

Design and semantics of form and movement : DeSForM 2006

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Loe Feijs, Steven Kyffin, Bob Young

Design and semantics of form and movement

DeSForM 2006

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Loe Feijs, Steven Kyffin, Bob Young

Design and semantics of form and movement

DeSForM 2006

Program DesForM 2006

Thursday October 26

Welcome and Opening

Steven Kyffin – Philips Design

Keynote Speakers

Jurrienne Ossewold, The Creative Media Consultancy, The Netherlands

James Moultrie, Cambridge University, UK

Heather Martin, Copenhagen Institute of Interaction Design, Denmark

Masamichi Udagawa & Sigi Moeslinger, Antenna Design, New York, USA

Speech

Jeu Schouten, Dean Industrial Design

Exhibition Dutch Design Week & Drinks

Master of Ceremony: Prof. Loe Feijs

Speech

Hans Robertus – Philips Design

Friday October 27

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Long papers

Short papers

Demonstrations

Presentation Demo Award

Announcement next DeSForM Conference

Foreword

DeSForM 2006 : Reading the Object

Welcome to DeSForM 2006, the second DeSForM conference. Last time in 2005 many of us met in the Baltic Flour Mills in Newcastle Upon Tyne in the UK, a building with a rich cultural heritage, a rich story to tell and essentially a driver of cultural change in the local contexts. Welcome also to the Evoluon Building, which we regard in the same light within the wider Eindhoven environs!

A cultural icon. A Design Idea which communicates its own narrative, an expression of its cultural qualities, potential for human engagement and pragmatic function. It is instinctively read and interpreted by its participative community, which in-turn triggers desired cultural growth and change.

These examples of creative endeavour are culturally rich and complex architectural constructions, in many ways much like the emerging typologies of co-designed, content rich, connected, intelligent and adaptive driven objects. This conference aims to raise this debate around how do we as designers communicate or mediate the “ideas” as well as information and functions and how do we enable people to perceive these intentions as they encounter and absorb the ‘things’ we design together into our everyday lives. We now have a much broader palette of channels of expression available to us and our multiple senses, which we have to explore more rigorously.

Design has always concerned itself with the general relationship between us and the world we create, whether it be at the architectural level or at the single object level. Interaction design, has focused on the specific relationship between ourselves and the ‘things’, which in turn mediate the human to human interactions!

As interface and interaction design begins to consider the richness of the physical domain holistically integrated with the digital, it is more and more important that we use the full spectrum of mediation afforded to us.

To take full advantage of the richness of human-object interaction and to use the potential of affective (emotional, physical and cognitive) interactions, there is a need for a new, considered approach.

We are privileged to host five very important keynote speakers, each of whom have a very strong personal passion for different aspects of this debate and who are driving a research agenda which seeks to unravel more and more of the potential available to us. They are invited to guide Design so that it can indeed focus on delivering propositions which are culturally meaningful and relevant: Ideas and solutions, which actually MATTER or make sense and are delivered simply and delightfully.

Through this conference we will engage, through presentations, debate and activities, on issues including: searching out new ways of exploring channels of expression and behaviour, not in isolation but in relation to traditional and new forms of mediation: questioning whether language emerges through usage and context or can it be scientifically directed and defined. We share research into the nature, character (from abstract to anthropomorphic) and behaviour of the emerging new typologies of “things”, together with creative methodologies employed from both from Design and other relevant disciplines to conceive of such ideas, which drive our social transformation and innovation.

We have sought to bring together researchers in these fields to assess these outcomes and begin to identify research questions, opportunities and territories for future investigation and exploration.

We trust you’ll be invigorated and provoked by this event to explore new avenues and return to Newcastle Upon Tyne in 2007 to participate in the future growing debate.

Herewith we offer the concept proceedings of the second DeSForM workshop, initiated by the Industrial Design Department at Eindhoven, Philips Design, and The School of Design of Northumbria University, under auspices of IFIP and the JF Schouten Research School and with support from Philips Design, TU/e and Northumbria University.

26 October 2006

Prof. Steven Kyffin, Philips Design Eindhoven

Prof. Loe Feijs, Technische Universiteit Eindhoven

Prof. Bob Young, Northumbria University, Newcastle

Keynote speakers



Jurrienne Ossewold

The Creative Media Consultancy, The Netherlands

Her professional domain is the crossover between design, media, technology and communication with a focus on concept development and product innovation. She approaches this domain from two perspectives: academic and business. Momentarily she combines both as a professor at the Design Academy Eindhoven and as a Creative Consultant (the Creative Media Consultancy). She has been specialising in interactive media since 1990, with a focus on interactive concepts and product innovation, interactive narratives and interaction design.

What can design learn from storytelling?

Abstract

Why can a story immediately grab our attention, why are we willing to suspend our disbelief to find out what the story is about and do we always want to know how the story ends?

Apparently stories can provide us with an experience that is emotionally, sensually and intellectually enriching and satisfying. Even though the principles of narrative (storytelling) are centuries old, they nevertheless still have the same impact.

The question is if these principles have changed in this era full of technological developments in the field of media and communication. For instance what is the influence of 'interactivity' and 'non linearity' on the principles of narrative and do 'interactive narratives' enhance the same experiences as linear narratives?

The answers to these questions can provide us with information that can be very interesting for product designers. Since product design is focusing more and more on the role of the user, the 'design of interactivity' has become the 'design of experiences'.

This lecture links storytelling to product design and shows how the principles of storytelling can be a source of inspiration and thus be of interest for product designers who want to design rich experiences.

Keynote speakers



James Moultrie

Cambridge University, United Kingdom

James Moultrie is a University Lecturer in Innovation and Design Management, Institute for Manufacturing, Department of Engineering, University of Cambridge. His research includes work on understanding product aesthetics and specific interests include design management, design strategy and the role of the physical environment on enhancing innovation.

Seeing things: consumer response to product appearance

Abstract

This presentation focuses on the development of a model used to conceptualise and communicate the way in which consumers respond to product appearance. This work was initially inspired by the observation that despite a wide array of literature from many sources addressing aspects of product appearance, there was little to integrate this body of knowledge. We aimed to provide an initial point of reference to integrate well known concepts and raise awareness of lesser known texts. We also wanted to present a generalised framework, which would enable better explanation of complex concepts, for both a design and a non-design audience.

The framework: how objects are read

The framework is based around a simple communications model, which suggests that designers have intentions about how the products that they create will be perceived. This intent is embodied in the form of the artefacts that the designer creates, which will then be interpreted either immediately, or more likely at a later date, in a different context by potential users and consumers. The model is primarily based around the visual senses.

As the transmitter of the designer's 'message', the artefact is essentially nothing more than a collection of surfaces, interfaces, images, textures, transitions, colours and materials. For convenience, the consumer's interpretation of these has been divided into sensing, cognition, affect and behaviour, whilst recognising that in practice these tend to happen simultaneously. Attention has been focused on the complexities of the consumer's cognitive response, or the judgements that the consumer makes about the product based on the information perceived by the sense. These judgements can be grouped into three classifications:

- Aesthetic impression: or the sensation that results from the perception of attractiveness (or unattractiveness) as a result of viewing a product.
- Semantic interpretation: what a product is seen to say about its function, mode-of-use and qualities.
- Symbolic association: the perception of what a product says about its owner or user, the personal and social significance attached to the design.

In this presentation each of these will be described, with illustrative examples.

The future of product semantics ...

As a relatively new body of knowledge, there remains much to be done in understanding and classifying the various elements of consumer response. Work in consumer response remains largely unconnected to research in the design domain. Of particular interest is the evolving interplay between aesthetic impression, semantic interpretation and symbolic association. Arguably, the 20th Century has been dominated by a Modernist perspective on Semantic Interpretation; which emphasises understanding of form over exuberance. However, growth of mega-brands and increasing brand awareness has raised the importance of the social significance that may be associated with artefacts. Finally, over the last 5-10 years, there has been a steady return to decoration, and the application of pattern. This is in part a reflection of the availability of new production methods and may yet be a short term fashion. It could also perhaps indicate a longer term progression from the modernist style towards an emphasis on the emotional over the rational in product design.

Keynote speakers



Heather Martin, Copenhagen Institute of Interaction Design, Denmark

Her focus is on creating new forms of tangible interfaces for products, services and environments & on tangible interfaces for objects and spaces. She has worked on creating new interfaces for various clients including Sony (2004) and for the Italian lighting manufacturer Artemide (2005). Before joining IDII she worked at IDEO in London as a senior interaction designer and project manager. From 2000 to 2001 she was a project manager and creative lead for IDEO on the Prada New York Epicentre done in collaboration with Rem Koolhaas and OMA/AMO, where she helped to design and develop the RFID enabled interactive dressing rooms. From 2002 to 2003 she led a worldwide team at IDEO on the creation of a wireless LAN in-flight entertainment device for use on-board private VIP airplanes by Lufthansa Technik. Recently she co-founded the Copenhagen Institute of Interaction Design (CIID).

Abstract

The definition of interaction design is the design of products, services and screen-based interfaces enabled by information and communication technology. In the past, the focus has been on how to enable humans to directly manipulate and understand computational machines. The aim was to design interfaces that were primarily functional, understandable and easy to use.

Now that the discipline has matured, we are experiencing an era that goes beyond ease of use. We are now concerned with how an interface feels, how it behaves and the experience it offers.

Physical computing is one area of interaction design that explores the possibility of making intangible data tangible – as a way to inform the user of its functionality. Up until recently, digital devices tended to indicate activity through a set of pulsing LED's and information via icons on a screen. Physical computing, on the other hand, looks for new ways to make devices express their functionality via physical elements that move, adapt or morph depending on the functionality being conveyed. Embedded microprocessors and sensors mean that devices can now sense the environment, the user and the presence of other devices - and respond accordingly. They can now adapt to their environment, and therefore deliver only the appropriate functionality - at the appropriate time.

But in the process of making devices more expressive, we also have a duty to question what is relevant. Does it make sense that buttons morph physically, or devices shrink in size depending on their digital load? Should objects wave at us when something is wrong? Does adding physical movement to objects really provide us with a richer and more meaningful experience - that surpasses the flashing of an LED or a number on a numerical display? Can we move beyond mimicking animalistic or humanistic behaviors (such as twitching, breathing, expanding, contracting, expanding etc.) and design new object behaviors that are abstract, physical, yet understandable and meaningful? Or is it possible to design a set of universal physical behaviors that work seamlessly across numerous platforms, which quickly transmit functionality (on/off, active/inactive, receiving/transmitting etc.) in an understandable and effective manner? How abstract can these universal behaviors become before they become meaningless and incomprehensible?

By showing recent work from IDII, such questions will be addressed and illustrated in an attempt to understand if physical computing really does have the opportunity to make devices more understandable, expressive and meaningful in the future.

Keynote speakers



Masamichi Udagawa and Sigi Moeslinger, Antenne Design, New York, USA

Antenna's mission is to make the ex-perience of objects and environments more meaningful and exciting. Antenna's projects range from public to com-mercial, from applied to exploratory. Among Antenna's best known projects are the design of New York City sub-way cars and ticket vending machines, JetBlue check-in kiosks, Bloomberg displays and interactive environments, such as Power Flower; an installation in the windows of Bloomingdale's activated by passersby. Antenna's user-centered design approach helps understand human behavior, which is particularly important when designing the unfamiliar, elicited by new technology.

Reflection to Reflex Action

The design of interactive systems in digitally enhanced products and environments

Abstract

When a new technology - in an abstract sense - is inserted into an existing socio-cultural fabric, we have to negotiate how this entry can be made. In this process, technology be-comes tangible and has a new meaning assigned to it. We are quite keen to be involved in projects which embody this process as there is a lot of new ground to break. Sometimes these projects are more experimental, as in our interactive installations, other times they are more pragmatic, such as kiosk interfaces.

The essence of interaction design is about control, in multiple senses. It has to predict and control the process and outcome of the interaction between the user (or viewer, participant) and the artifact. The user, driven by his/her interest and prompted by the cue from the artifact, does something, then the artifact has to provide a good response, so the user gets a strong sense of control, the user feels s/he is in the driver's seat. In order to achieve this, interaction design should have a clear logic. To what extent this logic should be made obvious, depends on the context. In practical applications there shouldn't be any ambiguity, as it will lead to frustration and failure of the intended goal, such as, for example, a quick transaction.

In the context of art and entertainment, the process of discovery can be part of the reason of existence of a project, thus the underlying logic doesn't have to be made as explicit. Nevertheless, experience has taught us that people have a very limited attention span. Demanding too much commitment from an audience to reap a "reward" may result in loosing the audience before it ever gets any reward. Therefore, we have come to like interaction design that's obvious, simple and delivers delight.

Our approach to interactivity is strongly informed by our background in product design. Using a product or moving through an environment is inherently a process of reciprocal actions. We see the application of digital interactive technology as an extension of this reciprocal nature of products and environments. So we apply the same thinking. We design for and around the users. We try to predict their behavior and design to guide them through a series of prescribed actions, which trigger desired events.

Context is always the starting point of our design. Each of our solutions is the result of a thorough study into the unique context of the project. What unifies the various projects is our focus on human behavior and our pursuit of designs that achieve both simplicity and emotional resonance. We strongly believe that to create a coherent user experience a inte-grated approach to hardware and software design is crucial.

The phrase " reflection to reflex action" was coined by Paul Virilio to describe the nature of interactive media, which tries to generate a reflex action from the user/viewer as opposed to reflection as in the case of traditional media.

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A new dialogue

Abstract

The central concerns of the following text focuses on addressing the cultural meanings attributable to form, and initiate a discursive dialogue with respect to the inherency of meanings which potentially reside within forms themselves. The meaning of form is a human production, as it is both malleable and undefined. As a cultural construct, it has the potential to consecrate meaning as well as confound it. New definitions of form semantics can be revealed through the examination of the intersection of human behaviour and emerging technological discourse in the present social climes.

Keywords

Form, Meaning, Emergence, Possibility, Context, Multiple Perception, Relationships

Introduction

Design, once codified in physical infrastructure is difficult to reverse, and it is rarely up for public debate.

Victor Margolin

The fish trap exists because of the fish. Once you've gotten the fish you can forget the trap. The rabbit snare exists because of the rabbit. Once you've gotten the rabbit you can forget the snare. Words exist because of meaning. Once you've gotten the meaning you can forget the words. Where can I find a man who has forgotten the words so I can talk with him?
Chuang-Tzu

Roads. Where we're going, we won't need roads.

Doc Brown, Back to the Future

The capability and meaning of any form can be defined by the limits of people's ability to imagine what it can be physically or represent spiritually or intangibly.

In essence, form has no meaning; it is an invitation, a window to possibility. Meaning resides, and is latent within us, in the relationships we perceive and cultivate in our minds and through what we negotiate with others. This is the paradox that makes the stable attribution of meaning to anything so difficult, whether it is form, color or motion. People see more, they see differently, and thus, they challenge existing limitations. Meaning is emergent, and so forms trigger multiple shifting associative meanings. However, we subvert meaning by designing it into form. These meanings or constructs of thought stagnate possibility and curb the creation of one's own meanings through the discovery of "what is this?" or "what can this be?" By considering the relationship of form while engaging in a critical and open-minded conversation about people as producers and vessels of meaning, we can form a deeper understanding that will inform the development of a new species of communicative signs. Forms are variable over time and so too are our perceptions of them.

What can we learn from these characteristics while evolving a language of form and movement?

What can we learn from our experience with the existing languages of form and movement within the places we presently inhabit? How can we create an evolutionary platform of meaning and representation that works in the forms that will surround us?

In addition to the content presented, this paper is a living open-content formation of inquiry and a framework of consideration. This paper contains more questions than answers, and, like the objects and forms it explores, is an invitation to an evolving conversation in which these concepts can be expanded upon, challenged and remixed.

How can we, as designers, challenge the need for designing explicit meaning within a language of form and movement?

How can we create a new dialogue between objects and people to harness the emergent properties of meaning within the human experience?

2 Form Triggers Multiple Meanings

Transformers, more than meets the eye.

Optimus Prime

A gun locked safely at a hunting lodge has entirely different denotative and connotative associations than the same gun in the hands of a man in a dark alley. The sign itself, the gun and its function, within the context of alternative environments, is pollinated with probable outcomes that are associated with location and situation. Context influences interpretation of the purpose of that form, shaping the message it conveys. It is through the process of negotiating meaning between social actors, place and location, that form evokes multiple meanings, and likewise meanings can inspire multiple forms. Physical properties in differing contexts can trigger landscapes of ulterior meanings around and between people determined by their personally and culturally informed associations. Context alters the meanings that forms and motions may trigger, influencing their social role. Moments pass and reveal many faces of the same form. What may evoke meaning in one place may evoke an alternative meaning in the next. There is a constant divergent and convergent play between individual and shared meanings, and between the idiolects of individuals and the dialects of communities. How can we enable forms to embrace this continual process of the production of meaning? Is it our objects that adapt, or do we?

How can a language of form and movement make use of 'context aware technologies' within forms (objects and spaces) to be better aware and more relevant to what is going on around them?

Can a form change its mode of expression to fit those who are present to it?

How can a single meaning be maintained through multiple modes of expression in multiple contexts?

2.1 Migrant Meanings are those which Experience the Passage of Time and the Passage of Space

The introduction of new information and the mutation of old information alters associated meanings because of what is accumulated and lost during the reallocations and migrations of forms. A Los Angeles gang, The Crips, have evolved a language of form and movement dubbed the Crip Walk [***]. The Crip Walk is an intricate dance where each movement has an attributed meaning, to convey larger contextual information or more specified personalized messages from afar. Due to its use in music videos and content portals such as YouTube [MoDzy] this "language" has migrated far beyond the borders of California. It has been appropriated by clubbers, break dancers and YouTubers all over the world, but has lost its linguistic qualities in these realms, the very reason why it exists. If one were to relocate a Toronto club goer to the streets of L.A. right now, after the proliferation of its public popularity, the dance would convey gibberish to those who are native to the language, and the clubber would be met with anything but applause. Time Matters. Location matters. Context matters.

How can these unfolding dialects, migrations and morphologies of the compositionality of meaning over time be documented? What will they say about us? How can it be used as a resource?

Can this documentation of semantics aid in the evolution of communication through form and movement? How can it help in the translation between alternate modes of expression?

Will context be the dominant hypermedia form? Will it be the request, the curator, the aggregator and synthesizer in relation to one's identity and state, emotional, situational and physical context?

2.2 Meaning and Functionality

Functionality affords meaning through the use of an object. Meaning is cultivated through experience, not by what the thing is supposed to be.

Traditional forms conveyed functionality through their form only after one has gone through the process of learning about it in a given context. Through the process of doing, understanding and participating with a given form, a sense of meaning is developed. Emerging forms that possess processing and communicative capabilities add a new layer to form. It makes the form variable and responsive. Forms were formerly limited by their physical capabilities, and to the imagination of those who encounter them. However, once they are enabled, and networked, they will have a new breadth of roles, social relationships and possible meanings that are physically bound to place, yet extend and include that which is beyond place borders.

How can these new roles and relationships be visualized through form and motion?

Once the environment becomes populated with these objects, what do you show in the cinema of place?

How do the objects determine what information is critical and explicit, and what is ambient?

2.3 Without 'Any-Thing' I Cannot, But I Will Because They Are

Things enable behaviors, and behaviors find themselves eventually as forms. All of the forms of our built environment are signifiers of behaviors that bind beneficial material and immaterial relationships. We must satisfy our physiological needs, and therefore the forms within our networks of infrastructure need to conform to the requirements of our unique physical formats. However, there are levels of meaning that satisfy multiple levels of self, such as our immediate physical mental and spiritual needs. These levels of meaning can be realized and attained through interfacing with a solitary form. Depending on the vantage one views it from, and how one wields it one can determine what need or motivation the object, space, service is satisfying.

This can be observed in the specialized context of jail, as prisoners draw on a restrictive palette of materials and

forms, shaping a wide selection of objects that perform various functions and hold widely different values [Angelo] Through the reshaping of one form, prisoners can satisfy different levels of human needs. The toothbrush can be multiple things at once. At a given time it can be a shiv, a tool for cleaning teeth, or a carved piece of art. One form can participate in events that contribute to fulfilling one's physiological needs, esteem needs in social settings, or the form itself can be a medium of self-actualization. It is our motivations that curate the relationships we engage in to trigger revelations of what can be, and what meanings those relationships bring. We perceive context and conditions that we are participants within, and we forge our own meanings; in turn we can contribute this meaning in a shared dialogue to negotiate normative ones.

What can we learn from this perceptive ability of people and the potentiality of form?

The field of ethnography poses an interesting point in this regard. Ethnography is the study of how "alternative cultures do the same things differently." [Haviland] Cultures develop arrays of tools and networks of infrastructure that support their survival. We all have the same physiological needs, yet we develop many differing tools and support systems with various permutations to achieve them. Forms are driven and shaped by goals and intentions of the mind. Artificial forms are the facilitators of our daily lives, they dictate how easily and fluidly we can go about our day: because they are, we can.

How can objects be sensitive to our goals? Can they be literate to our actions? How can we better equip them to help us achieve?

