whether these need to be shared for an activity, and even the size of pens may make a difference in terms of how easily they can be shared or hidden for private use. If we could easily overcome the constraints proposed by these physical configurations, they would be powerless and not perform the role of embodied facilitation. We even react to such signs in virtual worlds (e.g. people trying to avoid running into other avatars or walking around the virtual gap in the floor instead of across it) as we still tend to interpret them in relation to our physical body.

ACKNOWLEDGEMENTS

Geraldine Fitzpatrick, John Halloran, Paul Marshall, Mark Stringer and all other members of the Interact Lab contributed to various drafts of papers on the framework, discussed about it and gave feedback to talks. Jacob Buur encouraged and mentored the development of this framework. This work was financed during the last months by the Equator IRC GR/N15986/01.

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Beyond Physicality: Towards a Phenomenological Approach in the Design of Embodied Interactions

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ABSTRACT
From the point of embodied interaction in ubiquitous computing, physical engagement has mostly been operating within the already mastered context of the physical world. This paper makes a point to include phenomenological concepts into the design of applications in ubiquitous computing to push the boundaries of embodied interaction into an exploration of conscious life. The paper looks at some of the concepts of Merleau-Ponty's embodied phenomenology, as the philosophy/ psychology community has understood them. It draws on these and relates them to a more contemporary phenomenological approach which centres on a praxis called reduction. Here the paper identifies points for possible connective links to the design of phenomenological embodied interaction. It recommends for future work a more detailed investigation into the points established by this paper.

Author Keywords
Embodied Interaction, Phenomenology, Merleau-Ponty, Consciousness, Interdisciplinary

INTRODUCTION
This paper looks at physicality from the point of embodied interactions. Humans interface through their senses with the physical world; they interact with nature and human artefacts accumulating experiences in this interfacing process. These experiences inform the possible relationships that can be created with others, with material content, and with the person's sense of self [6]. In embodied interaction, the body physically delineates the manifested, perceptive world from the inner world which encompasses thoughts, mental acts, and emotional states. Yet, it is through the body's interaction that both can be drawn together, and therefore making the actual experience between inner and outer inseparable [2, 5, 8].

Embodied interaction as an approach to design technologies in ubiquitous computing takes the notion of embodiment, the acting, physical manifestation in the here and now, as the central idea. Tangible computing draws on the concept of embodied interaction in its analogy by utilizing skill sets that are inherent to the physical world. Similarly, social computing takes into account the situated perspective in which social action is performed [4]

Until now, the study of embodied interaction within the framework of ubiquitous computing has centred on the development of environments that are reactive to a user's presence, as well as interactive through the expression of the user's gesture-based interaction with technology.

In other cases the approach has been product-based [7], where existing artefacts or concepts thereof have been augmented with ubiquitous technology. In both cases, the engagement through embodied interaction is relatively conventional, relying either on sensing the context of use or interpreting tangible manipulation of objects. The integration of body, mind, and technology is rarely fully exhausted.

Embodied interaction as it has been understood in ubiquitous computing can be divided into levels of integration of body, object, and social engagement:

a) Centres on the object to be manipulated e.g. tangible interfaces such as Equator's Pin&Play [10]

b) Centres on other people's input into the system e.g. games such as Equator's Seamful games [1]

c) Centres on one's own body e.g. gesture recognition, predictive, reactive systems such as Equator's Headracer wearable [7]

In these mentioned cases, coupling technology with embodied interaction known from the physical environment recreates the grasping of worldly content within similar boundaries, centred on goals and worldly attention. Technology here has the potential to give rise to knowledge beyond the acquired, embodied knowledge, by exploring relationships that are more intrinsically focused on the body and mental awareness. Introducing phenomenological concepts could create opportunities that could characterize anew the embedded existence of physicality and consciousness further than what is known from the interaction with the purely physical world.

THE PHENOMENOLOGICAL APPROACH
The intent of this paper is to focus on selected phenomenological concepts of embodiment.

[7] http://ubicomp.org/ubicomp2005/programs/demos.shtml

Phenomenology is a vast area that cannot be tackled within the scope of this paper. Therefore I will construct some relevant concepts and then relate them to a possible intersection in the design of embodied interaction. Ubiquitous computing builds on the skills acquired through embodied interaction with artefacts and the environment. The phenomenology of embodiment reflects on how bodies interact in their environment, and could thus inform the design process in ubiquitous computing.

The phenomenologist Maurice Merleau-Ponty proposed that a human's fundamental knowledge of the world comes through exploration, and knowledge and understanding of the world is derived through embodied action [9]. In that, the body requires to be open to the world in three ways [5]

- The body's physical shape and its innate capacities.
- The perpetual refinement of skills when interacting with things and the environment.
- Acquired cultural skills that relate to cultural customs and the body's expression within them. For example, sitting in a chair versus on a cushion on the floor is determined by cultural developments and the body's capacities.

From this basis, Merleau-Ponty investigates the origins of perceptual knowledge and consciousness. His premise is that from co-existing with the world, humans attain the primary meaning of it. In other words, the body through its worldly activity evokes meaning; it does not find meaning pre-existent in the world [9]. Furthermore, the body coalesces with time and space creating consciousness as the capacity to act- what Merleau-Ponty referred to as the "I can" [5]. He differentiates embodied action into reflexive thought and pre-reflexive thought. Reflexive thought is consciously aware and pre-reflexive thought operates below the level of conscious awareness [9]. Herbert Dreyfus [5] elaborates on the five stages of adult skill acquisition, how reflexive thought, the conscious engaging with new material evolves to pre-reflexive thought, the unconscious, habitual thought of the expert. A few examples from his discourse focusing on a chess player will follow to illustrate these concepts.