Will a language of form and movement inevitably produce a Universal Homogenous dialect, or alternatively will a heterogeneous explosion of dialects evolve?

Can contextual mapping and meaning mapping over time be achieved to form a living document capturing a language unfolding in real time.

2.4 Form Collapses Possibility

Forms alone do not collapse possibility, but the essentialist framing of forms that associate a sole meaning to a form neuter ones perception to imagine what the form can do or be. Forms will be a platform of dialogue: they will be

simultaneously the substrate of a question or goal, the expression of a possible answer, and a passport to exploration of possibility.

What else can this be? How can it help me achieve my goals right now, how can I leverage this?

I think therefore it is.

Kevin Kelly of Ideo has been developing a blog “Street Use”[Kelly] about how objects are repurposed to fit specific needs of people. The blog exhibits fans that are made into satellites, and regular pick-up trucks that are re-appropriated as highly reinforced armed assault vehicles in Iraq. The engineers at NASA practiced this method of thinking during the Apollo Mission when a filter was broken, jeopardizing the lives of the crew and the integrity of the initiative. They quickly “MacGyvered” a solution through finding similarities in forms available on the ship, and devised a filter from scrap containers, duct tape and socks.[Luscombe] These interventions are a testament to not only possibility inherent in forms, but also to the multiple potentials people see in them as a way to facilitate their goals.

How can these characteristics be viewed as ways to enhance a language of form and motion?

How may objects speak in multiple ways simultaneously depending on how you read it?

3 Meaning is Emergent

And I am, whatever you say I am

Eminem

I use the term “semantic plasticity” to refer to gradual change and adaptation of meanings of words, phrases and other linguistic constructs. Apart from the well-known phenomenon of large-scale semantic change over time (as studied in historical linguistics as part of the general phenomenon of linguistic change), semantic plasticity occurs in single dialogues, between specific dyads or communities of speakers, and in the adaptation of linguistic resources to specific activities.

Steffan Larsson

The idea of forms having multiple meanings can be substantiated by the fact that meaning is emergent. This is why we cannot design semantics in a systematic and

scientific way, for they are individually variable, as well as culturally and socially formed. The failure of Esperanto and the success of Creole and Pidgin languages [Diamond] illustrate this vividly.

Have we considered how this inherent human characteristic of emergence can be harnessed, socially and individually through forms?

“Real Time Graz”[Ratti] is a project where GPS mapping of cell phone trajectories is used to illustrate the nomadic portrait of people in the city; this information describes in a rather low resolution how people use space. These traces of flow are then used to inform the emerging shape of the city to complement how space is actually used. “The BCN Formula Game”[Hubers] has taken this further by developing software that generates building proposals for Barcelona in real time through modeling software that creates structures in response to flows of people, traffic and commercial activities. Although both of these platforms embrace emergence they are crude examples given the oncoming ability and impact of responsive and adaptive technologies that have been developed to date, not to mention the potential developments that could support such changes in the future.

How can our traces influence the language of form and movement to best-fit context and particular actors in real time?

What if an object’s form or gesture was a word and its definition was based on how people see, use and understand it in relation to its current context?

3.1 Meanings Will Develop Around Form Through the Experience They Participate in and Through Discussion in Communities of People

All interpretations of meaning are relevant and add to a diverse repository of possible meanings. In general, the most valid current definitions of forms, which are the ones most widely and currently understood, are the ones that are commonly applied day to day. How can we allow for these definitions to evolve and be continually negotiated? The Association of Robotic Architecture & the Bureau of Responsive Architecture work together to develop responsive architectures that adapt to changing functions as well as environmental conditions. These architectures have fluid form/function relationships. On an object level,

the Tactile Dynamics Textiles has developed the idea of a coffee cup made of a thermally sensitive polymer that sprouts spikes on the exterior if the content of the cup exceeds a safe temperature. [Tsu]

The future may depend on building upon existing senses and semiotics as they have evolved over time. We can devise new modes of communication through form based on our native capabilities of recognition, understanding and sharing. When the clouds lower and darken, the wind picks up, and the leaves dance, we don't think, "what is happening?" We run for cover or pull out our umbrella.

It will take time to learn to "read" newly emerging responsive architectures and objects as innately as we respond to natural events. Only after we have interfaced with them on an ongoing basis will we be able to effortlessly understand them. For example, being able to understand the state of the internal social dynamics of a building by observing its shape from down the street, or recognizing the state of the contents of a container by its visual attitude from across the room at a glance. It will take time and communication between people to form a consensus of a shared meaning associated with the expression of animate forms; however, we also need to allow for change in this process. Borrowing from nature may be a natural next stage, such as the physical biomimicry of the thorny puffer fish inspired cup. [Tsu]

3.2 Ecology of Meaning

Is there a Cycle of Meaning? How is it produced, "represented", transferred and consumed?

One possible model

Meaning may begin from a percept of the senses, information in the form of a sign or signs, a sound, a visual or tactile experience. One assesses the sign within a given context and it is measured against what is 'known', in relation to someone's personal disposition and life experience. This engagement creates a concept of meaning which influences behavior according to personal motivations. We engage in the act of the social negotiation of meaning with others, we establish a normative meaning that is harvested from group consensus. These behaviors, if beneficial, are codified into forms such as artifacts, spaces, systems and media, so as to extend its benefit to people, and become once again percepts to feed this ongoing cycle.

Our ancestors identified opportunities and devised means of protection through observing threats in the environment, such as the cold and predators before the development of a formal architecture. Concepts that satisfy needs and motivations are established in this environment and are in turn exemplified as meaningful behaviors of survival codified in forms, as walls, spears, and clothing. We continue to make observations and build upon the constructs that we have built before, and in doing so have created forms and meanings that are further and further from survival, but which carry no less meaning. This process is automated in the former example of the "BNC Formula Game" [Hubers] where forms are generated according to what is happening.

This process is cyclical in nature, from percept to percept, our observations and behaviors are transformed into things that can be seen, heard and felt. These things are an index to possible meanings, or signifiers of what is meaningful, which in turn influences forms that are open for reconsideration and change.

What new variables alter the composition of meaning?

Can our signs become deeper participants and documenters of this process?

3.3 Triggered Meanings and Emergent Meanings

Meaning can be residual, formed in the past. It can also arise as a unique development of an individual, or can be negotiated by groups of communicators. It is cultivated from experience, encounters and interpretations of our perceived realities and relationships, due to our unique human ability to see and communicate, "more than meets the eye." [Bloom] How then can our eyes perceive multiple meanings? When we see forms, we conduct imaginative simulations of possibility, which are translated into action. These actions and behaviors, if beneficial in context, are then codified as new physical forms, or as new software forms.

We are all producers of meaning; form triggers these meanings or the production of new ones, but holds no inherent meaning itself. Instead it triggers a dimension of self that can be achievable in a variety of forms. Objects or produced forms are codified, commoditized beliefs and behaviors. However, there is a big difference between what an object can do, and what an object is meant to do, and why doing it is relevant. Moreover, there is a difference between what an object is supposed to mean

and the meaning that people attribute to it. Meaning is myth. The desire to understand, unfold, know and create unique perspectives has been overshadowed by the traditional way of perceiving forms as hyperlinks to a normative known. By diverting philosophical meaning and understanding to that which is static and consumable we destroy whole landscapes of unique expansions on the 'meaning' of anything.

Disruptions such as Geocaching, context aware gaming and location based technologies alter the emergent meanings of a space as well as the forms within. Context aware games like Pacmanhattan [Bloomberg] transform the streets of New York into a dual virtual physical Pacman playspace. In Japan the game Mogi [Tester] requires players to discover hidden virtual items; these experiential properties transform the perception and the meaning of what that space is. Shifting meaning can be achieved by something as simple as a laptop in a park: the park then becomes a studio. A personal phone transforms whatever space it is in into a bank, a mailbox, a voting booth or a gamespace. Meaning is brought to places and objects by people as we encounter them and the properties of these spaces and objects afford the kind of meaning is manufactured.

Conversely, Kyle Machulis, a robotics engineer from slashdong.org, has created a teledildonics interface for Linden Labs' massive multiplayer online community, Second Life. [Lynn] Players may now control the physical stimulation of others through a hardware vibrator compatible with an in world virtual controller. The immediate physical experience contributes to an alteration in the meaning of Second Life, previously known only as a virtual space. This new interactivity alters our perceptions and triggers an outbreak of new behaviors such as new forms of tele-prostitution, intercourse and remote intimacy.

3.4 Emerging Perceptions- A New Literacy

What would the effect of a language of form and movement have on perception of forms and on the perception of our environment in general?

The hactivist and the modder have a highly developed and community supported capability to see possibility in everything. Pre-established notions have eroded and people have the ability to see through forms, hard and

soft.. This new perception sees product forms as a series of behaviors and associations like Lego blocks that can be rearranged. Due to this perception, we have the ability to see the relationships and flows between forms.

When the physical form/motion has multiple meanings does form then mean nothing? Or does it require a new language for form, and a new species of dialogue with our environment and the objects within?

Or does it require simply a new perceptual framework?

Should we 'teach' objects to say more, or should we learn to see more?

Can emerged possibilities -formless meanings- be formalized? When and where is it appropriate or necessary to give formless meanings a form?

The structure of language affects the cognitive framework of how we think. This in turn affects our perception, how we see, and what we see contributes to what we find and "what we find changes who we become." [Morville]

4 Platform For Emergence

Compositional Language can arise automatically through grounded communication within populations of communicators. This language is compositional both in terms of form and in terms of meaning, and arises within a generation, over the course of hundreds of communicative interactions. Crucially, this is accomplished as the emergent product of simple communication and learning mechanisms.

DeBeule, Bergen

The search for truth is in one way hard and another way easy- for it is evident in that no one of us can master it fully, nor miss it wholly. Each one of us adds a little to our knowledge of nature, and from all the facts assembled arises a certain grandeur.

Aristotle

By providing the conditions and tools within objects themselves we can create an open platform for naturally unfolding semantics. If we are to create a language of form and movement, then its core elements should embrace the emergent nature of meaning and the process of triggering multiple associated meanings. As much as it is a proposition of characteristics, it is just as much a call for

expansions and alternative models. Embracing emergence requires an object to have a recognition and memory of what happens around them. In addition to expressive capabilities and the ability to build on the past, these forms should have the plasticity to allow transformation in all of its capabilities to adapt to people in the present. A form will be able to observe the world around it, but human participation with it will continually re-define what it is, to re-contextualize of the purpose of its form. These forms should be aware of this process of emergent meaning if they are to be deeper participants of social practice. The forms that comprise our objects and spaces are igniting a new dialogue when they explicitly become a form of media and interface. Building a living framework of consideration, by engaging in an inquiry around the proprieties and impact of such a platform of dialogue will be helpful in determining which capabilities are most necessary.

“As we ask how to maximize digital capability to enhance physical space, we must also ask how we can maximize physical capability to enhance digital space. These are not distinct questions – they are two sides of the same question: how to we maximize our current capability to enhance experience and provide benefit?”

Matthew Jones, BISC

As we create enabled and communicative forms that comprise our objects and spaces, we will require an equal consideration of both the virtual and the physical aspects. The new method should consider relationships that are happening between things and people in spaces. The attention and sensitivity we prescribe to physical representation and expression of associated meaning has to be directly proportional to that which we devote to the sensing, processing, understanding, storing and sharing in the ecology of meaning surrounding it. This language will enable a new spectrum of authoring and expression of meaning. The following are characteristics of expressive forms that should be considered:

1. Awareness and Memory
2. Expression and Literacy
3. Transformation: an element that is pervasive in all the others

Only after a conversation on the what and why of such a platform can we begin to think of greater hows.

4.1 Awareness and Memory

We leave traces of ourselves behind as every moment passes. Streams of gestures, wafts of pheromones, a wake of heat, a dynamic gait emanating a chorus of continuous audio. This species of media is the most valuable; it is the unfolding map of self, of who a person is and who they are becoming. When these individual maps are read on a larger scale it is the Map of Us, it is the combined interactions and behaviors of communities of people that illustrate underpinning motivations and meaning. Objects, equipped with the culmination of several maturing and emerging technologies, including sensing technologies, have the potential to seek the meanings of our traces, and observe their composition and morphology over time. They will inquire what and why of the observable phenomenon that occupies the who, when and where in their perception, or shared perceptions. This raises the opportunity for objects to be cartographers of experience, to be moment hunters, seekers of the zeitgeist of place.

Doctors can monitor the heart, could a shirt? A lover will read the landscape of the face of their beloved, could a cell phone, or a point of purchase? The expressions of self that comprise our unique fingerprint of behavior are what make us who we are. Our inquiry will be visible, our expressed knowledge will be legible, and our mastery will be explicit to objects and people.

Our immaterial traces are codified in an array of manifestations. Objects can be seen as traces of beneficial behaviors. Architecture and civic spaces are traces of social formations. As you read this sentence you are encountering traces of thoughts, codified in type. The sensory perception capability of things is directly proportional to its ability to read not only the physical but also the invisible relationships that sculpt our environment. Most of today's objects and spaces are blind, deaf and mute, however, scores of new capabilities are migrating to the shores and guts of products, and are being woven into the very fabric of architecture. This will result in more than just a perceptual extension of us. This distributed sensory organ will read, store, reflect and respond expressively to us in a way that is beneficial and valuable.

It's not about the objects or spaces themselves, but of them as images, products of what happens in-between. They will increasingly become a form of socio-cultural barometers that aid in the flows in ways that they have

never before. The purpose of all of this is to document and share what has happened and what is unfolding in the present, to engage meaningfully in what is happening and what will happen. The shared memory of this network will be as beneficial and as epic as the impact of the World Wide Web. It will be a living documentation of our memetic propagation, and our behavior in the physical environment, and its resulting effect on the shaping of the environment itself.

How can we enable a co-evolution and interplay between our personal traces, and objects and spaces?

How will our traces (a form of Social Capital), our digital shadows, interact with each other? How will our pasts converse to enhance our present physical experience?

How will our present physical, situational and emotional context contribute to what is displaying?

4.2 Expression And Literacy

Blogs such as Information Aesthetics and We Make Money Not Art [Debatty] successfully showcase emerging practices and developments in object expression including and form and movement showcased from sources as varied as basements, art galleries, and university laboratories. The projects are tagged and tracked to reveal how memes catch on and how methods evolve.

What if the projects, the Objects themselves circulate and share these developments?

What can we learn from heraldry, patina and natural expression, such as a ripening fruit, as a pre-existing historical or natural form of communication?

Communication between objects will, in the beginning, work in chorus to combine sensor capabilities, processing power, storage, expressions, behaviors, and share memories, to understand and render responses to meaning. Our meanings will be derived from our behaviors in context, read by objects, which become a responsive porous vessel, a new form of media. They are becoming dynamic content.

This language of form and movement has been around forever. Throughout the course of a day we may employ about a thousand words, however, we express 30,000

facial expressions, and 5,000 hand and bodily gestures [Danesi]. Most of our communication happens through our visual interpretation of form and movement. We can “read” clouds, water and the landscapes of rock and of flesh. Undoubtedly, if we were to propose a semantic framework for form and movement, we should employ the wealth of experience in our literacy of displayed behavior.

Expressive capabilities are already migrating from screens to the surfaces and movements of objects for public use. Ambient Devices [2], a Massachusetts based startup, pioneered by graduates of the MIT media lab. Their products enable data from the internet to be translated into personally programmed color and movements in forms such as The Orb, which can display stock information, weather or any other information from the Ambient Information Network. The Inflating USB key [Komissarov] alters its size in relation to how much data is stored on it. Email erosion [Ham; Muilenberg] is a more art centric piece that aims to display relationships that are usually invisible. Erosion is a project that uses a water-soluble block as a display; incoming emails cause flows of water to alter the form of the block in proportion to the flows of email. Alternatively, the broadband cord project [Weiser; Seely Brown] displays data packet flows in physical space through servos that shake the cord in accordance to Internet activity. These projects are examples of how this language is alive and its evolution underway.

What can we learn from these isolated developments when viewed as examples of a larger language?

Can we allow these solutions to contribute to and fuel negotiations of the evolution of a sensory language?

It is also important to ask: Who shapes the message, who shapes the medium? How does the behavior of form affect and influence the behavior of people?

Can we naturally create modes of expression? How do we create standards that are responsive to transformation?

Can form communicate a unified meaning when people have alternative associations?

What new forms of object ‘tribes’ may form in this new ecology of networked objects to better express information?

What expressive properties are appropriate for which situational conditions? What defines the need for either ambient or explicit information? Under what conditions does a shift occur between the two?

What can we learn from observing these evolving methods of communication? If they extend beyond form and motion, how will we inevitably develop a full spectrum sensory language?

Can we develop a notation system that formalizes and documents form and motion?

5 Open Ending

Due to the emergent properties of meaning we cannot design semantics in a systematic and scientific way, for they are individually variable, culturally and socially formed. Instead, we should provide the conditions and tools that create a platform for semantics to unfold naturally, because people already shape form and produce meaning around them continually. If an enhanced dialogue with the environment is to evolve through a language of form and movement, then it will be sensitive and responsive to context and identities of people in the transformative process of meaning making.

How can we begin to bring into motion a platform to allow the public to assist in the creation and evolution of this language?

How can an open source, open content community be shaped to best monitor, review and engage in the developments of this language?

Enabling characteristics that thrive off of the morphology of meaning, rather than being threatened by it, turns a very difficult problem into an opportunity. This approach includes and complements the ongoing development of forms that communicate. The future of design is not in form or movement, color or texture, but in the temporal curation of relationships within changing landscape of social practice.

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Designing benevolence: a study on a food vending machine taking into account cultural preferences in movements semantics in Japan and France

Abstract

This paper presents a research design study aiming at contributing to the design of benevolence through movement dynamics. This leads to the question of how to identify the factors of benevolence and how to seek what is the optimal materialisation of the required functions. This study has been conducted in both Japan and France. We focused, on each population, on what is the best components arrangement of the product (what to show and how, what to hide), and on which kinematics is meaningful for the user during interaction with the product. The paper describes the design study on food dispensers through a cultural comparison of the perception between Japanese and French people.

Keywords

Expression, movement semantics, benevolence, user centred design.

1 Introduction

Traditionally, man makes tools to extend their abilities. The main disadvantage of the resulting tools is the lack of flexibility, due to the inability to react to changes in the environment, which has to be controlled and kept constant as much as possible. Integrating intelligence into the product should make it able to perceive the environment and to act accordingly, in a benevolent way. This is the way a product should behave, adapting to the variety of users in the diversity of contexts in order to support their social well-being.

Contrary to all expectations, this idea is not new. We can find such a principle in the initial development of the Karakuri Ningyo, the Japanese mechanical puppets, started in the Edo Period. The famous ChaHakobi, a tea server puppet, was developed to seduce the guest, by bringing tea in an abstractive way, through the stylisation of the movements of the face, deepness of communication between the guest and the host. This is the first example of a product adapting to the users behaviour and conveying benevolence stance. We believe that, since ancient times, people aspire to transformations and self-achievement. If any product could support this aspiration, how could it bring its contribution?

2 Method

Designing a new product can be seen as an opportunity to investigate the consumer's needs and expectations as well as the behaviours in particular contexts of the daily life. In the process of designing an automatic food dispenser, we tried to investigate the perception people get from the existing ways of delivering food (automatic movement and manual gestures) in order to integrate the main features characterising the aforementioned delivery modes. This paper presents the output of the study that compared the Japanese and French cultural perceptions about vending machines.

The first step of the study is to reveal the values that people associate with the existing food vending machines and with the existing most pleasurable manual food

delivery modes. The resulting semantic attributes are illustrated by drawings showing the most current food delivery modes presented to the participants through a questionnaire. The first results present the semantic values of each delivery mode regarding both populations (French and Japanese). The second however, reveal 5 factors that have been found to influence the perception of the delivery modes. In this step, we evaluated the existing delivery modes for both populations, thus taking into account the semantic attributes found in section 1. In the third step, we selected the most relevant food delivery modes for each population and tried to measure the influence of each of the 5 factors independently and correlatedly.

2.1 Needs and expectations regarding the food vending machine

The first market study on this topic was done on 40 participants, 20 in Japan and 20 in France. The results we gathered showed that the main drawbacks of the vending machines are their connotations; being seen as cold and not user-friendly by both people in France and Japan, especially among the female participants. In fact, vending machines are perceived as not creating any positive experience for the user. It only completes the function of “food delivery”. Vending machines delivery modes involve for instance throwing the goods purchased in the retrieval zone of the machine, which may be inaccessible to some customers. This may be the case because the machines have been designed that way to prevent from vandalism and robbery. This is conveying as well as inconvenience a feeling of rudeness that does not offer a pleasurable moment to the consumer. A customer that wants to buy a product that is selling on the top shelf in the vending machine, puts his money in the coin slot and then the vending machine drops the product from the top shelf all the way down to the very bottom of the machine to deliver the food. The main expectations of the participants are to feel carefulness, simplicity, elegance, respect and benevolence during interaction with the food vending machine.