Dreyfus states that the novice, and therefore the first stage, plays slow, trying to remember all rules and their priorities. When reaching the second stage, the advanced beginner, the former novice, has gained experience and learns to recognize over-extended positions and how to avoid them. In the third stage, the competent player's involvement in the task becomes increasingly emotionally charged, and at the same time it becomes increasingly difficult to adopt the detached rule-obeying stance of the beginner. Further, the competent player decides for him/herself what plan to choose without being sure that it will be appropriate in the particular situation. In the forth stage of proficiency, a large repertoire of types of positions can be recognized. Almost immediately and without conscious effort can he or she sense his or her position in the game and calculate the next move to achieve a specific goal. In the last, the expert stage, the player moves at a speed of five-second-a-move and depends with his or her approach on intuition. Unlike the proficient player who sees what needs to be done and then decides how to go about it, the expert moves beyond analysis and comparison of alternatives. Dreyfus explains further that if the expert responds to each situation as it occurs, and which has proven successful in the past, his or her behaviour will achieve the past objectives without having these objectives as goals in his conscious or unconscious mind.

This spectrum of stages renders vividly the evolutionary path of reflexive thoughts to pre-reflexive thoughts, which are part of what Merleau-Ponty has termed the intentional arc. Though this is illustrated on the example of chess playing, learning to engage with most things will follow the course of perpetual refinement, where the notion of habitual thought and judgement are underlying. Embodiment connects to mental activity, such as a game of chess, in that it enables the person to perceive the visible, and respond to the situation using the body as vehicle. Perception of the visible commences the exploration of things. As the visible unfolds it becomes consolidated in the body along the extension of time [9]. Over time, past-sensory and affective experiences form the structural foundation, in which pre-reflexive thought is anchored. Together with the intention towards future explorations, they map out what is to come. Essentially the way a person copes in a certain situation of activity origins from perception as opposed to being consciously imposed [9].

CONTEMPORAY PHENOMENOLOGICAL PRACTISE OF ACHIEVING AWARENESS

Contemporary phenomenology highlights equally the relationship between reflexive and pre-reflexive thought, where the focus of embodiment is not explicit but lies in the pragmatic approach. The praxis of so-called phenomenological reduction, a "reflective act" has been developed with the aim to tackle directly, by practical implementation, the description of phenomenon as a method of exploration of conscious life [3]. The relevance here is that phenomenology tends to be of a theoretical dimension even though it could be considered on the pragmatic side of philosophy. Making it applicable entails successive abstraction, which is often left to those who seek to implement it.

The main interlinked and self-recycling phases in phenomenological reduction are [3]:

a) Suspension of habitual thought and judgement

b) Conversion of attention from "the exterior" to "the interior"

c) Receptivity towards the experience

One of focal points for this paper is the suspending attitude of habitual thought and mental acts for the purpose of

identifying points of departure to link to design goals. A suspending attitude towards a known activity and the following immersion (phases B and C) produces a quality of the interior state that moves beyond the kind of awareness attributed earlier to reflexive thought. And yet, similarly, attending to one's own mental acts, which coordinates acting on the world, is a learned process that could be induced otherwise, for example through technological means.

According to [3] a suspending move can be motivated, not necessarily initiated, but can unfold in the course of action through:

a) An external event as trigger

b) The mediation by others as role model

c) Exercise initiated by the individual

Beyond the dynamic components of phenomenological reduction mentioned above, the entirety of the approach extends further to "expression and validation", the communication of the acquired knowledge, and the "temporality" of the act of becoming aware [3].

POSSIBLE INTERSECTION BETWEEN EMBODIED PHENOMENOLOGY AND INTERACTION

I now want to highlight where in phenomenological reduction the areas are which could influence the design of applications. From the greater picture inwards, the "expression and validation" component becomes significant for practical exploitation. What has been gained from the *applied* "reflective act", let's say the result, could be communicated back to the application and treated as part of user input. Obviously that result has to become known to the system in the first place. Measurements that analyse the quality of interaction between user and application over time are a conceivable suggestion. If, for a moment, we go back to the example of the expert chess player, the speed of interaction, the five-second-move, could be seen as one evolved measurement yet it becomes meaningless without other measurements that have also matured with the user over time. Technologically, this could well be a system that operates on artificial intelligence, where the evolution of the user is transmitted to the system determining in due course input demands and output solutions. However, more crucial is the type of trigger that would correspond to the "external event as trigger" aspect in order to move the user into the direction of the "reflective act". For the moment, that investigation would represent future work and more analysis in phenomenology is needed to understand the breadth of such a trigger. What can be said for now is that the trigger needs to infiltrate the user's action, shifting him or her from the object to the "act", in order to evoke a change of attitude. The points of possible influence for design should be seen in the context of Merleau-Ponty's three-way openness of the body mentioned earlier. They represent a metaphorical envelope in which a given reflexive and pre-reflexive thought can exist and which I will illustrate in the following example. The body's physical capacity is to sit cross-legged on the floor. In Western custom bodies sit on chairs rather than cross-legged on the floor, and sitting on the chair is also part of a body's physical capacity. The act of a person, their reflexive and pre-reflexive thoughts are embodied in these situations and the earlier mentioned "external event as trigger" from phenomenological reduction should operate under these conditions. Incorporating phenomenology as a genre into the design of embodied interaction is to create technologies that are open-ended where the user arrives at insights about him or herself. The phenomenological influence on design is not seen as a method for designers to sample a user's experience, it is seen as way to design technologies where the goal is in and of itself to create phenomenological experience for the user. Naturally, these are specific applications within the context of embodied interaction, and ideally constructing a framework on the basis of some of the points made in this paper could be the next step to staking out the design space.