New innovations like the “soft drop”, which is a lift that conveys goods more carefully in the retrieval zone of the machines, are being made recently in Japan and France. Also, some Japanese makers, through a universal design approach, are now proposing a more user-friendly food vending machine that catered for the needs of elderly consumers (numerous in Japan) and women by making

the product retrieval easily accessible. But still few have been done to adapt the delivery modes to the diversity of users and major aspirations.

2.2 Existing food delivery modes and semantics of movement

The following section presents a selection of existing food delivery modes that can be observed in food markets, fast-food and non fast-food restaurants. Each mode is a schematised drawing associated with photography. Physical, observable similarities and differences between the delivery modes contribute to determine the semantic attributes associated with each mode or group of modes. The pictures of the gestures were presented to participants who were asked to classify them by preference and ascertain whether they have a positive or negative impression as well as the meaning they convey.

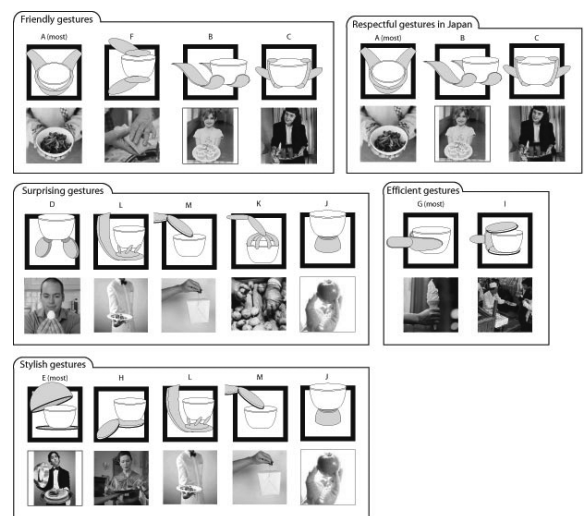


Figure 1. Resulting semantically common groups of modes done by participants

Food delivery modes B, G and I are commonly observed in France and Japan, while more specifically to Japan are modes A, B, C and F. Gestures A, B and F have been perceived as friendly by both populations, gestures D, E, K, L are perceived as being surprising, while E, L, H, J, M as stylish gestures.

The results of this first survey show that people’s preferences are, most of the time, for one specific group of gestures (i.e. some people had a positive impression on the stylish gestures and preferred them). It allows us to see that some gestures are perceived as positive and are appreciated by the majority of the people: A, B, C, E, H, and L.

The preferred gestures are mostly categorised as respectful, stylish and surprising gestures, while more common or efficient gestures were chosen in second position. Probably those choices would be different in a real life situation, where the persons will be expecting a quick and efficient service of the vending machine and will be busy. Those results thus cannot be considered as real expectations, but allow to define potential expectations of people for the delivery of food. The first step enables us to notice the preferences among Japanese participants in regards to two-hand gestures associated with the semantic attribute of respect in the first place, whereas French people selected mostly elegant and friendly gestures. However, one weak point of this questionnaire was that it relied on people's imagination and personal experience with only static pictures. Nevertheless, this questionnaire has been a means to determine more precisely the semantics of the gestures, highlighting the factors that could influence the perception of the food delivery systems.

Factors influencing food delivery gesture semantics:

The factors influencing perception of delivery modes have been classified as follows from most impacting (Factor 1) to less impacting (Factor 5) :

Factor 1: Two- or one-hand gesture

Factor 2: Size of the surface of contact with the goods

Factor 3: Direction of movement

Factor 4: Position of the point of contact on the goods

Factor 5: Speed of movement

Factor n°1: One- or two-hand gestures have been found as being strongly linked to the semantic attribute of respect and politeness.

2 hands gestures:



1 hand gestures:

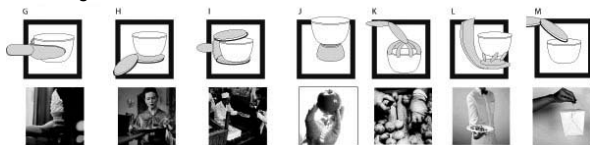


Figure 2. Two-hand and one-hand gestures selected among existing food modes of delivery

Factor n°2: The importance of the contact area with food affects the preferences. Below, the selection is organised using the size of the contact area with the food.

Factor n°3 : Position of the point of contact

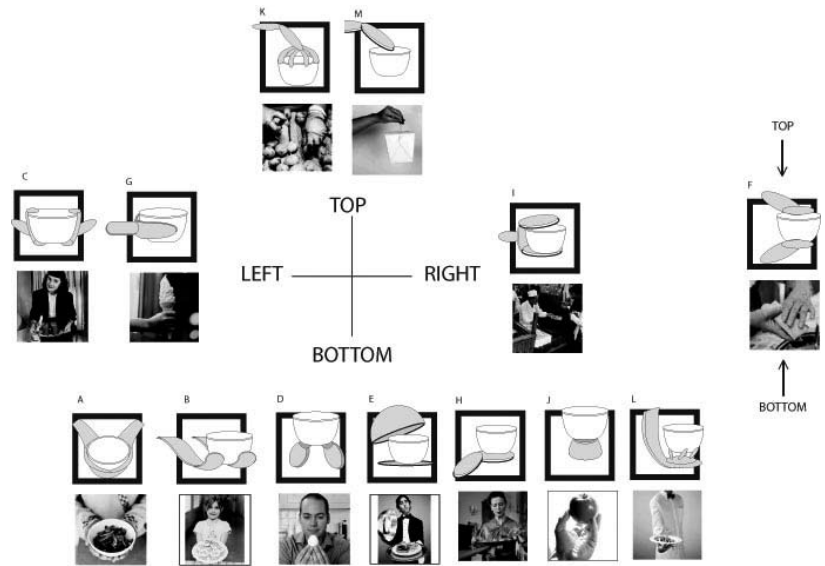


Figure 4. Classification of the food delivery modes using the point of contact

Factor n°4: Direction of movement of the mechanism

Factor n°5: The speed of movement of the mechanism

$t = 60 \text{ ms} / \tau = 100 \text{ ms}$

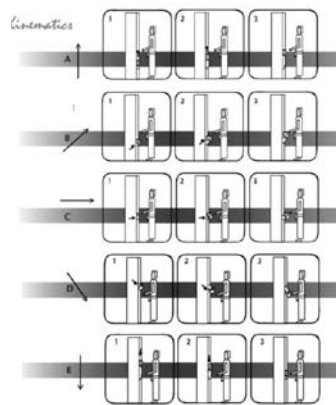


Figure 5. Classification of the gestures using the direction of movement

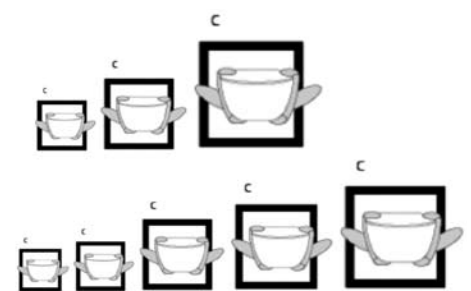


Figure 6. Qualitative representation of two different delivery speeds

Among existing vending machines, the parameter of speed is not used to convey any meaning or used to play a role in the expression of semantic attributes through movement dynamics. This parameter is defined in order to deliver the goods as fast as possible without damage.

The main advantages of vending machines are obviously to get goods immediately and to avoid waiting queues. However, taking into account fast service and respectful handling of the goods it can be interesting to exploit the speed variations (acceleration and deceleration) to evoke a meaningful gesture to adapt to people's expectations and contexts.

3 Outputs of the preferences and semantic analysis

3.1 Protocol

In the previous sections, 40 participants were involved through a questionnaire method; 20 Japanese (8 females/12 males, 8 employed/12 students), and 20 French (10 females/10 males, 13 employed/7 students).

As shown in the figures below, participants have been asked to express their preferences, their positive impressions and to express the connotative values conveyed by each presented gesture.

3.2 Results

3.2.1 Preferences

From the first question, major preferences observed in Japan and France seem not to converge at all. Indeed, while gestures A and B are by far more preferred by Japanese people, French participants timidly announce their preference quite equally for the modes E, L and H.



Figure 7. Qualitative representation of two different delivery speeds

The modes selected in the first place by the Japanese participants are gestures that were previously classified as “Respectful” and “Friendly” (see figure 1). On the other hand, the gestures chosen by the French participants were classified as rather “Stylish” and “Friendly”.

Those results show that people's preferences, most of the time, can be found in one specific group of gestures (i.e. some people positive first impression were the stylish gestures). At this stage, we noticed that in one specific group of gestures there are physical similarities. In fact, gestures A, B, C are two-hand gestures and have an important surface contact with the goods. Whereas,

gestures B, L and H have got a small surface contact with the goods. L and H have got nearly the same physical similarities but the direction of movement is different. Apparently, Japanese participants' preferences are focusing on two-hand gestures, as they convey a meaning of respect, particularly important in Japan, while French preferences are mostly found among “Stylish” gestures using “one-hand”.

Regarding the mode E which is the “bell jar service” that was a direct metaphor of a food delivery mode, it has been appreciated by both groups of participants, also less strongly by the Japanese. In this case, people could identify more rapidly the meaning conveyed by this metaphor that brought a positive impression to every participant as it was clearly understood.

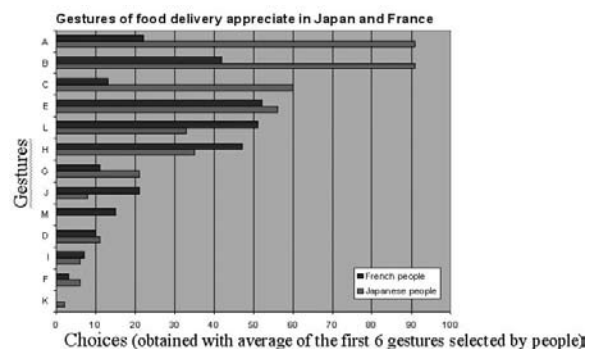


Figure 8. Japanese and French preferences regarding the delivery modes

Regarding the aversions, the Japanese and French seem to share the same judgement for disliked gestures. Indeed, as we can see in figure 9, mode K is neither appreciated in Japan nor in France.

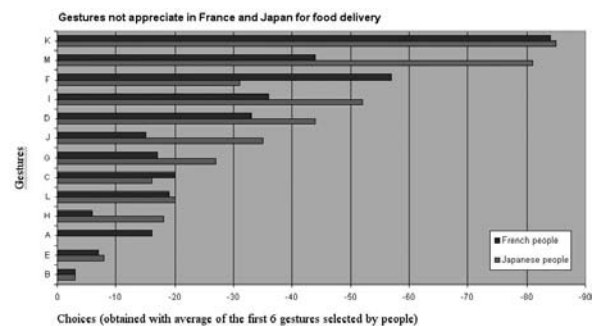


Figure 9. Japanese and French aversions regarding the delivery modes

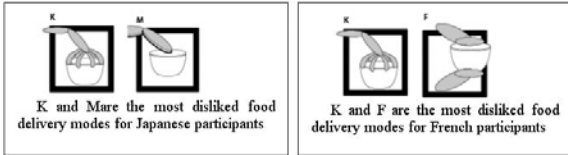


Figure 10. Aversions of the participants regarding food delivery modes

Gesture K is badly perceived by people in both countries. This shape is conveying a negative connotation. How did the people interpret this shape in Japan and France? Some verbalisations mentioned the characteristic “UFO catcher” and the top position of the point of contact with the goods that convey a bad connotation in both countries.

We could notice that the top position of the point of contact with the goods had been badly perceived by people, as K and M gestures, selected in last position by participants, commonly show this feature. However, M gesture has not been as badly perceived by French people as by Japanese people. We guess that it is a difference of recognition of the meaning conveyed by this gesture. This gesture previously classified as “stylish gesture” is expressing signs to people in different ways in France and Japan.

L, D and J gestures get two different appreciations among French participants, while they were apparently converging in a positive impression for most of French people, they have been chosen as the worst by a sub population of French. The gestures have got physical similarities as they have a small surface contact with the goods and convey a rather surprising emotion. Apparently, a minority of French participants are not sensitive to those signs and will not like to be surprised during the interaction.

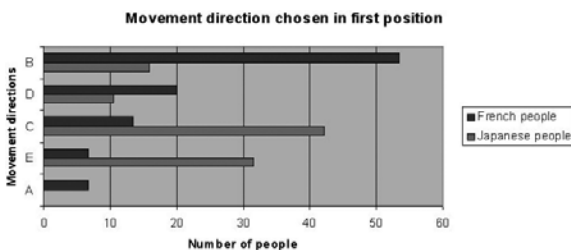


Figure 11. Preferred movements directions chosen by Japanese and French

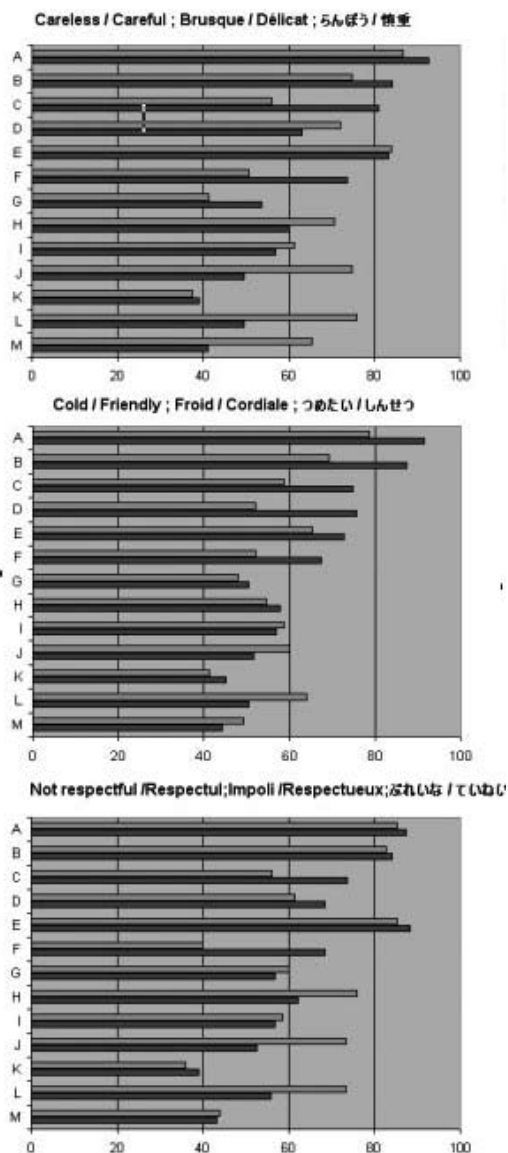
B and C gestures have been preferred firstly by these participants; The “B” movement direction has been largely chosen by the French participants while the “C”

movement direction has been preferred by the Japanese participants. We presume that they have been chosen firstly, as the final position of the device is the same and convey and impression of easiness as the good is coming directly in the hands of the person.

We also assume that they have been selected as they both allow to have an upper view of the goods purchased before it comes to hands and thus allow to visually check the aspect of the food.

3.2.2 Semantic values

Regarding the semantic evaluation of the delivery modes, the 13 gestures have been evaluated regarding the following attributes: careful, respectful, friendly, stylish, efficient and simple. The results are shown above in figure 1.



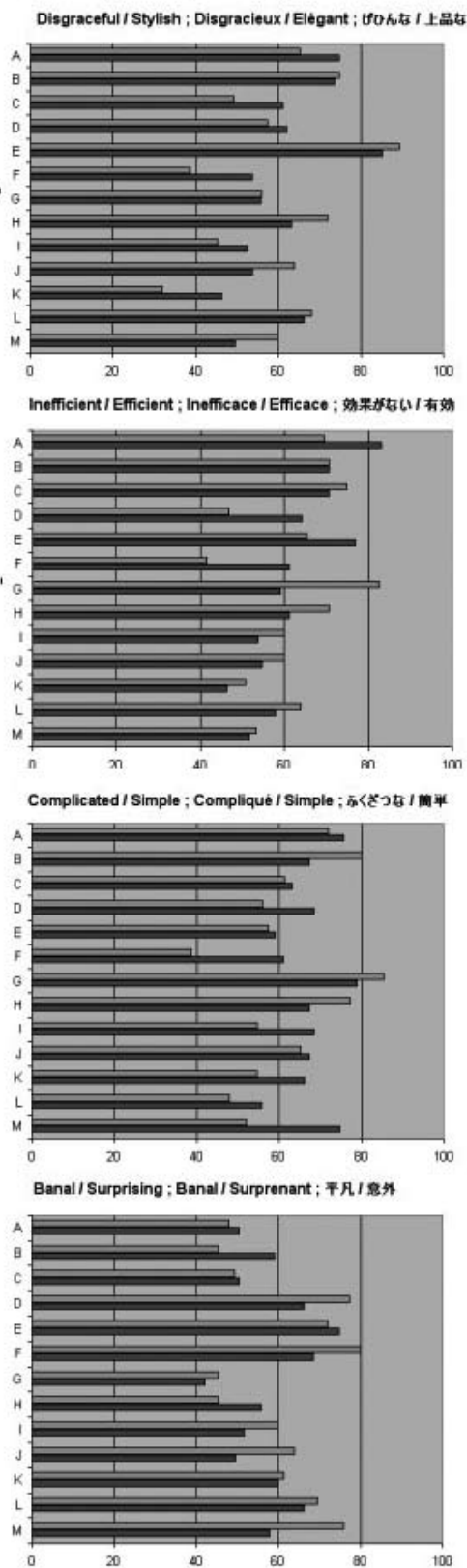


Figure 12. Repartition of the 13 food delivery modes regarding the semantics attributes from the Japanese and French points of view.

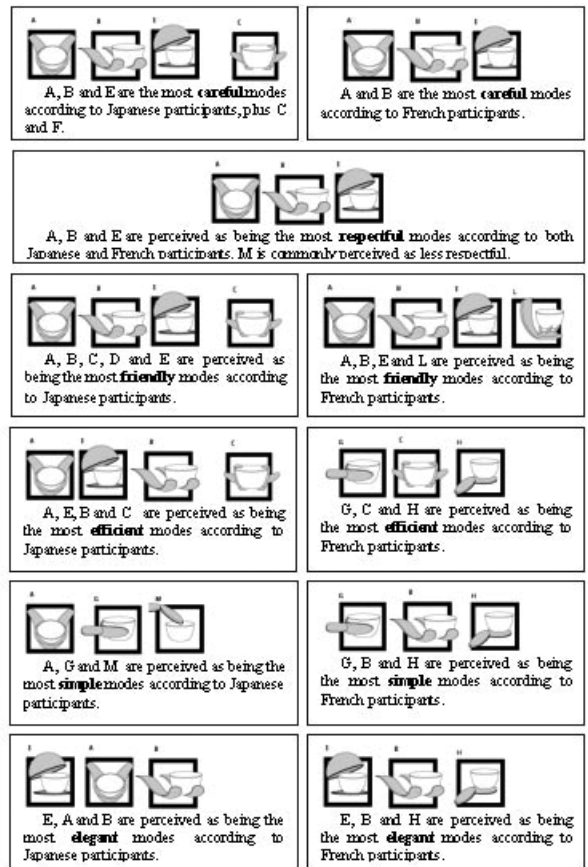


Figure 13. Repartition of the 13 food delivery modes regarding the semantics attributes from the Japanese and French points of view.

In order to insure if there is a gap between the French and the Japanese individual perception of respectful gestures, considering the gap found in the use of language, we wanted to know if the signs were understood in the same way by the French and Japanese participants regarding the two keywords chosen : Respectful and Friendly.

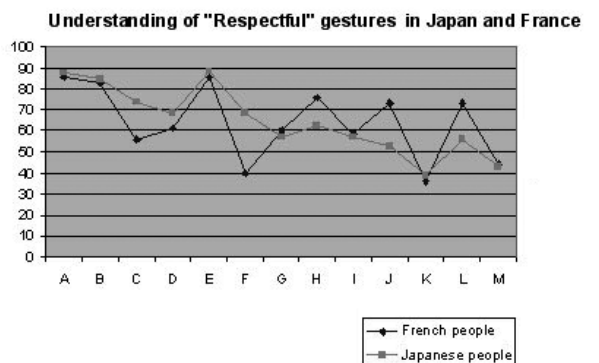


Figure 14. Differences in the perception of "Respectful gestures" by the Japanese and French

The understanding of “ respectful” by people in France and Japan shows that Japanese participants have associated “respectful gestures” with two-hands gestures only, as expected, especially gestures, E,A, B. While French people have associated as well many one-hand gestures with “ respectful gestures” : H, J, L are found in fact not respectful gestures. We assume that there can be a link with any or no existing respect in the French language in comparison with the highly developed Japanese language of respect known as Keigo. 敬語

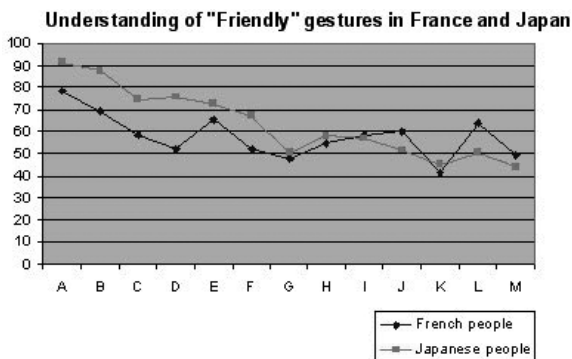


Figure 15. Differences in the perception of “Respectful gestures” by the French and Japanese

We can advance that if we want to express a “Respectful gesture” to people in France and Japan, we will not use the same physical signs to convey this connotation in both countries as they can be understood differently by each population. However we can use the “bell jar” metaphor to convey a positive impression to all people.