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Music, Physicality and the Physiology of Listeners

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ABSTRACT
Music affects listeners, but we are just beginning to understand what happens physically and neurologically when we are exposed to music. In our research, we are exploring the physiological changes brought on by listening to music and trying to understand the connection between various musical features and observable physiological changes in listeners. Areas as diverse as health, computer games, and industrial safety systems stand to benefit from a deeper knowledge of the music-physiology connection, and with a deeper knowledge, many new applications based upon the physical aspects music listening can be developed.

Author Keywords
Music, Physiology, Physicality

SOUNDS AND BODIES
Music and physicality are concepts not generally considered together, but the musical experience contains many very physical aspects. Control over breathing and finger movements, for example, is a required part of playing a brass instrument. A feedback loop forms between the sound and performer via the response of instrument. Performance, response, refinement. The sound informs performers and enables them to make physical changes. We can build on the physicality of the musical experience to create new types of musical interactions and musical interfaces. For example, music can function as an auxiliary aid for physical training as in Digiwall, a full scale interactive, sonically enhanced, (rock) climbing wall developed by the Interactive Institute in Sweden. [1] However, there are also many less conscious but similarly physical aspects of music, and the physical component of music extends far beyond motor control. Music's affects listeners. There are centuries-old folk traditions that utilize music to cure or induce various mental states, but we are just beginning to understand what happens physically and neurologically when we are exposed to music. Some musical affects are readily apparent, for example, a loud sound or alarm can trigger a startle reaction or adrenaline rush. But, what about less dynamic, less survival related responses? Current research indicates that auditory stimuli of different kinds can induce a variety of physiological changes. Recent results suggest that music stimulates a variety of physiological and neurological responses, and potentially has an affect on the autonomic nervous system. [2-7] The autonomic nervous system, including the sympathetic and the parasympathetic systems is known for its affect on several physiological parameters, such as heart rate, blood pressure and breathing. In our research, we are exploring the physiological changes brought on by listening to music and trying to understand the connection between various musical features and observable physiological changes in listeners. This is a complex relationship, as music cannot be wholly disassociated from various, not strictly perceptual, mental affects that may subsequent impact the physiology of the listener. Just as bottom-up perceptual process shapes what we hear, high-level cognitive processes also impact musical perception. Attention, emotion and preference are all factors that need to be considered when studying the relationship between music and physiology.

INVESTIGATING MUSIC AND PHYSICALITY
To probe deeper into the connection between the music we hear and its physiological impact, we must take a musically sophisticated approach. Musical features may be described in many ways and saliencies may vary amound listeners. Therefore, it is necessary to relate specific musical features and changes of observable physiological responses. Currently, however, much of the research within this field relies on commercially produced, stereo recordings. These recordings are frequently selected by the experimental designer and usually have characteristics that are believed (a priori) to be associated with a specific physiological state. For example, experimenters investigating relaxation often use harmonic, melodious music with low tempo in their experiments. Not surprisingly, results are inconsistent. Some studies report significant changes in various physiological parameters, whereas others report no observable physiological change.

This established approach for linking the physical and physiological to auditory stimuli is problematic in several ways. For one, listeners parse an auditory scene shifting attention among various features, instruments, sound events, etc. To understand the affect we need to track listeners' attention. Complicating matters further, listeners' prior musical experiences, their preferences and biases, may also have an impact on what is attended and its subsequent affect. It is important to note that this complexity exists whether the musical experience related to physical, motor control or involuntary physiological change. Current music

technologies allow us to be more pragmatic when connecting musical stimuli with the listeners' responses. In our work, we strive to correlate the affect to particular stimuli features and modes of processing as much as possible.

We have developed a software application that helps us to correlate physiological data with features of individuated musical parameters. This system includes sensors monitoring and recording different physiological parameters in listeners. It also has the functionality to synthesize the musical stimuli, in real time, according to custom specifications for each experiment. The features of the musical stimuli are variable through adjustments to individual musical parameters, such as tempo, instrumentation and rhythmic complexity. The system tracks real-time changes made during synthesis and preserves them in symbolic representation (MIDI-data) for later re-synthesis or analysis. As the music is rendered, the physiological readings are recorded and synchronized with the musical stimuli. During an experiment, different musical parameters may be modified in precisely measurable increments, and correlated to physiological readings associated with each version. The experimental designer defines the musical parameters a priori. In this way, we gain enormous control over the stimuli and have readily available, strictly controlled variations of the same basic, musical material. As needed, we are also able to give the subject control over the musical parameters themselves allowing them to optimize the stimuli to meet their preferences, or modify the stimuli to match a specific target feature.

We feel that this parameterized approach deals more realistically with the complex nature of musical signals, gives us greater control over the experimental setting, and leads to stronger correlations between stimuli and observed physiological response. The functionality of the software alone is not sufficient for teasing apart the complexity of the music-physiology relationship. Since it is unlikely that we will find a 1:1 relationship between features and physiological change, we are looking towards identifying combinations of sensors/physiological signals that can provide a snapshot of the listeners' physiology and insight into significant changes. Because our experimental scenario is non-medical, we must also consider what kinds of data can be collect easily while the subject is exposed to the stimuli, and tightly correlated to features in a musical signal.