4 Validation of the movement semantics through physical experiments

4.1 Protocol

Three food delivery modes have been tested with 8 Japanese and 8 French participants through a short food delivery experience. Videos have been recorded in order to support the researcher realising the delivery test to master the speed and direction for each mode. (see figure 14). Each test presents, for one delivery mode, three variations of speed and three variations in direction. The other factors – number of hands involved, surface contact and position of contact – have been tested in the previous sections.

In this part, however three modes have been selected among them, two are the most appreciated by French and Japanese, they are A (very appreciated by Japanese), H (very appreciated by French) and one that was less appreciated by

both populations but that was considered as very efficient, G (less appreciated by Japanese and French people). Participants were asked to give their impressions while watching the videos (negative -, neutral =, positive +).



Figure 16. Videos showing the experiment on movement semantics for the mode A (movie n° 1) and the mode H (movies n°5, 2, 6, 3 and 4)

4.2 Results

To experiment with videos was very difficult and cannot be considered as being relevant to precisely determine what the impressions of people would be in a real context. The participants had some difficulties transferring the action in a real situation of interaction with a vending machine. However, this short experiment allowed to confirm the cultural preferences previously described. Japanese participants (82%) had a better impression again on the A gesture and French participants (67%) had a better impression again on the H gesture. However the impression was varying according to the speed factor. It would have been interesting to experiment using acceleration or deceleration of speeds of movement. For this experiment the speed of the movement was maintained constant. We proposed three speed variations :V1 = slow;V2 = average speed;V3 = fast, to evaluate a potential impact of the speed factor. Regarding the influence of speed, we observed that speed has an important impact. In fact the delivery modes that were previously very appreciated by Japanese and French people were badly perceived after a drastic augmentation of the speed (V3). On the other hand, slow speed (V1), was not perceived as negatively by participants. We also observed that a minority of people selected as positive the “G gesture” previously perceived as looking efficient associate with a fast speed, V3. According to their verbalizations, they appreciated to have the fastest service as possible as it is a vending machine.

4.3 Proposals

Taking into account the results of parts 3.2 and 4.2, we propose two different delivery gestures for Japanese people (see figure 17) and for French people (see figure 18)

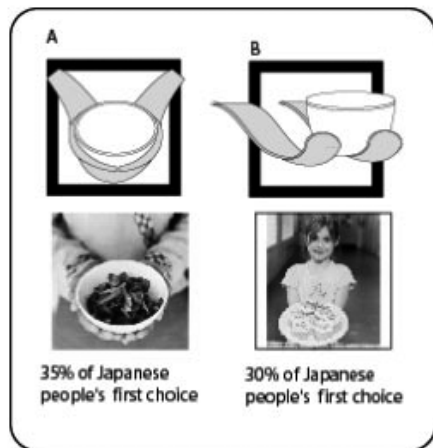


Figure 17. Proposals of gestures preferences in Japan

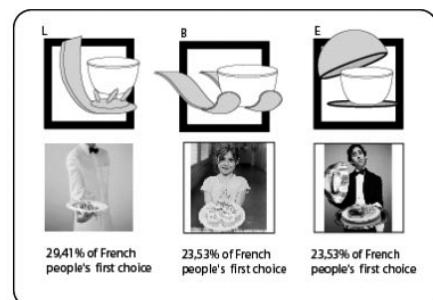


Figure 18. Proposals of gestures preferences in France

The A mode has been perceived as being the most benevolent delivery mode for Japanese people. As previously shown, thanks to the market survey, Japanese people perceived the vending machines as being very “cold”, and the A gesture has been selected as the most friendly gesture by Japanese participants (see figure 13). The “A gesture” is also the favourite gesture in the preferences of Japanese participants.

As for French participants, the benevolent gesture selected is the “E gesture”, the bell jar gesture. In fact, according to the market survey, vending machines are seen as “boring” by many French people and the “E gesture” has been selected as the most surprising and friendly gesture (see figure 13) by French people. “E gesture” is a good balance between the “Surprise” and “Friendliness” for French people. The “E gesture” is also one of the favourite gestures in the preferences of the French participants.

5 Conclusion

As products are dedicated to people, and people are invited to act because a design fits their physical measures and skills, it is to the responsibility of the designers to propose intuitive and context adapted systems for people. In the present study done within the early stage on a food vending machine design, three questions have been treated. The first one concerned the expectations of the users. The semantic attributes “respectful, stylish, friendly, efficient and surprising” are representing the expectations of both Japanese and French participants regarding food vending machines. Secondly, each of the existing food delivery mode (manual as well as automatic modes) has been evaluated through a semantic differential by both Japanese and French population. The outputs bring different results for Japanese and French people. While Japanese participants put in a very high position two respectful delivery modes, both involving a two-hand gesture, French participants focus on more stylish and surprising modes, involving one-hand gestures. The preferences analyses led to 5 factors, influencing delivery mode semantics. Beside the one- or two-hand system, the position of the food and the surface contact with food seem to be discriminative as well. The grasping mode (Referenced as K) is perceived as being the less attractive for both populations. Finally, the speed and the direction of the movement have been found as factors influencing the perception of the benevolence of the delivery modes. These 5 factors impact the perception of quality and influence the acceptability of the final product by the final user. We will use these factors on real mock-ups that are under process, in order to experiment more objectively the variation of the speed and direction of movement for each gesture, and the construction of experience for the user, in each mode. We also try to seek the relationship between factors and perception of action for the user. It should help to seek how to support the user to anticipate what to do and how to do each task requested for the vending machine. We tried proposing to contribute, within the design field, giving keys for making vending machine systems more attractive and benevolent to the users.

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How emotion affects behaviour

Part one: comparison of tools for tracing behaviour and emotion to assist the design process

Abstract

The importance of the study of behaviour in design has often been highlighted. This paper studies ways in which the relationship between the effects of emotion on behaviour may be studied in industrial design. The paper considers the interaction people-objects ontologically as a conversation, as a reflection of emotion through movement, and discusses how behaviour is connected to emotion in design.

Tools for the observation of emotion and behaviour were compared. The tools include Conversation Analysis, Laban Notation, Thinking Out Loud, and the designer's note taking. A new tool was suggested, Feeling Out Loud, for the specific recognition of emotion in users. All tools were used to notate the same interactions between people and objects in controlled experiments. The findings suggest that a combination of these tools can be very useful for studying users' emotional responses, and their effect on behaviour in the interaction with products.

Laban Notation proved useful for studying movement in design, Conversation Analysis helped facilitate the communication of behaviour within organisations by offering detailed description of observed behaviour. Thinking Out Loud assists externalise users' inner thoughts; while Feeling Out Loud helps assists recognition of user emotion.

In the cases in which behaviour was believed to be connected with emotion, Laban Notation and discussion with the choreographer were very useful for revealing a connection between the emotional response obtained from Feeling Out Loud, with the resulting behaviour. Further research will include both techniques in order to assess more thoroughly the connection between emotion and behaviour.

Background

Design Research has often highlighted the importance of developing a better understanding of human behaviour in order to improve user experience (Frascara, 2002; Jordan, 2000; Laurel, 2003). Some research has focused on observing product users and suggesting ways in which their experiences may be improved. A number of tools have been developed to assist in these observations (Don & Petrick, 2003; Ireland, 2003; Laurel, 2003; Plowman, 2003; Purpura, 2003).

In order to study behaviour, it is necessary to understand how it is motivated. One way is to relate it to emotion. Psychologists agree that the main role of emotion is to motivate and control behaviour (Cornelius, 1996; Frijda, 1986; Lattal & Chase, 2003).

Currently, there is a lack of a coherent structure or framework that addresses the way in which behaviour is affected by the emotions products elicit. Moreover,

there is no consistent way in which behaviour may be reported in order to share information inside and across organisations. Often, researchers are required to verbally explain their observations, and as 'digested' accounts of observed events are no longer objective descriptions. Furthermore, reports of behaviour are limited in that they focus on only some aspects of behaviour, and because the complexity of behaviour renders it virtually impossible to explain every single detail.

This indicates two main challenges. Firstly, to offer a more structured description or framework of the connection between emotion and behaviour in design. Secondly, and in order to work on the latter point, to develop a consistent way to report observed behaviour that, even if it presents a version of behaviour, it is also open to interpretation and is *closer to reality*. The first point requires discussion broader than this paper would allow. However, this paper attempts to offer an introduction to the subject.

These points bring up further challenges. Is it possible to encompass a report about behaviour that is *closer to reality*? Reality according to whom? Even if behaviour is reported through media such as video, there are factors that are not included, such as people's thoughts and feelings; even the angle of the camera influences what we see and how we see it. Furthermore, *what* behaviour we see depends on *how* we look at it. A study of behaviour could start by studying its relationship to emotion, and how emotion affects it. This approach would encompass only this side of the equation, and although limited to the connection emotion-behaviour, it would cover an important part of the process.

Observation has been stressed as a necessary way to discover information about users. The inclusion of other tools can be helpful. Interviews can offer insightful information about users. However, many researchers agree that observation expands the gathering of information by making manifest details that users are many times not aware of. However, observation by itself is not sufficient input for developing a relevant understanding of the complexity of behaviour.

If seen under a causal perspective, emotion may be considered as a determinant of behaviour. However, there seems to be a closer relationship between emotion and behaviour, and not a linear continuation. It has been

suggested that behaviour is a part of the expression of emotion, and not a simple reaction (Sheets-Johnstone, 1999). While sometimes it is possible to observe traces of emotion in users behaviour; for instance through facial expressions, many times this is not so evident, and may be misinterpreted. In such cases, it is necessary to obtain feedback directly from the user in order to have more thorough information.

Some tools, such as Thinking Out Loud (TOL), offer an insight about what the user is thinking while performing a task. TOL can also focus on what the user is feeling and thus offer an insight of the emotions that she or he is experiencing. However, this tool may be too intrusive for the user. Some users admit, and even complain, that TOL was too uncomfortable and that the task they performed was influenced by having to say what they were doing. It is also difficult for many people to verbalise their feelings, which could diminish the effectiveness of TOL for this purpose. Nevertheless, some research on CHI has proven that there are some techniques to make users feel comfortable in TOL sessions (Gould, Marcus, & Chavan, 2006). Furthermore, TOL has also been proven as effective as 'retrospective reporting', in which users watch a recording of the performed task and talk about the problems they faced, and so forth (Van Den Haak, De Jong, & Schellens, 2003).

The assessment of people's emotion to objects has taken place in different ways. Desmet developed the tool *Premo* for assessing emotional responses to the appearance of products (Desmet, 2002). People need to be watching a screen where animations of a cartoon expressing different emotions are being played. However, this tool has limitations when used for assessing emotional response to interaction with products. This research suggests Feeling Out Loud (FOL) as a new method to assess people's emotion during the interaction with objects.

These are just a few of the complexities that research needs to face in order to develop a process for the study of behaviour. Behaviour can be defined as what people do. As broad as it is, this definition of behaviour is quite simple. This broadness contributes to the complexity of studying it. This research starts by comparing tools for observing people interact with products, and attempts to highlight advantages from each tool for the recording of behaviour and the recognition of emotion related to behaviour.

This research addresses the following questions:

- a How can design researchers trace and report behaviour in a clear way that can be reinterpreted by other researchers and by designers?
- b How can these reports offer an account of the performed behaviour, and the emotions users were experiencing?
- c How can this be used to address the relationships between the emotions a product elicits, and the resulting user behaviour?

In order to address a) tools for recording and reporting behaviour from other disciplines were compared. The tools include Thinking Out Loud, Conversation Analysis (CA), and Laban Notation. Feeling Out Loud is suggested in this research as a new tool, and was also tested. Each tool offers a focus on a specific part of behaviour. For instance, Laban Notation is a tool to transcribe movement; while CA would normally focus on the speech between two or more people. These techniques are further explained in the Methodology.

In order to address b), three designers assessed the notations extracted from a), including their ease of understanding, flexibility to be reinterpreted, and value for design practice. The discussion section deals with incise c). Each tool offers a focus to a particular part of behaviour, be it movement (Laban Notation), emotion (FOL), interaction (CA), or motivation (TOL). This, in Aristotle's words, would be *the substratum*. According to Aristotle, a particular *substance* is a combination of *matter* and *form*. The matter of the substance is its *substratum*, or the elements that give potential to its form; for instance, the bricks of a house, the movements of a dancer, or the movements of a person using her mobile phone. The form of the substance is what gives it its *differentia*. The actual house is the form, or the dance performed as a whole, or the task performed on the mobile phone, with particular *formal characteristics* that *differentiate* them from any other house and any other dance and any other interaction with a phone. The formula that gives the components is the account of the matter, while the formula that gives the *differentia* is the account of the form.

A record of behaviour is limited and may be misleading if only the account of the matter is reflected. This may happen if only the mechanical part of behaviour is reported, such as movements without a connection

of how and why the movements take place, or without a consideration of the thoughts and feelings of the person. The account of the form needs to be part of the documentation in order to be understood as a whole. In Aristotle's words, the substance needs an account of the matter and an account of the form.

Sheets-Johnstone suggests that emotion is not a precursor of movement. Rather, movement and emotion are part of the same whole (Sheets-Johnstone, 1999). Emotion not only motivates behaviour, and therefore movement, it is rather intrinsically connected to it. Phenomenological theory argues that the human body is a unity that reacts according to stimuli from the environment. An emotion is not processed only in the brain; it is a complex reaction that is connected with movement. In other words, both movement and emotion form the matter and the form.

From an ontological perspective, the behaviour a person engages in when interacting with a product may be seen as a *conversation* with the object. If there is knowledge embedded in the object, the person can read such knowledge and interpret it. The person can then react and engage in an interaction in which there is information passed from the person to the object, and back. If the interaction is seen this way, then it can be analysed with Conversation Analysis tools. Although some authors suggest the knowledge embedded in the object as affordances (Norman, 1990), it has been suggested that a conversation implies more than what an object affords for the user; a conversation allows a more complex relationship between people and objects that is flexible and can grow to different levels than the initial affordance offered (Rodríguez Ramírez, 2006).

Methodology

Step 1

Five people were video recorded performing specific tasks. The tasks were intended to be very simple and short in duration, in order to decrease the complexity of behaviour, and to isolate specific behaviour connected with specific emotions. The tasks were differentiated by the expected level of emotion they would elicit (low, medium, and high). Three different designs of products were used for each task. The tasks were:

- To use a USB memory key to back-up two files (inserting the key, copying, ejecting the key)

	Designer						User						Professional (not explained to designers)						Professional (explained to designers)					
	Notes from field			Notes from video			TOL			FOL			Conversation Analysis			Laban Notation			Laban Notation					
	Mark by designer 1	Mark by designer 2	Mark by designer 3	Mark by designer 1	Mark by designer 2	Mark by designer 3	Mark by designer 1	Mark by designer 2	Mark by designer 3	Mark by designer 1	Mark by designer 2	Mark by designer 3	Mark by designer 1	Mark by designer 2	Mark by designer 3	Mark by designer 1	Mark by designer 2	Mark by designer 3	Mark by designer 1	Mark by designer 2	Mark by designer 3			
Ease of understanding	4	3	3	5	4	4	3	5	3	3	5	3	4	5	4	1	1	1	1	4	5	5		
Average	3.33			4.33			3.67			3.67			4.33			1.00			4.67					
Flexibility to re-interpret	4	3	3	4	3	3	3	2	1	2	2	2	2	1	1	2	1	1	3	3	2			
Average	3.33			3.33			2.00			3.67			2.60			1.33			2.67					
Flexibility to re-observe original behaviour	2	1	1	3	2	2	2	2	3	3	3	3	3	3	3	1	1	1	3	4	3			
Average	1.33			2.33			2.33			3.00			3.00			1.00			3.33					
Value of data for stimulating creativity	3	4	3	3	4	4	4	3	4	3	2	4	4	4	4	3	1	2	3	3	4			
Average	3.33			3.67			4.33			4.00			4.00			2.00			4.67					
Ability to understand the emotional experience of the user	2	1	2	2	2	3	3	4	4	4	4	5	4	4	2	1	1	1	3	4	5			
Average	1.67			2.33			3.67			4.67			3.33			1.00			4.00					
Total	13.00			18.00			35.00			17.35			16.00			6.33			19.33					

Fig. 1 Results from designers' feedback to different notation systems of behaviour and emotion

- To open the packaging of a water bottle and drink from it
- To show off a mobile phone to a friend, specifically by talking about the aesthetics and whether it is easy to send a text message.

The recording of the behaviour took place for each task as follows:

- By a designer: Note taking on the spot, and note taking from the video
- By two professionals: Conversation Analysis transcription, and *Laban Notation* transcribed by a professional choreographer
- By the user: Thinking Out Loud (TOL), Feeling Out Loud (FOL) by the user (focused on the way they were feeling), and deep interview with the user after using the product.

Linguists normally use CA in order to transcribe conversations between people. This may include a casual chat in a café between friends, or an exchange of information between a pilot and control tower. CA transcribes speech, but it can also include other details such as expressions, tone of voice, length of a word, pitch, and so forth. It normally involves two or more people taking turns to talk (Sacks, 1995). In the experiments in this paper, the object is seen as one of the interlocutors, engaging in a conversation with the user. The person doing the transcription was asked to imagine what the object is telling the user, and how the user replies back even if speech was not used during the interaction.

Laban Notation is a system that was developed by Rudolph Laban and initially called Kinetography Laban. It notates human movement, and has not only been used in dance, but also in sports, physiotherapy, and occupational therapy. Its design is considered so universal, that it claims that any movement could be notated by it. It separates the movement system into body, effort, shape and space. The body is divided in body parts and subcategorised on initiation, connection, and sequencing. The effort depends on space, weight, time and flow. The shape is analysed in forms, modes of shape changes, qualities and flow support. Finally, in space, the area that the body is moving

within and the spatial intention are notated (Nahumck, 1978). For this research, not all parts were notated. The choreographer was asked to notate only the moments in which the user came in contact with the specific object under study. Full transcription of the three minute video recording would have taken several hours.

In the TOL and FOL tests, users were asked to say out loud what they were thinking while performing the tasks. For TOL, users were asked to verbalise what they were trying to achieve, how they were trying to achieve it, and what obstacles and aids they found. For FOL, users were asked to focus on verbalising how they were feeling during performance of the task. For the mobile phone test, users were asked to include the way they were feeling about a product in their descriptions to their friend. Users were introduced to the techniques (TOL and FOL) through practice tasks, prior to the version recorded. In the case of FOL, the practice tests had to be repeated several times before people felt comfortable to express their feelings out loud.

Step 2

The recordings were shown to three industrial designers with many years of international experience in practice and research. They were asked to evaluate the behavioural notations according to the

- ease of understanding
- flexibility to re-interpret
- flexibility to re-observe original behaviour
- value of data for stimulating creativity
- ability to understand the emotional experience of the user.

Each of the five points above was qualified in a range from 1-5 (five as highest). A table was drawn with the results from all designers (Fig. 1).

Step 3

Participants were asked to give feedback about the tools and this was included in the final discussion.

Results and Discussion

Designers were asked to write and draw notes from the observations in order to have a 'control group'.



Fig. 2 User B feeling 'frustrated' when performing the task.

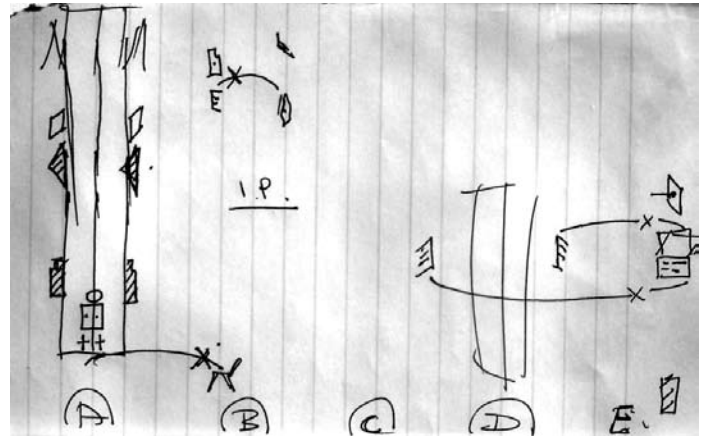


Fig. 3 Detail from the choreographer's notes, using the Laban Notation system. It also expresses user B's frustration from Fig. 1.

This allowed the researcher to compare how useful designers found the other tools, compared to their own notes (Table 1).

First of all, designers found useful to watch the video and the response increased from 13/25 from their original notes (25 being the highest possible), to 16/25 after watching the video. The lowest score was given to Laban Notation. This is not surprising given that designers had been given an introduction to the technique, but were not proficient with the system, which is difficult to comprehend and comparable to encountering a new alphabet. This response suffered a dramatic change when the choreographer explained her notations and findings to the designers. Laban Notation with explanation by the professional received the highest score with a 19.33/25. FOL was second with 17.33/25.