APPLICATIONS

Through our research, we hope to identify physiological functions that are responsive to changes in musical stimuli and draw correlations between perceptual responses (or attributes of the auditory system) and observed physiological responses. We hope to apply our findings to the development of new music technologies and interactive scenarios expanding our possibilities for musical expression and use. Areas as diverse as health, computer games, and industrial safety systems stand to benefit from a deeper knowledge of the music-physiology connection, and with a deeper knowledge, many new applications based upon the physical aspects music listening can be developed.

Recent clinical studies have tested the efficacy of music to reduce pre-operative anxiety [8-9], but better knowledge about how music is perceived by different people and what physiological reactions result would help us to design, better musical stimuli for these kinds of experiments. Furthermore, these findings would inform the design of new, assistive music technologies that connect listeners to their physical and/or physiological state, for example, an intelligent music player that able to select music according to the users' current and target state. Similarly, in industrial settings, responsive music systems may provide new mechanism for monitoring. Such systems could not only provide feedback about a listeners' state but might also help to regulate it.

In entertainment, in computer games, the visual display is seen as the primary feedback device. We have only just begun to tap into music's utility as a vehicle for storytelling, creating convincing atmospheres and inducing moods in these sorts of interactive environments. Additional potentialities exist. Physical challenges can be connected directly to music and sonic feedback expanding not only the role of music in the gaming paradigm but introducing new types of games. Whether it be in health, industry or entertainment, as we gain a deeper understanding of music's affects on us we are better enabled to use the music in a more potent and evocative way, increasing the listener/players' involvement in stories, games, or directed activities.

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Interaction with the Physical Aspects of Visual Displays

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ABSTRACT
This document proposes a simple two-dimensional categorisation of interaction with visual displays. The two aspects it concentrates on are: interaction with the display surface and interaction with the physical display itself in terms of movement and orientation. For both types of cases, possible digital and physical effects are considered. This leads to the suggestion of visual displays the physical properties of which can adapt. It is suggested that this can be used as a form of information output and as a means to accommodate interaction with them as well as social interaction among their users.

VISUAL DISPLAYS AND PHYSICAL INTERACTION

Visual displays are a fundamental part of most computer systems. Although computers frequently output information via audio and sometimes via other channels as well (e.g. force feedback), visual displays are clearly the most frequently used output devices. Visual displays can be categorised along a number of different dimensions. For example, Milgram et al describe them according to their usefulness for various Mixed Reality applications [6]. Alternatively, a categorisation might be based on their physical properties as those arguably have an effect on interaction with them. Display size is probably the most obvious relevant property, where an individual handheld PDA display affords very different interaction from a wall-sized shared display at the stock market for example. Flexibility in terms of location is also relevant. Larger displays tend to be fixed in place and interaction will differ from that with a mobile device.

It might be argued that the categorisations above discuss visual displays in terms of their properties as output devices and this is further confined to their output in terms of the digital content that they display. This document is mainly concerned with visual displays as *input* devices. Two separate issues are of concern here. Both are related to the physical properties of the display: interaction with the display surface and interaction with the display itself in terms of its orientation and position. Feedback to this input will be considered in terms of digital output, output on the display surface and regarding the display's orientation and position.

The following considerations are limited in a number of ways. Only single display devices are of concern. Also, other devices that might be associated with a display (e.g. buttons associated with a particular display such as with an ATM) will not be discussed. Finally, displays are defined here as those that are capable of displaying digital content visually.

Interaction with the display surface

Through the application of touch screen technology, interaction with the display surface on portable devices is now common-place. Technologies such as the HoloWall among others allow interaction with larger and projected

Touch screen	HoloWall	Priva-Lite	Rain Curtain

Figure 1 Interaction with display surfaces

visual displays [5]. In both cases the technology is aimed at enabling users to manipulate the digital material that is being displayed.

There is also a class of display devices that can change physically with interaction on their surfaces. One example is the Priva-Lite Glass product that changes its transparency with the application of different electrical currents [7]. In its translucent state it can be used as a projection surface. In its transparent state it is unusable as a visual display surface but provides access to the area behind it. In addition, more ephemeral materials such as water and fog can be used as projection surfaces and are also adaptable [4] [2]. Interaction with such displays can have direct effects: the surface will be broken with no projection possible in the area that is interrupted.

Interaction with the display itself

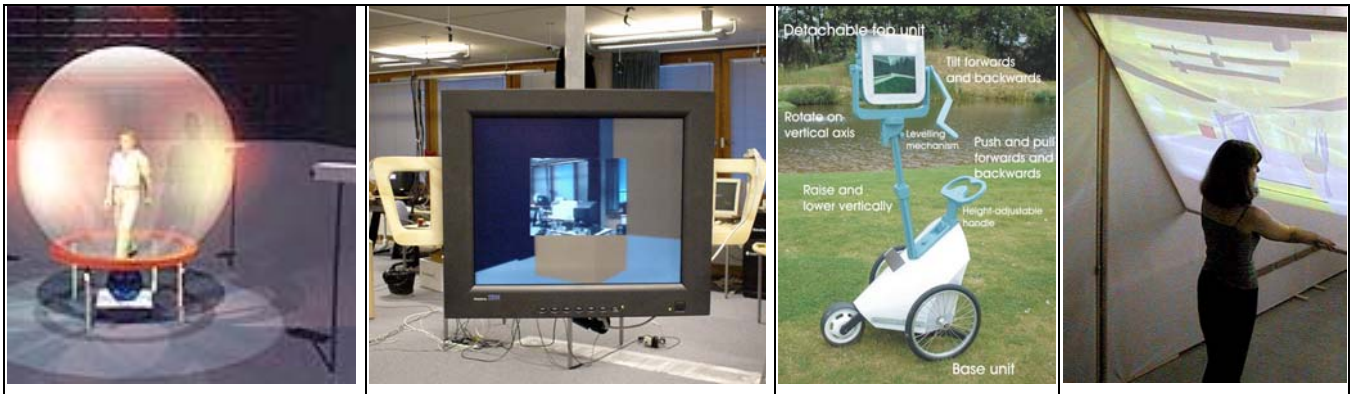
Various sensor technologies have also allowed visual displays to be used as input devices in a different sense. Their physical orientation and position can be tracked and translated into changes to digital content. Examples include the Cybersphere, a projected spherical display that users enter and walk within and the Periscope, a ceiling mounted display used to explore virtual environments [10] [1]. There are also a number of examples that are mobile. These include the Augurscope, a shareable mixed reality display for outdoors, among many others [8].

with an additional set of interface technology. Moving the physical display re-configured the space it was located in. Recent work at Nottingham with Mixed Reality Architecture has now demonstrated the effect of the presence of displays in a particular space in more detail. The nature of the space itself changes (e.g. adding the properties of a corridor to an office space) and the movement patterns within a space change (e.g. people enter a space because of the presence of a person who appears on a visual display located in that space). Moving such displays can therefore physically re-configure the space and re-configure it in terms of different types of interaction that are possible within it.

CHANGEABLE PHYSICAL PROPERTIES OF VISUAL DISPLAYS

The above arguments have then prompted another look at the role of visual displays as output channels. As stated in the introduction, visual displays are mostly considered in terms of their digital output. But, it is also conceivable that displays could be constructed that adapt their physical properties, or change their physical location and orientation automatically. This could be used as a form of information output, or it could be used to accommodate certain types of uses.

One such example would be a water or fog display that changes material density or colour as a form of information



Cybersphere	Periscope	Augurscope 2	Traversable interface

Figure 2 Interaction with display position and orientation

There is also a group of visual displays, where the interaction with the display can be described as having physical effects. These effects are concerned with the position and orientation of displays in relation to other features in the environment. Traversable interfaces were developed to simulate the effect of stepping from physical space inside virtual space [4]. In practice they consisted of a series of prototypes of projection surfaces that could be moved physically to allow access to an area behind them

output (a change on the display surface). Another example would be a robotic Augurscope-type device that would automatically reposition itself to alert users to interesting physical areas (a change in the position and orientation of the display). Of course, these new types of physical output could still be combined with the existing forms of digital output as discussed above. Related to this, but going beyond the functionality of just an output device, physical changes to visual displays could also be used in a different way.

Recently, flexible display technologies have appeared [9]. More common are projection screens that are motorised and fold away when not required and the Storytent demonstrator has explored a projection surface the shape of which can be changed by users [3]. It is therefore conceivable that visual displays could be constructed that expand and contract in response to certain outside influences. An example might be a small display sufficient for a single user which expands to a larger size once a group of people is detected interacting with it.

ACKNOWLEDGEMENTS

Thanks to Stuart Reeves for his input to this document and the EPSRC for their support through the EQUATOR project.

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Physicality and Something Else It's Associated with

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ABSTRACT
Physicality of today's technology devices offer more than just their appearances which give richer interactions to users. Mapping and feedback that associate to physical artefacts create a broader meaning and understanding. In this paper we would like to highlight the nature of mapping that exists in the relationship between artefact and its logical function, and the form of feedback that varies from one artefact to another. We believe these both notions are crucial in creating a natural interaction.

INTRODUCTION
In pre-technology times where physicality was understood just as it is, based solely upon its physicalness; the interpretation of what it is, or what we are supposed to do with it, depended heavily on its physical-bodily appearance. Then as now interpretation may be assisted by our understanding of physical attributes – directness, locality, and visibility [4], and may also be explicated by an understanding of affordances, be it by Gibson's interpretation [6], or Djajadiningrat et al.'s creation physical meanings [1].

But the way we now understand physicality, especially of artefacts, has evolved significantly with the invention of mechanical and electrical devices, objects, apparatus, and appliances. With these kinds of artefacts, our understanding of physicality has gone beyond that just one thing, i.e. the appearance of physicalness, as these artefacts now have something else associated with them, and at most of the time, they have designed purposes. And these are also true for almost every single computing device we see today.

In this position paper, we would like to focus on the associations that current physical artefacts now encompass, which gives a broader meaning and understanding of physicality.

MAPPING AS PHYSICALITY'S ASSOCIATION
If we take a light switch for instance, the physical state exposes itself as a surface that invites us to put our finger on and exert an action by pushing it up and down (or left and right). Switching between these two physical states wouldn't be a meaningful action to us if the switch does not associate or map the action exerts on its physical states to its logical states – on/off light.

Mapping that associates to physicality is a very common and trivial form of everyday interaction with devices. We have studied everyday appliances and devices in order to understand what makes interaction natural, and especially to inform how we could apply this knowledge in the novel design [4]. In this study, associations in the form of mappings to tie physical and logical states together exist in many forms. For example, the light switch may exhibit a one-to-one mapping, while a mini disc joystick controller exhibits a one-to-many mapping, and the mappings could either be identified directly or indirectly.

Correct, or expected, physical mapping is crucial to ensure any interaction between user and artefact. Mappings that relate to the underlying logical states, together with feedback as a result of actions, gives sufficient, if not complete, understanding of many of today's physical artefacts.