These findings do not attempt to be statistically valid. Their main objective is to highlight the advantages and potential of these tools for design research in observing and reporting behaviour. In spite of this, it is necessary to mention that the success of Laban Notation might have been due to the interaction with the professional choreographer. In this case, designers were openly excited to hear the interpretations of the beauty of movement given by the choreographer. This suggests that regardless of the tool used, the main value of the Laban Notation test was to observe behaviour from a dance perspective. Designers might not need nor desire to learn the Laban Notation technique, but agreed that developing such artistic sensitivity to movement would be extremely beneficial for the design of interactions with products.

The success of FOL in these tests might be due to the novelty of obtaining direct feedback from users about their emotional experience with products. This is particularly the case for designers that are interested in the emotional responses of users.

CA and TOL received the same score as the designers' notes taken from video. However, each tool scored higher on different grounds. Notes from video scored higher in terms of ease of understanding. TOL was highest amongst the three for value for stimulating creativity. CA scored high both in ease of understanding and value for stimulating creativity. Designers commented that CA could be a good tool for pointing out a particular behaviour that a design researcher wants to convey to the design team. It offers information in detail about the behaviour performed, and it is easy to read, there is no need to learn a new system. Moreover, combined with the original videos, CA can be rewritten and reinterpreted to communicate new findings across the organisation. FOL was considered as the strongest tool for recognising people's emotion. Laban Notation and CA were very useful tools for recording behaviour. For instance, when user B was performing the USB Memory Key test, FOL clearly expressed her frustration and deceit when it was difficult to insert the key to the laptop (Figure 1). In an independent observation, the choreographer notated this frustration and the behaviour that accompanied it. The transcription symbols read as: "B leaned to the side, with her torso to the front, attempting to put object 1 (the key) into object 2 (laptop), repeating movement three times, leaves objects and goes back to original position" (Figure 2). A combination of FOL, Labanotation and CA showed in this case useful for the study of behaviour.

Conclusion

The complexity of behaviour renders it impossible to find one tool that offers a thorough analysis from different perspectives. This study suggests that tools can be used for different purposes and that a combination of them offers a more complete analysis.

Note taking by designers was not considered as useful as expected. Feedback from other disciplines and from the users proved much more revealing. Re-watching the behaviour on tape proved to be a relevant research tool for design practice.

These tests suggest that TOL can be useful in becoming more familiar with people's inner thoughts. The initial problems for users that were uncomfortable with the technique, were easily overcome after carrying out practice tests. The main limitation of TOL is that users often end up saying out loud very obvious activities that were already easily observed by the researchers.

FOL proved to be a very useful tool for recognising people's emotional reactions to products. In this case it was more difficult to compel people to open up. More trials were required before people felt comfortable to express the way they were feeling. Furthermore, it was difficult for people to 'learn' to identify and verbalise their own emotions. However, when asked to re-watch the TOL and FOL videos, users agreed that most of what they said, especially during FOL, had been insightful. Some of them were even surprised to hear themselves speaking that openly.

It can be said that Laban Notation is a useful tool for addressing movement in design; CA helps facilitate communication of behaviour within organisations by offering detailed description of observed behaviour; TOL helps externalise users' inner thoughts; while FOL helps researchers recognise users' emotion.

In the cases in which behaviour was believed to be connected with emotion, Laban Notation and discussion with the choreographer were very useful for connecting the emotional response obtained from FOL, with the resulting behaviour. Further research could use both techniques in order to assess more thoroughly the connection between emotion and behaviour.

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These observations and comparisons fall short from offering a detailed description of behaviour. However, they are an initial step in organising the tools and identifying the areas in which they can be used in design. For instance, one of the designers expressed his serious interest on learning Laban Notation, because he would find it very useful for studying movement in his product designs.

Finally, the tools can be very useful for design research and practice, but there remains an important need for researchers to develop a sensitivity to people's needs, and desires, as well as the hidden beauty in behaviour.

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In search of a golden ratio for the aesthetics of movement

Abstract

There is a growing interest among designers and design researchers in dynamic forms, behavior and the associated questions regarding the meaning and the aesthetics of movement. In this article we address a simple, perhaps naive, question about the aesthetics of movement: are there one or more numbers that are as fundamental in a theory of beauty in movement as the golden ratio is in two-dimensional aesthetics and the plastic number is in three dimensional aesthetics. The paper is essentially theoretical, and as such it proposes a number of hypotheses that, at least in principle, can be tested by experiment.

1 Introduction

The theory of the golden ratio has been a cornerstone of the geometric approach to aesthetics in architecture, design and painting. At present there is a growing interest among designers and design researchers in dynamic forms, behavior and the associated questions regarding the meaning and the aesthetics of movement. Therefore we address the question whether there exists a kind of proportion like the golden ratio, that could play a similar role for movement.

The structure of this article is as follows. In Section 2 we discuss the problem statement in a theoretic framework of two, three and four-dimensional spaces. In Section 3 we enumerate the technical developments that motivate this research. In Section 4 we compare the situation with an

earlier phase in design history. Starting from the concept of symmetries (Section 5), in Section 6 the theory of golden ratio and the three-dimensional plastic number are explained.

Then Sections 7 and 8 form the heart of the article: in the section "exploring time-space" the concept of eigen-value is introduced. Sections 10, 9 and 11 tentatively relate the technical results back to their possible role in design.

2 Problem statement

The theory of the golden ratio has been a cornerstone of the geometric approach to aesthetics in architecture, design and painting. The basic idea is that in many well-proportioned compositions there are certain dimensions (lengths) that relate according to the ratio $1:\Phi$ where the number $\Phi = 1,618\dots$. This number can also be found as the solution of a simple quadratic equation; roughly speaking it is the ratio of a rectangle such that when a square is cut-off, the remaining rectangle has the same proportion again (more details in the next section). This ratio also plays a role in nature: many patterns that emerge are governed by the same ratio¹.

In three dimensions, there is another number, called the plastic number, first discovered by Dom Hans van der Laan (See Figure 1), which lies in the heart of a theory of proportions in architecture. In the same way as for Φ , there is no simple recipe for beauty. Like the golden ratio, the plastic number can be derived in an algebraic way. It is the solution of a cubic equation. As Padovan [1] puts it:

(quote) Its derivation from a cubic equation (rather than a quadratic one such as that which defines the golden section) is a response to the three-dimensionality of our world. It is truly aesthetic in the original Greek sense, i.e., its concern is not 'beauty' but clarity of perception. (end quote)



Fig. 1 Architect Dom Hans and one of his architectures.

Next to special ratios, also various concepts of symmetry lead to perceived beauty. In fact, the re-occurrence of the small rectangle inside the original rectangle with the golden ratio, is a special kind of symmetry. Important symmetries are rotations, translations, and mirrorings. At present there is a growing interest among designers and design researchers in dynamic forms, behavior and the associated questions regarding the meaning and the aesthetics of movement. In this article we address a simple, perhaps naive, question about the aesthetics of movement: are there one or more numbers that are as fundamental in a theory of beauty in movement as the golden ratio is in two-dimensional aesthetics and the plastic number is in three dimensional aesthetics. We may define 4D space as movement in 3D space, taking time as the fourth dimension. Of course we are not the first to look for designing beauty in 4D space. Apart from choreographers, we mention pioneering artists such as Laszlo Moholy-Nagy and Jean Tinguely (see Figure 2)²



Fig. 2 Jean Tinguely creating one of his playful machines.

Their devices used to produce a lot of sounds: motors, drive belts and assorted metal parts moving at different speeds. For Tinguely this was a feature rather than a problem, but imagine what becomes possible if the machines can be lightweight and silent. Imagine that we will have new technologies that give complete freedom to make let arbitrary forms make the movements we wish to design.

3 Technical background

There are good reasons to believe that within the next decade, a number of new technologies become available to let objects move. The two major developments are:

- advances in mechatronics, that is, the combined usage of mechanical engineering and electronics. This is the continued evolution of an existing field.
- advances in active materials such as smart memory alloys and active polymers. This is a revolutionary development, where radical new solutions are underway.

We discuss the advances in mechatronics first. The mechanical elements are still the same, but the numbers of components increases whereas their size decreases: solenoids, levers, gearwheels, axes, springs, etc. They form DC motors, AC motors, stepping motors, linear motors, electromagnets, and dedicated assemblies, as they do for decades. But the sensors for position, force, speed etc. become cheaper and smaller!

Therefore, feedback improves the precision and °exibility of whatever assembly (as in the servo-motor). Electronics of neglectable size does what used to be done by bulky components; step-up and step-down converters replace transformers; switched controls replace resistors and transistors that used to require heat-sinks. Notoriously difficult-to-control motors such as AC motors and stepping motors become easy. Energy can be stored more compactly, in better batteries, and with more precise charging control.

We discuss the advances in active materials next. Memory alloys such as nitinol are well-known for small and popular robotics projects, see for example the mosquito of Fig 3. More effective variants of this material are being developed.

¹ Some care is needed, however, there is no guarantee that applying the golden ratio in a design or painting automatically yields an aesthetically pleasant result

² Or better go see their works in a museum like the Van Abbe or see the movie fragment at http://encarta.msn.com/media_461546466/Jean_Tinguely_at_Work.html

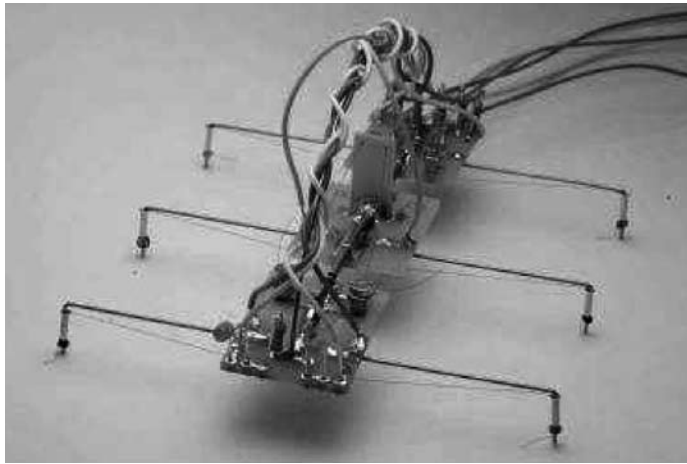


Fig. 3 Artificial mosquito with muscle-wires (Micronet Munich).

Very promising is the development of electric active polymers. The Intelligent Robotics and Mechanic Systems Laboratory (Korea) proposed already a dynamic braille display based on electric active Polymer (Figure 4, see <http://mecha.skku.ac.kr/research.htm>). More and stronger materials are being developed, amongst others by the Dutch Polymer Institute. Progress is being tested by an annual arm-wrestling competition between artificial muscle systems. For a survey we refer to Rauterberg et al. [2].



Fig. 4 ElectroActive Polymer Braille display by Ig Mo Koo

Extrapolating these developments, it makes sense to assume, at least for the sake of the discussion, that some day not too far from now, we will be in a position and have the complete freedom to let any object make the movements that we, as designers, want it to make.

4 The opportunity and the challenge

Now assume we have the complete freedom to let any object make the movements that we, as designers, want. At first thought this seems a fantastic opportunity to exploit such great freedom and get rid of conservative stereotypes. The situation is very much like in the 1960s, when electronics had become so small and flexible that products could have any form the designers want them to have. What happened in the 1960s?

With the advent of solid-state electronics, electronics became so small and flexible that products like radio receivers and amplifiers could have any form the 1960s designers wanted. One of the things that happened was that the designers turned to geometry. For example Dieter Rams who felt good design is as least design as possible.



Fig. 5 Braun SK55

He tried to keep the forms pure and simple. The Braun SK55 record player³. he designed with Hans Gugelot is shown in Figure 6. In the Figure its front plate is analysed on the basis of four squares. The move to geometry happened earlier in architecture (after mastering of concrete) and in furniture design (after the advent of steel, aluminium and plastics). In the 1960s electronics was ready for it. Another Braun example, the T1000 is shown in Fig. 6. Again, squares are the dominant geometric theme.

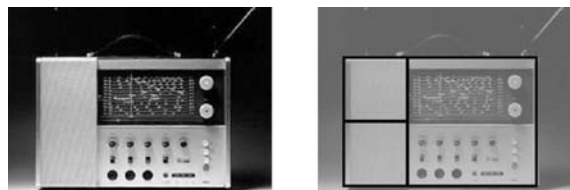


Fig. 6 Braun T1000

Geometry was a natural choice, because it is well-accepted that there is considerable beauty in the patterns and proportions stemming from geometrical

³This design is so pure, it even has been called Snow White's Coffin

constructions. It would be a big mistake to conjecture that geometry is the only, or even the dominant source of beauty: this is not a viewpoint I wish to take or defend. I am well aware that ethical viewpoints heavily influence aesthetic perception⁴. A product can be loaded with cultural values which may or may not be appreciated and this appreciation is translated into one's opinion about the beauty or ugliness of the product. Yet it has been and still is worthwhile to explore fundamental geometric principles such as symmetries and proportions, and use them for aesthetic reasons.

The value of the results are a complex and subjective matter. The geometry alone, belonging to the realm of abstract knowledge (mathematics), does not tell what will or will not be seen as beautiful⁵. Another designer clearly fascinated by geometry was Jacob Jensen, who worked for B&O. Not only are his designs geometric, they also contain references to the slide rule (Dutch: rekenlineaal), as shown in Fig. 7. The Beolab 5000 shows how geometry and cultural values are really intertwined.



Fig. 7 Beolab 5000 (1967) and slide rule.

5 Symmetries

A most important source of beauty in geometric constructions is symmetry. There are various types of symmetry, e.g. translations and rotations. The mathematicians explain symmetry as invariance under a transformation. In other words:² perform a certain transformation, and ² check, that the pattern is essentially unchanged. So for the frieze pattern of Fig. 8 the transformation is nothing but translation: taking the pattern and shifting it over a certain distance d to the right.



Fig. 8 Frieze (translational symmetry)

If we do that, we see that we get the same pattern again (assuming that it stretches to infinity at both ends, which is no problem in mathematics). Of course if we shift it over $2 \times d$ or $3 \times d$ we get the same pattern again. Another example is rotational symmetry. Rotate the pattern over 30° and check to find the same pattern. This has been

used e.g. in the rose windows of cathedrals such as Notre Dame, Paris, see Fig. 9.

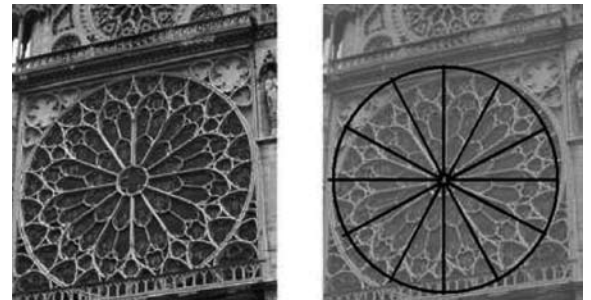


Fig. 9 Rose window (rotational symmetry)

Now we turn to one of the most famous geometric constructs, the golden ratio. Sometimes it is defined as a ratio, not referring to 2D space at all, as in Wikipedia: (Quote) two quantities a and b are in golden ratio if their sum is the larger quantity as the larger is to the smaller (end quote). If the quantities are a and b , the ratio $\frac{a+b}{a}$ should equal $\frac{a}{b}$. This ratio is a number denoted as Φ or just Phi. It can be shown that $\Phi = 1.618\dots$, say 1.618, approximately. At first sight this has not much to do with geometry, let alone symmetry, but we will explain this useful connection now. If we take a rectangle whose sides are in golden ratio, in other words, the long side equals 1.618 times the short side, then we can perform a transformation consisting of three steps:

1. cut off a square from the rectangle;
2. take the remaining smaller rectangle and turn it by 90° ;
3. scale it up until the short side fits the short side of the original rectangle.

Then we find the same rectangle, in other words, the long side of the transformed rectangle equals the long side of the original rectangle as well. For the formal mathematical treatment we refer to Section 6.

6 The golden ratio and the plastic number

Now we will derive the quadratic equation for the golden ratio. Readers who do not like math can skip this section. Consider the rectangle ABCD of Figure 10.

$$\begin{aligned}
 x &: 1 = 1 + (x-1) \\
 x \cdot (x-1) &= 1 \\
 x^2 - x - 1 &= 0 \\
 x_{1,2} &= \frac{1 \pm \sqrt{1+4 \cdot 1}}{2} \\
 &= \frac{1 \pm \sqrt{5}}{2} \\
 x_1 &= 1,618033\dots \\
 x_2 &= 0,618033\dots
 \end{aligned}$$

Fig. 10 Formal derivation of the golden ratio by quadratic equation.

⁴This has been well demonstrated by Philip Ross in Industrial Design who organised a workshop where we had to design after being put in a Nietzsche, Confucius, or Kant mindset; Also see Alain de Botton's book (the architecture of happiness) who explores links between ethics and aesthetics in architecture.

⁵An example of an approach that is extremely geometry-focused is Kimberly Elam's book (geometry of design)

The three-step transformation of Section 5 says that first we have to cut off a square from the rectangle. The square is AEFD. Therefore the remaining smaller rectangle is BCFE. Without loss of generality we may assume that the sides of the square have length 1. So $AE=1$ and $AD=EF=BC=1$. We want to know the length of AB, this is our unknown. Let's call it x . If $AB = x$ and $AE = 1$ then $EB = x - 1$. Now we have to take BCFE, turn it by 90° and scale it up until the short side fits the short side of the original rectangle. From this, the equation for x follows, see Figure 10. There are two values of x for which the equation holds. The largest of these solutions is ϕ .

In the same way, the plastic number can be derived as the solution of the equation $x^3 - x - 1 = 0$. The math is in Figure 11.

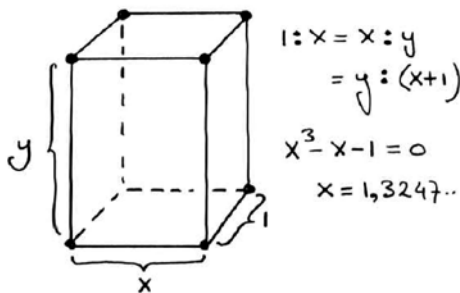


Fig. 11 Formal derivation of the plastic number by solving a cubic equation.

The golden ratio appears frequently in nature together with the so called Fibonacci numbers.⁶

The golden ratio is also used in the a-posteriori analysis of existing designs, buildings, paintings etc. By overlaying various geometric constructions upon existing works, one rediscovers or discovers occurrences of the golden ratio (see for example [3]). One may question the validity of such a-posteriori analyses, but that is not the point we want to make here. We just observe that it is a method of analysis, amongst other methods of analysis.

7 Problem statement, revisited

Question: are there one or more numbers that are as fundamental in a theory of beauty in movement as the golden ratio is in two-dimensional aesthetics and the plastic number is in three dimensional aesthetics?

Even if we consider only the movement of a small object along a path, we are faced with a fundamental difficulty. The trajectory (path) of the object and its orientation

(rotation) in space can be described by purely geometric means, describing the positions it occupies. But the (possibly variable) speed of the movement must play a role too, since a certain path with a certain speed may yield a beautiful effect whereas precisely the same path with another speed pattern could be ugly. If we want to describe position as a function of time, $x = x(t)$, say, we need to compare lengths and durations. Alternatively, speed has to be described as a certain number of meters per second. This is the difficulty: whereas the ratio of two lengths is independent of the unit used (meters, inches, etc.), it makes no sense to compare a length and a duration since the outcome depends on the units used. One meter per second is 3.6 kilometer per hour and since such units are arbitrary human artifacts, one cannot expect to find a fundamental equation or a number that is invariant under a change of unit-system. So how can we expect to find something fundamental at all?

The same problem appeared in the theory of relativity. The solution was found Lorentz and Einstein. They adopted speed of light $c = 300,000$ km/s as a universal constant. Their equations get there purest form if time is scaled such that c is taken as the unit of time. But for a theory of beauty in movement this solution makes no sense since there is no way by which the human eye could possibly follow movements of such extreme speed. In this article we explore another possible solution by studying the equations and the constants that define the "natural" movements of objects. Then we assume then they are related to the beauty and naturalness of the perceived movement. More specifically, we refer to the concepts of eigen-value and eigen-function that appear in many physical problems. The insights that may come out of this investigation can be combined with another important notion, human movement (anthropomorphism as a source of beauty). Again, symmetry can be considered as well. It will also be interesting to consider the possibility that the "natural" speed sets a kind of standard, by which the actual movements are judged. For example, in a value-system where control, thoughtfulness, peace of mind are highly valued, it seems plausible that a slow movement is appreciated over a fast movement and that "slow" means: slower than the "natural" speed.

8 Exploring time-space

There exists an elegant physical theory about the dynamics of moving mechanical systems constructed from elements such as springs, solid masses, dampers,

⁶ Fibonacci numbers work as follows: One starts with the numbers 0 and 1 and then one can produce new numbers by adding the two previous numbers. So $0+1=1$, $1+1=2$, $1+2=3$, $2+3=5$, $3+5=8$, $5+8=13$, $8+13=21$, and so on. The numbers 1, 2, 3, 5, 8, 13, 21 are called Fibonacci numbers.