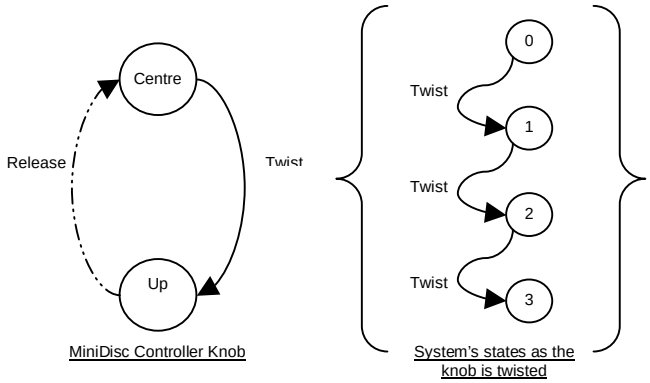

Figure 1. Mini disc joystick controller – one-to-many mapping

PHYSICALITY AND FEEDBACK
It is commonly accepted that feedback is extremely important in interactions. Indeed, in experiment we have found that even if the mapping of the physicality to its logical function is incoherent, users could still cope (adjust) so long as there is feedback to inform the user [5].

Feedback is given as a result of an action performed on an artefact. The forms of feedback vary from one artefact to another. The same goes for the associations between the feedback and how the user understood the devices' physicality, which could be described as either weak or strong, or somewhere in between. The strength level focuses solely on whether the form of feedback is intimately connected to the physicality of an artefact to its physicality ignoring any learnt knowledge which we may already have of that artefact. If we take a vacuum cleaner

for instance, we consider the association between the vacuum cleaner's physicality with the feedback is rather weak as nothing associates the button we pressed to the suction effect, and the same goes for most electrical appliances we could find these days.

The strength also varies considerably in tangible interface appliances. The association between an augmented desk MetaDesk [7] and its phicons is stronger than the one described above. As the physical lens is used to enlarge and enhance the digital map on the desk, the seeing-through-the-lens action gives an immediate result in the form of digital viewing of the map to the user. This association is, nonetheless, slightly weaker than the association showed by Technische Universiteit Eindhoven's camera [3] and videodeck [2]. Their ultimate idea is to create meaning in products by shifting the attention to *feedforward* and *inherent feedback*. In their re-creation of the camera for instance, which is described to be of sensory richness, the process of storing and removing pictures that have been taken is not just about the usual click-and-store, or delete, but one has to literally remove the camera's screen towards the memory card to store picture, or re-attach the screen back to the lens to delete the unsatisfactory picture.

REFLECTION

In adopting and adapting today's knowledge of physicality in and to the design of novel tangible and ubiquitous computing devices, the two most important notions we believe to be considered are the artefact's relationship with mapping and the artefact's association with feedback.

Physicality of an artefact invites interaction not only by its appearance and design, but also the way it exhibits its mapping of its underlying functionality and its association with the result. We have seen there are many forms of today's artefacts, from a device that on a press of a button could do a fantastic and in a way, magical, thing, to one which requires some kind of effort from the user to carry out a simple job.

The idea of what would make our interaction with artefacts natural is and still remains problematic. For instance, although we believe a clear state of mapping between an artefact and its logical function leads to a more natural interaction, are we prepared to see more and more digital and logical functions come alive, by creating their representations to become more palpable and physical? Are we ready to accept a rather novel design that fulfill the criteria of what makes a natural interaction and yet fail to give any meanings to wider human population? Does natural interaction of an artefact is all about intuition and no longer about learning? The struggle we have now also contributed by the phenomenon of the reality of today's companies, which although at times we may have the ideal design, in reality it is still difficult to be implemented especially when the product companies are not yet ready and prefer the low procurement cost to the ideal design.

The creation of meanings of physical artefacts has definitely triggered a lot of open questions. We are continuing to analyse this subject and looking further into the circumstances of incoherent associations between the physicality and mappings, and feedback which yet gives a flow of interaction between artefact and user.

ACKNOWLEDGEMENTS

Thanks to Alan Dix who helped me writing this paper. This paper was inspired by my fascination of everyday mundane things.

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Information Seeking in the Humanities: Physicality and Digitality

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ABSTRACT
This paper presents a brief overview of a research project that is examining the information seeking practices of humanities scholars. The results of this project are being used to develop digital resources to better support these work activities. Initial findings from a recent set of interviews are offered, revealing the importance of physical artefacts in the humanities scholars' research processes and the limitations of digital resources. Finally, further work that is soon to be undertaken is summarised, and it is hoped that after participation in this workshop these ideas will be refined.

Keywords
Digital Libraries, Humanities, Information Seeking.

INTRODUCTION

The User-Centred Interactive Search with Digital Libraries (UCIS) project is concerned with the needs and behaviours of humanities scholars both in digital and more traditional information environments. This research will then assist in the development of digital library systems to better support humanities scholars.

Increasingly information is provided electronically, including through digital libraries. This may suit the research practices of the sciences, but may not always be adequate for humanities researchers? Although there is an established tradition of studying information seeking, little of this work has addressed how information seeking fits within the broader information task, such as writing, and how the detailed design of the system interface influences individual behaviour. Understanding the existing nature of humanities scholars' research practices forms the basis of our research.

INTERVIEWS WITH HUMANITIES SCHOLARS

Over the past few months interviews have been conducted with scholars from English, History and Religious Studies departments from London, Cambridge, Bangkok and Sydney. These interviews have discussed scholars' research experiences, in some cases over forty years, and how technologies have been introduced that can facilitate (or hinder) their work, or the work of their students. The themes that have been emerging from these interviews begin to reveal the importance of physical artefacts in their work and some of the benefits and limitations of electronic equivalents and support tools.

This work is on going and initial analysis has revealed some interesting themes that are shaping further studies. Here is an overview of some of the themes extracted so far:

Insights into the positive and negative aspects of the Humanities 'research experience'

Detailed descriptions of their research activities revealed the "Sherlock Holmes" nature of their work; how it develops across the use of many sources and how the 'mystery' is investigated by 'chasing up leads'. Additionally, the depths of engagement experienced during interaction with the actual source materials were described. So for example, hunting down a rare 16th Century book in a second hand shop and slowly leafing through it over the weekend was described as a highly pleasurable, personal experience. This poses a significant design challenge: How can digital resources best support the work of the research 'Sleuth' and how can the experience of doing so be enhanced to facilitate engagement whilst interacting with technology?

The Physical and the Digital (Real and Virtual)

Different experiences in a variety of physical libraries were discussed, and how these research experiences differed to the use of electronic resources was also explored. We shall be addressing how some of the qualities of the physical browsing activity can be best supported by electronic resources. This is being done by developing, prototyping and testing interfaces that offer additional information to the user in a variety of ways, such as statistics on article use, related material, and similar search pathways through the data.

Space, place and people

The importance of, and problems of, places (libraries, auction houses, book fairs), spaces (e.g. working in particular libraries) and the relationships with other people

were also revealing. These findings can be set against electronic resources to see how well they support or hinder these relationships. Do these technologies need to consider ways of incorporating additional communication tools to support research communities?

How resources are assessed

The criteria scholars used to evaluate resources were often implicit. These interviews revealed issues of accuracy and ease of use for both physical and electronic resources. Our prototyped interfaces are exploring ways of expressing, for example, how results are ranked and how the user can interact with the system in order to present the data according to their own preferences.

Embracing technology

Participants discussed how different sorts of technology fitted into their research practices over the last twenty-five years, including first use of email, and more recently the Web and electronic resources.

Problems with technologies old and new

Critiques were offered of microfiche, microfilm, CD Roms as well as library catalogues and Internet search engines. By understanding barriers to previous technological take up in general, improved techniques can be developed to promote these resources to the Humanities research community.

NEXT STEPS

Offering accounts of how humanities scholars work, and the role of physical artefacts in their research endeavours, are important for the future of computing in the Humanities. With a better understanding of their work in context and with how current technologies support or hinder their research practice will help to develop and refine supporting technological tools.

Humanities scholars often require the context and full text of the original documents whereas other disciplines are concerned more with the content, regardless of the structure. However, increasingly humanities scholars are using digital resources as a means of accelerating their information searching habits as well as using digitised artefacts.

The next piece of research will be a case study of humanities PhD students that will shadow them through information gathering tasks, paying particular attention to the shifts between the physical and the digital. For example, from the initial documenting of ideas to the use of digital resources such as the Internet and online library catalogues, to note paper and physical library shelf searching through to writing up and search refining. It is hoped that this will draw up a clearer picture of how well existing practices work and how future digital resources could better compliment the research practices of the humanities scholar. Additionally, we expect to gain a deeper understanding of the “research experience” and of the qualities (and importance) of the physical in their work activities.

ACKNOWLEDGEMENT

This project is funded by the EPSRC (GR/S84798).

Project Website

http://www.uclic.ucl.ac.uk/people/a.blandford/DLUsability/UCIS.html

Understanding Physicality on Desktop: Preliminary Results

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ABSTRACT

This paper describes the functionality of desktop from users' perspectives. The preliminary results update and extend earlier studies carried out in 1985 and 1995. The study is aimed at investigating users' organizational habits across their workspace by comparing the structure of their document, email and web bookmark. We found that desktop serve more functionality such as availability, permanent location as visibility and security and safety.

Keywords
Desktop, functionality, organizational habits, users' perspectives.

INTRODUCTION

The desktop metaphor whilst presenting digital objects also clearly borrows from the users understanding of the physical. Ghazali and Dix [3] discuss various properties of physicality: directness of effect, locality of effect and visibility of effect, some of these are preserved in the desktop whilst others are violated (e.g. transferring of the main documents folder to 'Trash'). In addition other aspects of physicality, in particular spatial location and layout, are critical for the desktop. Through its visibility and availability the desktop acts as an area for rapid access to applications and documents, and as a reminder prompting action. However, also it has the potential for clutter and where issues of privacy and security surface.

In order to study these issues, we conducted interviews discussing with people how they work, organize and retrieve their information on the desktop, in folders, in emails and in web bookmarks. In this paper, we present selected results of these user interviews that showed why the 'physical' properties of digital objects are important in performing their tasks in the desktop metaphor.

A variety of studies exist that address aspects of paper based (e.g. [4, 6, 7) and electronic office organisation (e.g. [1]). In addition studies about refinding information in three important domains such as folders, emails and web bookmarks are growing (e.g. [2, 5]), however, these have not addressed the relationship between each of the domains and the broader information lifecycle.

We report on selected results of our interview study, focussing on the following points:

i. Confirmation of previous results relating to the reminder and temporary holding area function of the desktop.

ii. Whether desktop clutter is a problem.

iii. Individual user preferences relating to 'physical' features of the desktop.