Formally $F(n) = F(n-1) + F(n-2)$. It can be shown that the ratio $F(n) : F(n-1)$ approaches the golden ratio Phi for large n . This is one of the reasons why the golden ratio pops up in many examples of growth in nature. Assume that a species of trees grows as follows: a branch has to have a length of at least two units before it gets a new side-branch. After that, it generates a new branch after every unit length growth. The number of branches at each level follows Fibonacci's sequence. Similarly it appears in sun flowers, pine cones and so on

ropes, hinges and joints moving under the influence of internal and external forces. Even robotic and human walking can be studied in such terms, for example in [4] (quote) the equations of motion when one foot is on the ground are determined by using angular momentum balance, of the free leg about the hip, of the torso about the hip, and of the whole system about the ground contact point (end quote). The theory is formulated in the language of mathematics, which has the advantage of precision, but the disadvantage that it is not so easy, except for engineers and scientists, who are trained in these matters. We present essential aspects of the theory through examples. We show what the mathematics looks like, but also summarize the essentials in ordinary language.

One of the most instructive examples is a simple pendulum, a blob of matter suspended by a rope or a rod. When the object moves to the right over a distance x , there is a force F that tends to move the object back towards the center. The source of this force, of course, is gravity, described by a single number that is roughly the same all over the world, viz. $g = 9.8 \text{ m/s}^2$. This means, as discovered by Galileo, that whenever an object falls, every second it gains 9.8 m/s in speed⁷. If x is the object's position, then "x dot" denotes its speed and "x double dot" the acceleration, the rate of change of the speed itself. This is how the mathematicians write it:

- x is the position: where the object is,
- \dot{x} is the object's speed: how fast it changes where it is,
- \ddot{x} is its acceleration: how fast the object changes its speed.

Newton's law provides the final missing piece of information: the effect of a force F is to make an object of mass m move according to the equation F equals mass times acceleration. The formal details are given in Figure 5. The solution of the boxed equation comes as no surprise: the value of x oscillates in a smooth manner known as harmonic movement and described by the mathematic sinus function with a frequency that depends on g and on L , the length of the pendulum. Funny enough it does not depend on the mass m .

The physicists and the mathematicians have a most interesting terminology to speak about the numbers and the functions involved. They call them "eigen-values" and "eigen-functions". The word "Eigen" comes from the German, where it means "own" or "peculiar". It is almost the same in Dutch. This terminology is particularly fruitful because it captures the intuition that there is some

special frequency and some special behaviour built-in to the mechanical construction, quite independent of how the construction is used or triggered. But at the same time the terminology has a very precise mathematical underpinning which is in the heart of a variety of physical phenomena.

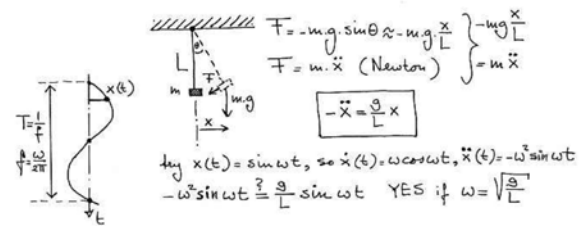


Fig. 12 Formal derivation for the eigen-function of a pendulum.

What is this essence of eigen-functions? The idea is that some operation takes place which works on behaviours and that transforms a given behaviour into more of the same behaviour. In the pendulum, where the position x behaves as a sinus function then the effect of the rope-and-gravity construction is to sustain that sinus movement. Mathematically this can be seen in the formula:

$$-\ddot{x} = \frac{g}{L} x$$

The operation is "minus double dot" and when this is applied to x the outcome is x again, except for a number, here g/L . Please note the analogy with the 2D symmetries, the effect is that the pattern goes on for ever⁸.

Whenever there is an operation O such that $O(x) = \lambda x$, the mathematicians say that x is an eigen-function and λ the eigen-value. In the case of the pendulum, the sinus function plays the role of eigen-function and the number g/L plays the role of eigen-value. What is the physical meaning of the eigenvalue? Here it turns out to be the square of the so-called angular frequency ω , which is nothing but 2π times the number of back-and-forth movements per second. One might guess that the example of a pendulum is too simple for being of any practical relevance. Two remarks are in order: first, that even human walking or running is not an arbitrary mechanic movement, but it turns out to be quite optimal with respect to energy (see [4]). The human legs swing like pendulums and the leg's tendons work like springs to buffer the movement energy when the foot lands. Secondly, the theory of eigenvalues is not restricted to pendulums, it also applies to many other systems which

⁷ On the moon or on mars, there is another number than our 9.8

⁸ Just as for the frieze pattern there is an invariance under transformation. Now it is the behaviour pattern which is transformed and for which we find that it is (almost) the same pattern again. The transformation is minus double dot, which means looking to the change of the change with a minus sign (action is minus reaction). Also the fact that it is not the same pattern again, but 'almost' the same pattern again is not so strange. The distinction is only a scale factor, a number. Something similar happened in Section 6 when we had to blow up the remaining rectangle by a factor of 1.618 to match the original big rectangle. It is a rewarding exercise to repeat the same exercise to the small rectangle and then to the smaller rectangle: also this pattern goes on for ever. It is a fractal, like the snail-shells from nature.

have one or more natural behaviours including other phenomena of resonance or damping.

9 Towards an interpretation

Now we make the hypothesis that humans have an intuitive understanding and are even used to making unconscious estimations of the eigen-functions of the systems, objects, products and bodies they encounter in life, including as an important special case, their own body. Several questions arise immediately:

1. how do people know or assume the parameters⁹ of such systems?
2. how do people know or assume the mechanisms that govern such systems?
3. how do people assign aesthetic values to such systems? In particular, what is the effect if the true behavior deviates from the expected eigen-function?
4. can we devise experiments to put the above hypothesis to the test?

Regarding the first question, people will work from their existing knowledge and experience, assuming the same every-day g of this planet to apply, estimating the length visually, estimating m by feeling it (if that is allowed) or otherwise working from assumptions that metal things are heavy, that mass is equally divided over uniform rods and so on.

Regarding the second question, people will know or assume probable and well-known mechanisms¹⁰. The obvious idea is to make them initially appear as classic mechanic systems.

Regarding the third question we hypothesise that a natural aesthetic quality is perceived if the system behaves as the suggested mechanic “real” system (i.e. when it shows the eigen-behaviour of the suggested system). Perceptions of artificiality or surprise are to be expected for movements deviating from the eigen-behaviour. Note that these are not claims; this is speculation, but at least speculation that can (and should) be put to the test.

Finally (question 4), a first simple experiment is to show several versions of a pendulum and ask to a group of people to rate their preference. All versions should have the same static appearance, but differ in frequency and in wave-form. At present we do not have any such experiment yet, but we consider the option to show several pendulum versions (perhaps at the DeSForM presentation).

10 Toward products

At present, many products which move do so because of functional reasons: the product’s main function is to move matter or transform matter. The function dictates the movement. Often the product is adapted to the human form or the human scale, but in certain cases this is because the user is part of the task; a typical example is shown in Figure 13, where the user acts as the motor, the energy source for the stapler.



Fig. 13 Hand-powered stapler.

A very different example is in Figure 14. This product has to be folded and unfolded by hand, but for a different purpose: the purpose is to adapt the light to the human scale, either to carry it (folded) or to provide the user with light (when unfolded).



Fig. 14 Foldable mini desk/table light.

In both these examples the user still is the motor, so rather than observing a movement, he/she creates the movement him/herself while feeling counter-forces and other haptic effects¹¹.

But in future both types of objects can be changed to move autonomously once the technology discussed in Section 3 is available. Rather being the human motor, working for the machine, we will design and use machines who adapt themselves to the human scale. When not in

⁹ In the example of the pendulum, these would be g/L and perhaps m .

¹⁰ But once there are many examples of systems which deny these assumptions, there is no more ground for the assumptions. They will gradually be replaced by new models, mental models, computerised models, which then will be part of human culture.

¹¹ There may be a certain aesthetic quality in this combined action/feeling; this leads to the important question how to design the aesthetics of interaction, which however is considered outside the scope of the present paper.

use, they better be small, when needed, they adopt the best position to perform their function, for example a media function (note that light is a medium too). Folding and unfolding are important but not the only examples. In both cases the artificial movement can be engineered in many ways, with less constraints than present-day solutions. It is for such products that we consider the theory of this article to be relevant.

11 Concluding remarks

We could not answer all questions raised in the present article. They represent an ambitious research program; probably we are only scratching the surface of this largely unexplored field. It will be interesting to investigate the relation between this work and the 'resonance' theory of Caroline Hummels. The author likes to thank Steven Kyffn, Tom Djajadiningrat, Philip Ross and Stephan Wensveen for earlier fruitful discussions that contributed to the ideas presented in this paper. It will be necessary to check in how far and where the idea that eigenvalues are useful symmetries has been described earlier. Mathematicians and physicists work are aware of the relations, but to the best of my knowledge this way of introducing them into a discussion on design is new. The author is also grateful to the reviewers for their patience and critical remarks, which have led to a number of corrections and changes in the text.

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Interaction walkthroughs and improvised role play

Abstract

How do designers of interactive media work on the dynamic aspects of their designs? Previous research has emphasised the role of gestures to express what users and computers do. This paper contributes with a detailed analysis of interaction design master students' enactments. Two kinds of enactive means for expressing behaviour are identified: interaction walkthroughs and improvised role play. Keywords: Sketching, models, design representations, gestures, enactment, interaction design.

1 Introduction

This paper investigates how interaction designers express and communicate the dynamic aspects of their design object using gestures, intertwined with talk and graphic representations. A key activity in interaction design is the exploration and communication of alternative design solutions. This makes it important to find adequate ways to describe the object being designed. It is well established that designers use models and sketches together with talk for this purpose. The problem for interaction design, however, is that its object of focus is dynamic: ways of interacting and using the system [2], [3]. Hence, the overarching question for this paper is how interaction designers work on the dynamic aspects of their design object.

The study points out the importance of designers seeing each other, as well as seeing the sketches and hearing verbal descriptions of the design. Indeed, as we will show,

some design ideas are never presented verbally, but only through gestures and common understanding.

1.1 The Role of Making Models in Design

When designers perform acts on their models, including sketches, scenarios, storyboards, diagrams, physical models and computer prototypes, we say that they act in the action context; that is, here and now in the workplace activity [1], [31]. The models, however, are also representations of what will happen in the target context, in the virtual world of hypothetical user activity where a future design solution will be used [27], [32].

Models are also used to collaborate, communicate ideas and jointly understand the design situation [18], [21], [30]. The understanding emerges in quick loops of making explorative design moves in the model, seeing the effects, and assessing the holistic consequences [2].

As the designer sketches, the representation of a design idea creates further ideas, and helps the designers to reframe their design problem. In fact, the sketch can precede the thought and hence drive the cognitive process [10], [28]. Designers reflect on their sketches in both acts of "seeing as", which stimulate new ideas, and acts of "seeing that", which prompts assessment of consequences [12]. Furthermore, designers tend to talk and draw simultaneously, a phenomenon called spatial-action language [28].

1.2 Models in Interaction Design

Turning to the area of interaction design, the models and design representations employed there typically include lists of tasks and functions, user personas and scenarios, diagrams of structures and interactions, user interface sketches, paper prototypes, and computer prototypes. Sketching on paper is particularly important during early design explorations [5], [17], [18], [19]. The sketches tend to fall into two categories: user interface sketches and storyboards representing sequences of interactions. Diagrams are used to develop site maps to visualize site structure. Schematics of the types of information and the information groupings on individual pages are used (also called grey models or wire frames). In mock-ups, high-fidelity representations of web pages are often created in graphics applications like Adobe Photoshop. These mock-ups are often used in specifications. The term prototype often refers to computer prototypes made in HTML or Macromedia Director. Prototypes are typically used late in the design process. Collaborative work is often done on whiteboards, but computer tools such as Microsoft PowerPoint are also utilized. Written scenarios and personas are furthermore widely used [18], [23].

1.3 Expressing Interaction

Interaction designers need to represent ways for people to interact, they need to represent usage, and they need to represent user experiences. Sketching in interaction design differs from sketching in other domains since the designer focus explicitly on expressing kinaesthetic experience, interactivity, temporal aspects, tangibility, immersion, sound, and haptics [11], [29]. Sketching in interaction design needs to be both static and temporal [20]. The problem is to express the dynamics of interaction. To represent and communicate the dynamics of a working interactive system, computer prototypes are usually built. Before such prototypes can be built, however, the dynamics must be represented in other ways and state transition charts in the form of branching storyboards are one such way. A major drawback of these state charts is that they become very difficult to read and draw as the system becomes more complex [22].

1.4 Enactments

Synectics, a technique for developing creativity, builds on analogical thinking and humour as central ingredients of creativity. One of its key techniques is making personal analogies: participants are encouraged to imagine what

it would be like to be the system or a component of the system [8]. For example, what would it feel like to be the garbage collector in the programming environment of LISP? By enacting this role, the designer can better figure out how the software should behave and appear to the user. Enactment, where a person acts out the performance of someone else or animates the behaviour of an object has been argued to be vital in design [24], [25], [31]. The enactment allows a designer to create and take part in a time-based representation of an activity, and others can join in this enactment.

Enactments can also be used to test how the user would behave. Jeff Hawkins, the inventor of PalmPilot, has been said to walk around with small pieces of wood in his pocket to prototype a PDA (personal digital assistant) and discover where and when he could make use of their product [26]. Buchenau and Suri describe this kind of prototyping as “experience prototyping”; they highlight “the experiential aspect of whatever representations are needed to successfully (re)live or convey an experience with a product, space or system” [7] (p. 424). If they are to experience the technology personally, designers must actively experience the subtle differences between design alternatives, and explore by doing. Buchenau and Sari argue that doing so will make it easier to grasp issues and feel empathy with stakeholders and their experiences. Thus, designers can explore by asking questions like “what would it feel like if...?”

In participatory design, developers sometimes engage users, employing staged and planned performances and role play in order to try out prototypes and mock-ups. The aim is to explore usage situations in a highly engaged way and to develop empathy. These performances can take the form of improvisational theatre or staged scenarios [9], [13], [15], [16].

The above techniques for acting out interaction are all planned and structured. Other enactments, however, are unplanned, situated, and taken for granted. These expressions of interaction and usage often take the form of gesture.

Designers frequently use hand gestures to make references [10]. This includes pointing to make references and gesturing to clarify or emphasize concepts (e.g. shrinking a square with the hands while asking “or can we scale the size down?”). Gestures form an important part of the spatial-action language of designers and making gestures is a convenient way to express the behaviour of both users and objects [4], [14], [24], [31]. These gestural

enactments are sometimes made in reference to a text or a sketch. In themselves, gestures and hypothetical user actions are ephemeral, and do not leave stable representations for future scrutiny [32].

Performing sequences of collaborative enactments is one way to explore ideas and share knowledge [6], [33]. They create a lived experience for the actor that also can be seen and assessed by others. This helps the design team focus on what the user is doing at all stages in the design [14]. Based on the observation that gesture and enactment play an important role in exploring how a product is used, we decided to analyse the spontaneous and unplanned enactments interaction designers do.

2 Method

This study reports a detailed analysis of a four-hour design workshop with four master's students in interaction design. This particular workshop is part of a series of workshops with students performing and learning interaction design. In total, the empirical material is encompassed by approximately 20 hours of video recordings made using multiple cameras.

Our studies took place at the Royal Institute of Technology in Kista where an interactive space called the iLounge was designed and built with the purpose of supporting co-located collaborative work. It is used both as a learning facility and as an experimental research facility. Two large touch-sensitive displays (smartboards) are built into a wall. In front of this wall is a table with a horizontally embedded plasma screen, also touch-sensitive. This interactive table is large enough for up to eight people to sit around it. In one corner of the room a smaller table and three chairs are placed in front of a wall-mounted plasma display, enabling a part of the group to work separately. The room has a wireless network and contains laptop computers with a wireless LAN card. The keyboards and mice in the room are also wireless, using Bluetooth. Finally, the iLounge contains high-quality audio and video equipment that can be used for videoconferences, or during user studies.

2.1 Procedure

Four master's students in interaction design, two male and two female, were invited to the iLounge. They all knew each other well, having taken the same courses for four years. The two female students were given a design brief asking them to design an interactive space to be used for

studio classes. The two male students were given a brief asking them to design a drawing tool for an interactive digital whiteboard. The briefs thus pointed towards design solutions in the direction of the iLounge they were to visit and experience. Our idea was that they were to seriously consider how they would like such an environment to be structured, and thus come up with ideas about how iLounge could be improved.

The participants had worked individually on their designs before coming to iLounge. During the visit to iLounge they synthesized their individual design work with the work of the other design student who had been given the same brief. Then presented their collective ideas to the two other students and ran a critique session. After these sessions we conducted an evaluation of the iLounge studio and what they thought about working there. During the first hour, an introduction to iLounge was given. Each group then used about thirty minutes each to synthesize their designs and about ten minutes to present their ideas; the critique session took about ten to fifteen minutes for each pair. The evaluation was performed during the following hour. We recorded all sessions using both audio and video from multiple cameras. This video material formed the empirical material for this study. No interventions were made during the sessions, except during the evaluation, which was facilitated.

2.2 Analysis

After we gathered the data, we analyzed it together. The focus of our analysis was on the gestures and dramatizations (i.e. enactments) of their design proposals. During the analysis we interpreted the enactments and their performatives. We also traced our interpretations of events in the synthesis sessions to events in the presentation sessions. All verbal utterances and gestures were transcribed into a protocol in our native language (Swedish). We then analyzed the transcriptions further as we engaged with them theoretically using previous research, and only then did we translate them into English.

3 Results

In this section we describe how the designers enacted their design sketches using gestures to make them behave. Often they incorporated these enactments within acts of speech, but, as we will see, some enactments had no signifying word or verbal counterpart during the sessions.

The enactments enhanced what the designers wanted to communicate, much in the same way that sketches provide simplified visualizations of a complex design proposal. In this section we present examples of how such communicative enactments were performed.

3.1 Without a Word for the Design

The two women, whom we will call Anna and Barbara, had the assignment of designing an interactive space using different digital resources. They started their synthesis session by quickly examining their sketches and summarizing their basic ideas about an interactive space. They had two basic ideas: that users needed plenty of space for sketches and that they needed space for both individual and collective activities. They were quite surprised that their sketches coincided. One of them, Anna, quickly took on the role of sketching on the smartboard and Barbara took on being the discussant: structuring the process of synthesizing the design by suggesting themes and discussing individual design proposals as well as documenting ideas. Anna generally expressed herself using many gestures, while Barbara was more modest with her gestures.

Barbara suggested that to structure the process they should start off by sketching things that would not need to be mobile, “like whiteboards etc.” In Excerpt 1 we see how she was abruptly interrupted by Anna who vividly presented an idea about a mobile whiteboard.

Excerpt 1. Group 1, Synthesis. The tilting table.

- | | | |
|---|---------|---|
| 1 | Anna | Some of these come on small stands with wheels. (Barbara: OK) It depends on, I don't know, it depends on how the transmission works, but if there are many sockets then you can put it in different places... or at least slant ((stands up and vividly enacts a “tilting table” with her arms)) it so it depends on if they are permanent like these or not. |
| 2 | Barbara | For the whiteboard then.. |
| 3 | Anna | Yes, like those old stands like those old rolling blackboards (Barbara: uh huh, OK) that you could move like a curtain ((walks like she is pulling the curtain)) at the theatre. |
| 4 | Barbara | Could you make them work that way too? |
| 5 | Anna | I don't know, but it would be cool. |
| 6 | Barbara | It would be cool ((writes)) I'll write work area |
| 7 | Anna | Write: for different purposes. |

Although Barbara suggested starting off with non-mobile furniture the discussion then focused on Anna's idea of a mobile smartboard that can be tilted. By demonstrating how a smartboard can be slanted from a vertical to a horizontal position Anna enacted the interaction, which was closely connected to the purpose of their design concept. First, in turn 1, Anna waved her arms to act out how it should be possible to slant the smartboard, and in turn 3, she makes an act of seeing-as where the smartboards can be pulled along like a curtain. In turn 4, Barbara made a mirroring tilting gesture. In this gesture she both experienced the interaction of tilting the board, and affirmed that she understood the concept. They both found this idea very appealing.

About 15 minutes later, while they were discussing and summarizing their synthesized design proposal they returned to the enactment of the tilting table. During the process said had said that they should denote different aspects of the properties in the room using different colours: blue was to denote technology. Excerpt 2 presents what they said, and Fig. 1 depicts the enactments in a picture sequence.

Excerpt 2. Group 1, Synthesis. The tilting table, continued

- | | | |
|---|---------|---|
| 1 | Anna | Okay, but then I'll draw them in blue as they are technology. |
| 2 | Barbara | The tables? Are they technology? |
| 3 | Anna | Well...the... ((enacts the “tilting table” with the arms)) |
| 4 | Barbara | Uhuh, ((mirrors the same enactment)) those ..yes |



Fig. 1. Sequence showing the enactment of "the tilting table". Anna waves her arms to enact "the tilting table" and Barbara mirrors the enactment.

When Anna suggested that she draw the tables into their design sketch using the blue pen to denote technology, Barbara did not understand why the tables should be denoted with blue. This misunderstanding is reasonable, as they had been discussing both tables in the sense of ordinary designed tables and an enacted “tilting” smartboard. When Barbara asked whether the tables counted as technology, Anna answered by again enacting the tilting table; this helped Barbara understand, and she then mirrored the tilting with her arms. Still they had no word to denote the table/board. The tilting table existed only in the enactment that the two designers shared.

3.2 Interaction Walkthroughs

The two men, whom we will call Christian and Daniel, had the assignment of designing a drawing tool for a smartboard. Their synthesis session started directly, as they discussed differences between traditional whiteboards and a digital counterpart in terms of affordances. Christian went to the smartboard and started up the installed sketchpad, and then sat down to listen to Daniel. Daniel first explained his view of the differences in what it is possible to do with a traditional whiteboard. They both pointed to the object-centred character of the digital whiteboard (that the user works with drawn objects rather than with pen strokes). In excerpt 3, we see how Daniel goes to the smartboard and presented his idea about the differences (Fig. 2).

Their preliminary and quite spontaneous analysis of the differences between traditional and digital whiteboards was clearly connected to their enactment of interaction. In fact, the enactments drove the analysis, moving it from an abstract and analytical perspective on the differences

in affordances, to the concrete and physical behavior of this actual digital whiteboard. By exploring this analysis of affordances at the same time that he explored the actual smartboard Daniel dramatized a type of user behaviour: a designer’s think-aloud exploration. This enactment also took place on the presentation level, since the designers explored the feel of the smartboard. In this case it did not feel natural. Christian, who was sitting down, was more distant in his attempts to take the floor, but Daniel was so engaged in his explorative dramatization that he seemed to more or less ignore Christian’s initiatives. When Christian prompted Daniel to think about whether he had an alternative idea about interacting, the discussion ended with a blunt no, with Daniel’s extension that maybe it all could have been done with a mouse. The explorative dramatization might have made Daniel a bit disillusioned about how one can interact with the smartboard as he reverted to an almost mundane form of interaction.

Excerpt 3. Group 2, Synthesis. Naturally not natural

- 1 Daniel Because when you....When you draw then... you know, this is not natura...it’s not natural. I must put this pen away then take my finger and drag this. You know, I do this only because I know I can put away the pen and use my finger as a mouse so to speak (Christian: yes)
- 2 Christian But at the same time I think that it is like..
- 3 Daniel But it’s good that you can do that as if it is an object.
- 4 Christian Did you have any alternative, or
- 5 Daniel No, not really, I just thought that you might have a tool to use? as a mouse...



Fig. 2. Presents his argument by making a sketch of how one does not do it naturally

3.3 Improvised Role Play

In the following excerpt we exemplify how the two male designers explored the different uses of the actual smartboards in order to design them to be used for collaborative purposes. It is striking that the pair started to dramatize their work using other voices, as if to explicitly express that someone else (the user) would say and act out what they think. These forms of voice dramatization quickly turned into examples of what each speaker wanted to do. In turn, the two amplified and enhanced these examples as they engaged in enactments, trying to do what they anticipated the users doing; see Excerpt 4. Here Daniel concluded by describing the concept of the traditional whiteboard. Fig. 3 depicts the two designers taking on the role of the users.

Excerpt 4. Group 2, Synthesis. You sketch there and I sketch here

- 1 Daniel But I think it's, what I think is a bit difficult about this is that we absolutely cannot work at the same time. Think of if I were to like "But check this out, then we cannot have that there..."
- 2 Christian Exactly. If we do that then I would come and say, "but this should be here", but you will say "no it should be here."
- 3 Daniel "But, we do like this".. hang on... wait a moment..
- 4 Christian Then I want to at the same time, and want to move these...
- 5 Daniel Exactly...or you want to draw... Say you want to draw down in the corner...
- 6 Christian There you have the advantage with the whiteboard. Okay, then you sketch there and I sketch here...



Fig. 3. Both designers are working together in vividly dramatizing the users' behaviours.

This episode of enactment is interesting in that both designers cooperated in the role play; Christian followed Daniel, playing along with his initiatives. In the earlier excerpts, we also saw that the female designers were playing along, but they mirrored each other's enactments rather than one taking a distinct lead. In this session the two designers cooperate and play along, using both gestures and voice in taking on the roles of users. These short role playing sessions evolve into a discussion of what target context the user would be in. They explore the concept of cooperative sketching by role playing.

4 Discussion

We began this paper with an overarching question: How do interaction designers work on the dynamic aspects of their design object? Looking at previous research as well as our results, we have seen that they create the dynamic aspects within a tight coupling of talk, graphical representations, and gestural enactments. The sketches are important as tools for thought, but it is the enactments and dramatizations that make the sketches behave. Playing the role of a user, and exploring the

potential technology with the intent of using it, helps designers explore the design and their design ideas, and also come up with new ideas.

The enactments help designers to focus and move themselves imaginatively into the target context where their design solution might be used. In the material, we saw how Anna and Barbara used their gestures as a shared reference to their design without even having a word for it. As such, gestures served as a powerful means to collaboratively assess the use of their design and engage in the situation of its use [24], [25], [32]. But not only do gestures help designers assume the role of the user. They also help them take on the role of the artefact-in-use. In the empirical material, we saw how Christian and Daniel imagined and enacted what the computer should be doing, for example, how drawn objects should behave in contrast to pen strokes.

In the action context of the here and now, designers speak, gesture, and modify graphic representations. The graphic representations create a space, representing the target context, in which designers can perform design moves [1]. They do so by continuously modifying the

graphic representations and by performing gestural enactments to communicate and explore the dynamics of interaction. This process supports the interaction designers in imagining themselves as part of the interaction processes of people and artefacts. Our observations support the work by Robertson, who describes how designers use enactments to create and take part in a time-based representation of process or activity that others can take part in [24], [25]. Sketches can be thought of as states in a state diagram; what the diagram lacks are the transitions. In order to represent the transitions between states, the designers make use of gestures. In fact, the tilting table has two states: horizontal and vertical. In between those states there is a transition, which the women designers represented by using arm movements. Similarly, as the Christian and Daniel dramatized the users' utterances and actions, they were representing transitions within and between functions, thus creating and experiencing structure and interaction. This can be seen as a form of experience prototyping [7]. The drama becomes a process of collaborative reasoning, firmly anchored in a situation of imagined use. Once again, this corroborates earlier research [24], [25], [31], [32].

4.1 Interaction Walkthroughs and Improvised Role Play

In our material, the participants performed enactments using gestures that mimic the actions of users in an interaction walkthrough. The interaction walkthrough is a gesture-driven enactment and it helps experiencing and figuring out the behaviour of the artefact-to-be-designed. Christian and Daniel took on the role of two users and imagined themselves in a certain situation of use. This improvised role play is a scenario-driven enactment, and is used as a designer's think aloud exploration which contextualises the design solution in an imagined target situation. Without these forms of expression, it would be difficult to express interaction and also the basic design concept behind their design solutions.

4.2 Future Research

The research presented here is conducted in workshops with interaction design master students. Further research conducted in cooperation with professional interaction designers will provide a more contextual insight into the expression of dynamics and behaviour in the practice of

interaction design. Future research also needs to address what the influence of gestural enactment is on the product, and give a more detailed analysis of the functions of different kinds of gestures.

As Tuikka has noted, enactments are of an ephemeral nature [32]. This means that there are no stable traces of them. In order to make specifications for construction and to support asynchronous communication it is however necessary to document the dynamics in some other way than gestures and role play. Hummels has provided examples of how arrows in sketches are used for that purpose [14]. Improvised role play can be documented in high-level storyboards, written scenarios, and video sketches. Interaction walkthroughs can be documented in storyboards, state transition charts, and simple animations. Building running prototypes is probably an even better specification. None of stable representations are however as swiftly used and convenient in collaborative design as enactments are, in the form of improvised role play and interaction walkthroughs.

4.3 Conclusions

In an analysis of gestures in interaction design we have identified two means for expression of the dynamic aspects of interaction design: Interaction walkthrough and improvised role play. Gestures drive the interaction walkthrough and scenarios created on the spot drives the improvised role play. These means for expression are two kinds of enactments. Given the ephemeral nature of enactments, the improvised role play and interaction walkthroughs still need to be documented in stable representations. Storyboards, scenarios, video, animations, and state transition charts are examples of stable representations that can be used.

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Interaction with the cultural niche is mediated by learning, attention, and decision making

Abstract

Those who design the human physical environment create ecologies of objects that shape human cultural niches. The actions and interacts that we learn culturally take the form of hierarchical control structures, forming 'schemas'. As schemas become habitual, individuals lose the capacity to re-evaluate options and take novel decisions. When communities as a whole develop similar habits, institutions that guarantee and constrain certain choices are formed. These institutions, both physical and organizational, form the 'cultural niche'. Against this empirical and theoretical backdrop, I examine how one might attempt to alter cultural behaviours. In particular I address how interactive objects could be designed to be most likely accepted as components of a cultural niche. I propose a set of hypotheses, namely that interactive objects will only become part of cultural niches if the options for interaction a) are salient; b) are predictable rather than novel; c) are limited; d) require minimal attention and decision making to use; e) are sensually or emotionally rewarding and simulate regard; and f) fit behaviourally into pre-existing cultural schemas.

1 Introduction

Recently, economists (Offer 2006) and political scientists (Ginsborg 2005) have pointed out that institutions, physical and organizational, both guarantee and constrain choices. Institutions can be described as

culturally constructed niches (Bowles 2000). Culturally constructed niches are analogues to the ecological niches constructed (i.e. modified over generations) by animals such as beavers and termites (Odling-Smee et al. 2003; Laland et al. 2000). The choices that institutions guarantee and constrain, are, in the economist's language, revealed preferences. Preference presupposes that we evaluate options, and prefer the option of highest value (subject to, e.g., informational, contextual, and discounting effects (e.g. Kahneman & Tversky 2000)). Institutions, physical and organizational, thus embody, guarantee, and constrain the values that we place on various options. A central question for the designers and users of our physical and organizational environments is how to create beneficial, equitable and enjoyable institutions. How do these cultural niches and their values achieve stability? How do they change? To address these questions I first review empirical studies, then suggest how they might fit into current theories relevant to cultural change, and finally propose some hypotheses regarding how my synthesis might be applied to design.

2 Cultural learning: A theory

Within the psychological literature on learning and memory, and the cognition of motion, there is some evidence for cognitive mechanisms that could improve recall of paired or combined stimuli (e.g. associative learning, Wasserman & Miller 1997; 'binding,' Sluzenski et al. 2006; 'consolidation,' Bauer 2005; perception of

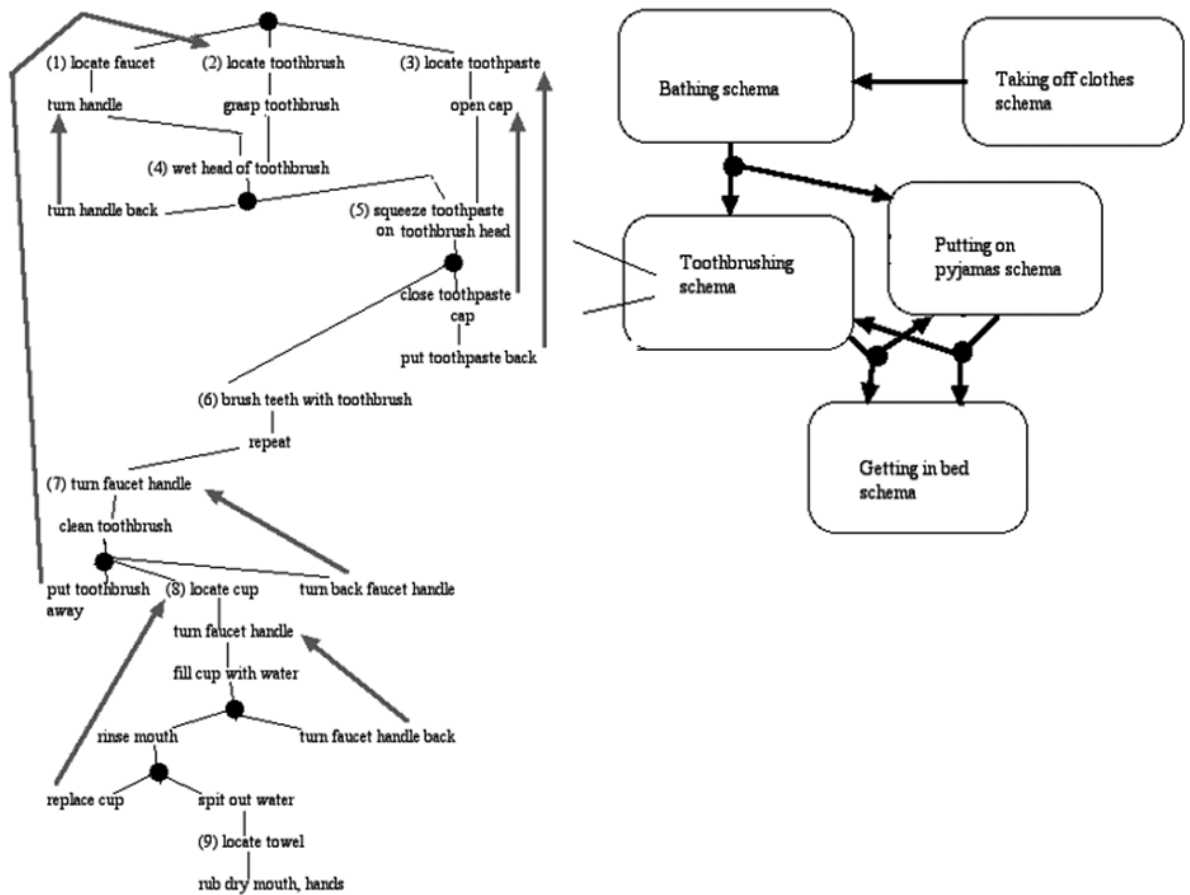


Figure 1. Schematic example diagram of a hypothetical hierarchical structure of toothbrushing that a child might learn, shown in relation to other sub-schemas making up the bed-time schema. On the right, black arrows show some possible transitions between sub-schemas. A black dot indicates optional transitions. On the left, the tooth-brushing schema is elaborated. Sequences of actions that could be learned via complementarity are marked with numbers (1-9). Obligatory sequence transitions are indicated with black lines. Decision junctures with multiple options, where value or priority is assigned, are marked with black dots. Grey arrows connect actions that restore the ecology of objects to equilibrium to the actions they 'undo'. Note that some action descriptions, e.g. 'brush' can be broken down into sequences of actions at a finer scale.

causality and intentionality: 'enabling relations,' Bauer et al. 1998; Barr 2002; Horner & Whiten 2005; Want & Harris 2001). I suggest that improved recall for sets of stimuli in cultural contexts would constitute 'cultural complementarity.' In general, complementarity is said to occur in systems where we find increased stability for interdependent non-random sets of elements, compared to single elements (Hunding et al. 2006; Root-Bernstein & Dillon 1997; Strauss & Irwin 2004). During cultural learning, in which offspring learn from older children, adults, or one another (see e.g. Boyd & Richerson 1985), cultural complementarity is predicted to result in stable transmission of action sequences.

An example can illustrate how cultural complementarity may help to build stable action sequences. Young children typically learn to brush their own teeth through a process of interaction with an adult. Most cultural behaviours

are not explicitly taught, but rather acquired through an incremental process of observation, sharing, and coordination between naïve and experienced individuals (see 'coaction' (Visalberghi & Fragaszy 1990); 'intent participation' (Rogoff et al. 2003); 'scaffolding' (Terkel 1996)). Tooth brushing could be described as a sequence of actions with a hierarchical control structure (see Figure 1) (Byrne & Russon 1998; Byrne 1999). Before-after or simultaneous pairs of actions join to form sets of actions, and sets of actions form action sequences. The control structure of the sequence determines the flexibility of the behaviour as a whole. According to the cultural complementarity hypothesis that I propose, the high fidelity of transmission of many cultural behaviours depends on learning complex sequences from the bottom up, where recall is enhanced for action sets joined by specific cognitive mechanisms.

3 Habits: How habit formation relates to niche construction theory

As we become enculturated, we develop schemas and habits. Schemas are patterns of behaviour, or hierarchical control structures for sets of behaviours (Bartlett 1954; Schank 1982; Smyth et al. 1987). For example, a 'bedtime schema' might be a sequence of bathing, brushing teeth, putting on pyjamas, and getting in bed. As we learn the hierarchical control structures for pairings of behaviours (at large or small scales, muscular or schematic), we learn which pairings are optional and which are obligatory. Many cultural behaviours become habitual. Some or all points in the control structure where options exist become fixed under habitual performance, like obligatory pairings. When acting habitually, we are impaired in our ability to evaluate, re-evaluate, and choose between different options at junctures in control structures (see Dickinson 1985). Learned habits, when performed similarly by many people, would form institutions in the cultural niche that guarantee and constrain certain choices and values.

Cultural behaviours may be dependent on the ecology of schemas in which they exist. A cultural behaviour that alters the existing environment in a way that improves the fitness of users of the behaviour is niche-constructing (Odling-Smee et al. 2003). In a market framework, 'reproductive fitness' might be replaced by increases in affluence or standard of living to describe a 'second-tier' cultural niche construction. Niche-construction is a process of feedback, resulting in intensification of the niche-constructing behaviour as the users become increasingly adapted to, and thus dependent on, the niche they are creating (see Johnson & Earle 2000). I suggest that niche-constructing cultural behaviours create the need for control structures, and promote the accumulation of regulatory and related behaviours. Culturally constructed niches are not stable unless their users actively maintain them: eventually the child learning to brush his teeth must also learn to clean and tidy the sink. Maintenance behaviours buffer the cultural niche.

4 Altering the cultural niche

The development of novel behaviours and technologies, when these become common in communities, can shift values by offering options that can't be refused. Context-dependent choice can alter the perceived value of options, leading to suboptimal decisions (Schuck-Paim et al. 2004). Context also changes the real value of options,

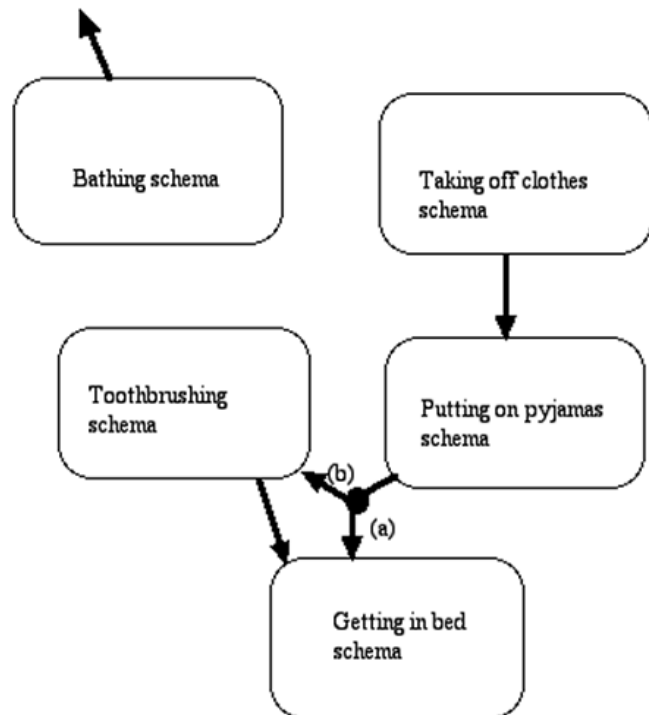


Figure 2. Two ways in which reevaluation can change schemas.

Compare to Figure 1. (1) Imagine that for some reason the child's evaluation of bathing at bedtime is reduced, perhaps in relation to the value of bathing after exercise or after waking up. In this case, the bathing schema would be incorporated in some other set of schemas. As a consequence, the relationships between the other bed-time schemas change. Note that not all relationships are equally likely. Here, as an example, toothbrushing becomes an option following putting on pyjamas. (2) This particular configuration makes the toothbrushing schema vulnerable. Imagine that the value of getting in bed is increased because the child feels tired. Option (a) then outweighs option (b) in the diagram above. In this case, performing (a) is incompatible with subsequently performing (b). If preferring (a) to (b) becomes habitual, toothbrushing never occurs, even though this is undesirable.

by imposing new costs and benefits. Feedback from valuing one niche-constructing option can lead to the re-evaluation of many options throughout related schemas (see Figure 2).

Once a set of habits and an ecology of institutions are in place, how can cultural behaviours be changed? How can new options be introduced, or existing options curtailed? A common view is that new technologies or desirable social outcomes can be promoted by increasing access to information and options, e.g. interactivity. On the one hand, people may be searching for novelty and

stimulation (Offer 2006), but on the other hand, novel behaviours by definition are not (yet) stable cultural behaviours. When options are novel rather than predictable (in space or time), one cannot form durable associations between pairings of actions and activities, or between desires and particular satisfactions. In a glut of options, none is salient and none is reliably associated with its context. Rats presented with unpredictable shocks become apathetic (Seligman & Beagley 1975), while consistent unpredictability in reward results in no learning, or unlearning of stimulus-response pairs ('learned irrelevance', 'contingency,' Wasserman & Miller 1997). Both rats and humans, in conditions of excess options, make 'myopic' and suboptimal choices (Offer 2006). None of these outcomes is desirable. To become traditional, the cultural complementarity framework predicts that options must be predictable, constrained, and salient relative to the cultural contexts in which they appear.