APPROACH AND PARTICIPANTS

We conducted a semi-structured interview on 17 computer users with different backgrounds. The average time taken was 45 to 60 minutes. During the interview sessions, we prompted the users to show us and guide us through their desktop screen, folders, emails and web bookmarks. In the case of email many of the users used several email clients for different purpose; they were asked about all, but focused on the most heavily used client. The interviews addressed several sections:

- the description of their job, age and area
- their computer skills (how well they used popular applications and Internet) by giving a ranking from 1 (low skill) to 5 (high skill)
- description of the OS and browsers
- the description of their management and organization of their desktop, folders, emails and web bookmarks
- methods and strategies they named their folders, methods and strategies retrieval process
- the usage of their search tools in desktop, emails and web bookmarks
- problems and wish lists of what they would like to make their tasks easier
- relationship of information inside desktop, folders, emails and web bookmarks.

In order to help them articulate their answers, we helped the users when they got stuck on certain questions by asking them to clarify certain information or offering examples.

Table 1 shows the distribution of users' backgrounds. All users are in the age range 20 to 40 years old. They have been using computers for more than five years. All the users are highly skilled in using MS Office applications. All users use Windows XP as their OS. However, none of the users used other tools to help them manage their

information (except for what was provided by the system 'out of the box'). All users use XP as their OS.

Area	Phd	Master	Researcher	Academician
Computing	8		2	1
Management	2			
Quality and Reliability		1		
Linguistics	2			
Total	12	1	2	1

Table 1 Distribution of participant main area.

PRELIMINARY RESULTS

The interviews are now completed and transcripts have been made out of the data. We have found several interesting results from our preliminary analysis of the data and have identified several exciting answers to analyze in more detail.

When asked why the folders are on their desktop, our results confirmed previous studies [1, 6] that showed the desktop is used for its reminding function and as a temporary holding area.

All users reported that the most frequently used applications are on the desktop. This served not only as a temporary holding area, but a permanent area at permanent location. As one user commented that *"I like the computer to lock the position where I arrange my icons before. I hate to see it back to the default position, because I know where the things are before."* Note that this user is borrowing from understanding of real space, but is frustrated when the virtual objects do not behave 'physically' when the computer crashes and their positions are reset.

Users varied in the balance they drew between the visibility of folders and icons on the desktop and the level of clutter they would tolerate, just as with physical desktops. One user reported that she used different areas of the desktop for applications, for things waiting to be printed, for work in progress. However, she also used different ways to keep the desktop relatively uncluttered. As reported by another user *"…all my icons application will be on my left side, and somewhere not in the middle but in between I put my documents to be printed out, and quite in the middle is current folder which I am working at the moment*". In contrast another user had virtually every file on the desktop despite high degree of clutter, although like the first user above he was able to know where files were based on location. He commented *"…I just want all my files to be there, my current folder and my long term folder for me out of sight out of mind syndrome will occurred…"*.

Another interesting answer as to why we put things on desktop is that users prefer to act based on single click activity. They do not want to click on too many programs as commented by one user. *"….I like about one click concept, for example I put my Working folder on my desktop so that when I want to do my work in that folder I just easily click on it, rather than select Start, chose My Document and so on…..*" This use of the desktop space to make commonly used things available was also mentioned by another user *"…I have two types of application on my desktop. One which I always use such as IE, Real Player and et cetera...."*.

The same user continued "… the other one which I consider not important and for me If somebody putting something on desktop, they want other people to see too, I do not feel so insecure about my information." Here the user had concerns about security and privacy as the machine in question was used by other members of the family and house guests, she therefore did not want her document folders to be on the desktop and easy to open, view or corrupt.

This desire for security and privacy is clearly in conflict with availability, just as in the physical world. However, the above user said that on her laptop, where other users did not have (real) physical access to the machine, the virtual 'physical' space of the desktop was used for folders with work documents in them.

Whilst many users exploited the virtual 'physicality' of the desktop, answers from two users without a computing background revealed that they didn't know that the desktop could be used to store folders etc. Whilst for experienced users these are 'natural' for these users the properties of the desktop were not clear and so they were not able to appropriate it to serve in its reminding and temporary holding function. When, as part of the interview process, we told them and showed examples putting documents on the desktop, they could immediately recognise the potential benefit. In both cases they reported that another member of the family was the organiser of the desktop "…. *I am afraid to delete anything on desktop, and my husband or my son who will organize things on my desktop. I only know it is there and that is it…"*

CONCLUSIONS

Physicality on desktop does not only suffice as reminder and temporary holding area. It functions as fast easy access and sharable application and folders among others. On the other hand, these two other factors need further investigation. Majority answers about physicality of their folders act as reminder and the temporary holding area which we think that physicality on desktop need to be improve to serve more function to users. At the same time the physicality must be able to trade off with other factors such as cluttered and effort which user take to manage their desktop. Surprisingly, users in Linguistics area who are not fully exposed to computing skills need to be educated about the function of the application. Technology is not only for technical people but also serve all human kind.

Desktop ‘physicality’ based on our study, highlight several issues such as availability of most frequent icons and working documents, the balance between cluttered and visibility of icons , security, and privacy of information appeared on desktop.

There are several suggestions from users about desktop physicality. One was to make it easier to alter the appearance of icons relating to active work, for example larger icons for the working folder. Another suggestion related to the use of screen areas for different functions. Whilst very flexible the computer does not 'know' about them. It was suggested that if these could be explicitly defined, then the system could use this, for example to save different kinds of document to different areas. These highlights an interesting tension between flexibility allowing user appropriation and explicit semantics allowing the computer to share these meanings, just as another human might.

In future, we are going to analyse the visibility and ‘physicality’ of folder reside in My Documents or any other folders in the root directory. Among the questions that we like to ask are: How they relate to the one on the desktop? Why certain participants prefer this way and not the other way. What do they want from user interface to facilitate their work activities?

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