5 Implications for design

I have argued that the learning of habits, by groups of people, is an important component in the shaping of values through social institutions and ecologies of objects. It is intuitive that the designer's choice of the options inherent in an object affects how users interact with it. Attention is limited (see e.g. Naveh-Benjamin et al. 2005; Offer 2006). When the objects with which we interact require constant attention and decision making, habit formation is affected. Valued actions are eroded when the ecology of objects tends to destabilize, and is not buffered. People often cut the corners of paths in parks. Walking only on the path requires an excessive effort of attention and commitment that becomes less and less salient as the corners of the lawn are worn away. The child brushes his teeth ineffectively if he does not attend to whether he has brushed each tooth; but in this case nothing in the environment aids attentional commitment. On the other hand, he is unlikely to forget to spit out the toothpaste as the flavour and feeling always attracts notice, and spitting it out is rewarding.

One way to accommodate our tendency to remove attention from everyday micro-decisions is to design for cognitive simplicity: remove options and design objects to regain equilibrium (locally and globally, in aggregate) without human interaction. Another strategy is to attract and reward attention and micro-decisions. In fast food restaurants, for example, the decision to enter is associated with a variety of sensual rewards (colour,

smell, taste, music, toys), and this association can form the basis of individual and social learning, and attentional commitment. Another strategy is to limit options through clearly marked incompatibility, as between PCs and Macs. Consumers often regard the latter two strategies as undesirable, particularly when choices made in the past prove to have been myopic, e.g. because the systems are not equivalent, or over-consumption results (see Spurlock 2004). Cultural niches can guarantee choices, but it is extremely challenging to guarantee choices whose outcomes, in the aggregate, and interacting with other choices, are optimal and stabilizing (see Diamond 2006; Ball 2004).

Robots present an interesting challenge in light of these claims. Such interactive objects could provide strong emotional and sensual stimulation to the bored and lonely. Personal interaction remains in demand even when machines can do the same jobs (e.g. in banks), and consumers will pay higher prices for satisfying personal interaction in service industries (e.g. hotels, restaurants). Offer (2006) stresses the demand for social status, the attention and concern of others, in an 'economy of regard'. Yet it is striking that most social interactions take the form of predictable schemas and ritualized interactions. Rituals are series of actions (or dialogues) that encode and embody information (Bronowski 1973), thus removing the burden of attention and evaluation from the actors. It is difficult to make social interactions, e.g. small talk, personalized and original; learning a set of conventional phrases allows one to interact automatically. Social rituals represent a compromise between sincerity and attentional constraints. Currently, we do not have social status in relation to a washing machine or a laptop.

I would hypothesize that to simulate the rewards of regard from an object, the 'attention' that it rewards us with must be limited and thus valuable. Otherwise, interaction will degrade like a path in the park. But equally, the value of the attention from the object should not be offset by too high a cost of attention on the part of the human: I hypothesize that ritualization will be important if interactivity is to become prevalent.

In summary, I predict that habitual use of interactive objects will only be learned by large numbers of people, passed on to a second generation, and incorporated into cultural niches if the options for interaction a) are salient; b) are predictable rather than novel; c) are limited; d) require minimal attention and decision making to use, rearrange, re-adjust, etc.; e) are emotionally rewarding

and simulate regard; and f) fit behaviourally into pre-existing cultural schemas (see e.g. Anonymous 2005). Interaction is costly: it increases the amount of attentional commitment required.

Design can change our actions and our behavioural schemas by constraining our interactions with the cultural niche. To promote the development of new traditions of interacting with our environment, human cognition, learning, and memory must be considered. The combined cultural complementarity-cultural niche constructing framework predicts that specific mechanisms of learning and memory will facilitate the acquisition of new behavioural sequences, when options are constrained, predictable, and salient. Object users manipulate their environment, or allow it to degrade, so that decisions become automatic, but users may make myopic decisions. I propose that interactive cultural institutions can promote beneficial decisions when designers take into account how cultural niches are formed.

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Kinaesthesia in synaesthesia: the expressive power of gestures in design

Abstract

Spatial bodily movements are extremely suitable as a design technique, because our body conveys emotions and expression, as well as geometry and (inter)actions. Moreover, these movements can stimulate the creative process. The computer could play an interesting and powerful role to amplify this technique. By coupling a designer's expressive movements to computational power, the computer can actively assist designers to explore the aesthetics of interaction and the richness of all senses. If a computer wants to make sense of a designer expressing his ideas with expressive movements, it desperately needs guidelines to interpret and capture the essence of these movements. As a first step to formulate these guidelines, we tested the suitability, subtlety and expressiveness of spatial bodily movements to capture expressive design ideas. Moreover, the premise is tested that outsiders, more specifically designers, are able to pick up the expression of bodily movements. Our findings support the potential of a gestural design tool. Results show that there is no significant difference between sketching and gesturing. Moreover, an interpreter was able to capture the expression when looking at the gestures.

1 Introduction

“Das Parfum war ekelhaft gut. ... Baldini wünschte, es wäre von ihm, dieses ‘Amor und Psyche’. Es war keine Spur ordinär. Absolut klassisch, rund und harmonisch war es. Und trotzdem faszinierend neu. Es war frisch, aber nicht reisserisch. Es war

blumig, ohne schmalzig zu sein.

Es besass Tiefe, eine herrliche, haftende, schwelgerische, dunkelbraune Tiefe und war doch kein bisschen überladen oder schwülstig. Baldini stand fast ehrfürchtig auf und hielt sich das Taschentuch noch einmal unter die Nase. ‘Wunderbar, wunderbar...’ murmelte er und schnüffelte gierig, ‘es hat einen heiteren Charakter, es ist lieblich, es ist wie eine Melodie, es macht direkt gute Laune...’

(Das Parfum. Die Geschichte eines Mörders by Süskind [1], p. 63)

Süskind shows us via Baldini the synaesthetic power of scents. Synaesthesia means a more or less constant relation between perceptions from different sense organs, like seeing colours when hearing music or seeing a marvellous absorbing guzzling dark brown depth when smelling ‘Eros and Psyche’ [2].

This link between the senses is a valuable mechanism for designers to enhance the experience of the user. Take for example a soft drink bottle. Although some bottles are very appealing and striking like the original ‘Mae West’ Coca-Cola bottle, most bottles are basically similar and could contain different soft drinks. However, if one aims at capitalising on the experience of drinking for example Ice Coffee, Ginger Ale and Dr. Pepper, one should design three completely different bottles. The designs shown in Figure 1 were made by second-year design students at the Delft University of Technology. The containers do not only express the taste and feel of a given drink in terms

of shape, colour, texture, and so on, but also enhance the character of the drink by the way in which people are holding, drinking and storing it [3].



Fig. 1 From left to right: Ice Coffee package, Ginger Ale package and Dr. Pepper package. The Ice Coffee package elicits firmness and strength with its dark colours, the two handles and the small opening to slow down the drinking speed. The Ginger Ale container reflects freshness and sharpness through the taut silver-coloured funnel and the small pinchable capsules which prohibit the consumption of large amounts of liquid. Finally, Dr. Pepper is bottled in a cheerful, exuberant reddish bulgy shape with flexible straws to attain a playful, sweet and exciting drinking experience.

Synaesthesia is a familiar concept in the design world, although it is generally not as profound as in the abovementioned examples. We believe that synaesthesia is not only powerful as a guideline to design rich products, but it is also a powerful tool for the designer during the early phases of the design process, especially using the relation between the designer's bodily movements when exploring and visualizing his ideas and the expression of the final product, including appearance and interaction. One can see this relation when looking for example at design sketches from Ron Arad and Luigi Collani, see Figure 2 and 3. Their view on design and the products which they develop are interwoven with their perceptual-motor skills. These drawings and models are not just made

by Ron Arad or Luigi Collani. They are Arad and Collani. Since 1994 we explore and develop design methods and tools that capitalise on this intrinsic link between the designer, his motor skills, his working method, the visualisation of his ideas and his designs [4]. In this paper we show the potential of a gestural design tool that maximises this intrinsic link. To develop such a design tool, we tested the suitability, subtlety and expressiveness of spatial bodily movements to capture expressive design ideas. Moreover, the premise is tested that outsiders are able to pick up the expression of bodily movements. Once that expression appears detectable, we can start looking for the salient elements of these movements in order to formulate rules for computer implementation.



Fig. 2 The sketches Ron Arad made for 'The Weeble', later known as 'Easy Big Volume 1' 1988 [5], are characterised by plain, powerful, explicit and almost explosive strokes, thus creating a strong image. Most of Arad's drawings are black and white, drawn with pencil or charcoal to underline the strength. With a firm hand he provides his line drawings with shadows. In this way, the entire drawing expresses the powerful character of his designs. This power is expressed not only in the shape of his designs, but also in the materials, such as steel and concrete which he welds and casts himself. He works quickly, transforming his sketches immediately into 3D. Right: 'Rolling Volume', a later version of 'Easy Big Volume 1', by Ron Arad, 1989 [5].

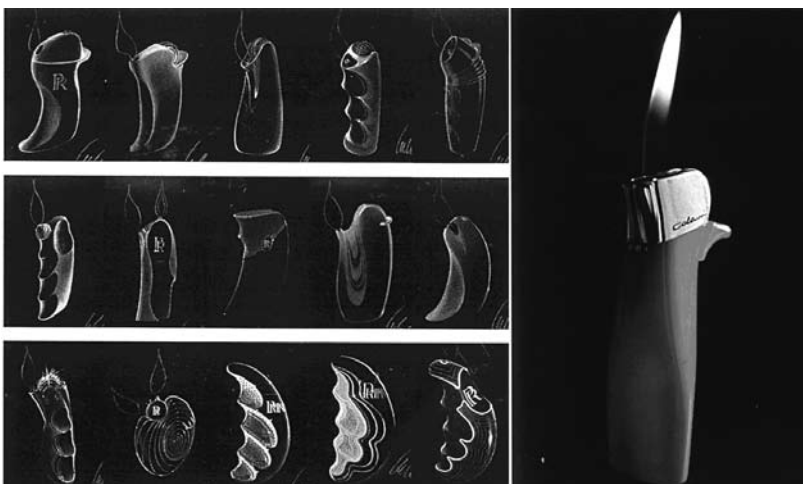


Fig. 3 The drawings by Luigi Collani are much more subtle and refined. His organic designs seem to rise from the paper. He uses mostly dark paper and indicates only the highlights. The soft touch of the white pencil on a dark blue piece of paper allows him to produce smooth and continuous variations in tint. This smoothness and subtlety of drawing emphasise the smooth and organic character of his design, such as this Cigarette lighter 'LC1' for Yoshinaga Prince Company which was produced since 1984 in Japan [6]. The material of the designs, mostly synthetic, fits the entire expression.



Fig. 4 MOVE ON offers the designer virtual material with which he can sketch spatially, thus intertwining the expressive wealth and 'interactive imagery' of sketching, with the spatiality and interaction possibilities of modelling.

We start by showing the potential and scope of a design tool that exploits kinaesthesia in synaesthesia. Thereupon we explain the experiment and our findings.

2 Movement-based design methods

We believe that spatial bodily movements are extremely suitable as a design technique, because our body conveys emotions and expression, as well as geometry and (inter)actions. Moreover, the movements can stimulate the creative process. The Bauhaus School in Germany already recognised and promoted the combination of design and dance, as e.g., "Triadische Ballett" from Oskar Schlemmer (1888-1943) shows [7]. A more recent example of this powerful link is Klooster's choreography of interaction. In this approach design is focused on creating activities and movements, more specifically on a choreography of interaction. The product itself comes into existence in the choreography of interaction. It is felt and hence discovered as a trace and missing link; the link that is needed to fit and to complete the choreography of interaction. The design process and the design outcome (creating and creation) are interlaced [8]. The computer could play an interesting and powerful role to strengthen the link. If it is possible to couple a designer's expressive movements to computational power to generate design solutions, one has a spatial and temporal sketching tool that combines the advantages of traditional sketching on paper, tinkering, modelling and dance, and even more than that. The computer can actively assist designers to explore the aesthetics of interaction and the richness of all senses. This support can be given in many ways. Since 1994, we explored the potential of digital gestural design tools that support the designer in creating expressive tangible interaction concepts [4]. We developed several scenarios and prototypes, all with a different focus in order to indicate the enormous potential of digital technology for design. For example, MOVE ON is a virtual reality design application that supports the designer sketching directly in 3D by leaving traces in space which can be manipulated and modelled, see Figure 4.

Design Dance is developed to exploit the motor-skills of designers and couples the richness of the senses with human-product interaction. In this scenario the designer's entire body has become his tool, as shown in Figure 5. The expression of his movements are interpreted by the computer and translated into a design, including form, sound, movements and interactions on the basis of synaesthetic principles. The expressive concepts slowly concretize into a product. This does not imply that the designer is forced to describe the shape spatially; he can also visualize the interaction with the product whereupon the computer translates the negative space into a possible product. Ideally, the designer could directly interact with the visuals and sound offered by the computer by using an augmented reality display [4].

However, if a computer wants to make sense of a designer expressing his ideas with expressive movements, it desperately needs guidelines to interpret and capture the essence of these movements. In order to discover these guidelines, we conducted explorative research. In this paper we will focus on one of our studies on the expressive character of gestures. Other studies on e.g., general approaches to gestural design, and the visualisation of geometry, can be found in separate publications [4, 9, 10].

The detection and formalisation of patterns in expressive gestures is extremely complex, therefore, we started this study with two central questions:

1. Is gestural sketching suited, or even more suited than traditional sketching on paper to develop and visualise expressive ideas?
2. Is an outsider, more specifically a designer, able to recognise the intense and extensive expression of the gestures used during the design process?

The first question can confirm our premise that gestural sketching is a useful addition to the existing design tools. The second question needs to be answered affirmatively to be able to formulate any rule. If one cannot recognise it, it becomes very hard to formalise it.

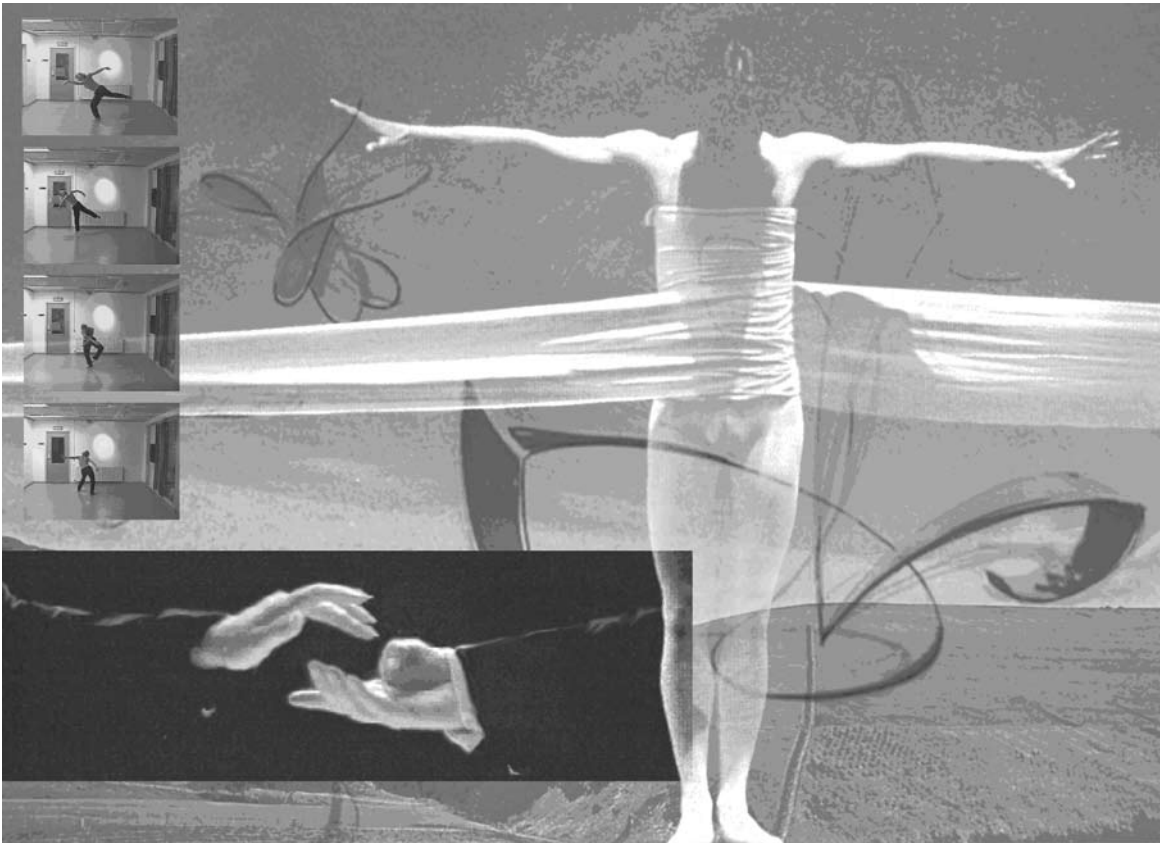


Fig. 5 Design Dance uses the expressive wealth of bodily movements to develop concepts.

3 The set-up

To answer the aforementioned questions, we needed to find a medium to make expressivity measurable and comparable, without losing the subtleties necessary for design. The answer is provided by synaesthesia.

Previous research from Smets & Overbeeke [11] indicated not only that design students are able to convert patterns from one sense organ to another as the example in Figure 1 shows, but also that the results between students are often related. In one of the exercises they asked the design students to create a sculpture expressing one of nine scents used. They found that a large part of the sculptures made within one scent are part of a family of shapes and colours. A selection of the sculptures was tested in a matching experiment, which showed that independent subjects are able to match the sculptures with the correct scents (78% correct matches).

Similar to the method of Smets and Overbeeke, we invited students to translate scents into expressive designs, although this time they had to use bodily movements to design and visualise.

Because we were still in an exploration phase, we chose

a rather extensive set-up with six types of stimuli, to study the different aspects of the expressivity of gestures. The experiment consisted of three parts: a design part in which the six types of stimuli were created, and two matching experiments in which outsiders matched the stimuli. In this paper we will discuss the design part and the second matching experiment. The first matching experiment is described in a separate paper [9].

3.1 The set-up of the design part

Six types of stimuli were created by the design students (see Table 1)

SkCo	Sketches and collages made by designers directly on paper
GeDe	Recordings of gestures made by designers with the colour on paper
GeDa	Recordings of dances made by dancers
SkGe	Sketches made by designers of their virtual sculptures made with gestures
SkInDe	Sketches made by an interpreter based on the gestures and the colour
SkInDa	Sketches made by an interpreter based on the dances



Fig. 6 These three families of sculptures made for three different scents were matched in an experiment. The objects are reddish (left), bluish (middle) and amberish (right).







Creator:	Conditions:		
Designers and dancers creating a sculpture or a dance	SkCo 	GeDe 	GeDa 
Designers visualising their design made with gestures in a sketch		SkGe 	
An interpreter visualising the gestures and dances in a sketch		SkInDe 	SkInDa 

Table 1 The six types of stimuli created during the design part of our study

To answer the first question, concerning the suitability of gestural sketching compared to paper sketching, we invited eighteen senior design students to design four abstract spatial dynamic sculptures that capture the expression of four given scents. To make the exercise not too complex, we asked the students to create dynamic sculptures that change over time, without imposing any functionality. Two of these sculptures had to be made in the traditional way with sketches and collages on paper (SkCo). The other two sculptures had to be designed through gestures (GeDe). Because gestures cannot convey colour, the designers captured the colour of the sculptures on paper with pencils, crayons or collages during the gestural sessions. The sketching sessions lasted half an hour per scent and the gestural sessions took maximally twenty minutes per scent. All the variables, i.e., the order of the two conditions and the four scents, were counterbalanced. Before the actual experiment started, the designers had a trial run for both conditions.

During the design exercise, the scents were continually present for the students by means of a small strip that was soaked in the scent and subsequently placed on a holder in front of the subject's nose. The scents were selected from the set of nine scents used by Smets and Overbeeke [12]. This way the previously designed sculptures could serve as reference material. The scents were so-called raw materials, i.e., singular basic scents that are used to compose, for instance, a perfume. Contrary to what you might assume when reading the descriptions of the scents, they were clearly distinct.

Name scent:	Description scent
A Ligustral	green, privet hedge
B Iso-amylacetate	fruity, candy, strawberry
C Iso-bornylacetate	pine woody, fruity
D Lacton c9 gamma	fruity, coconut

Because of the absence of a real gestural sketching tool, this set-up had two disadvantages. Firstly, the design students were experts in drawing but not in gesturing.

Therefore, we extended the design exercise with experts in movements, four dance students. They were asked to express every scent in a two-minute dance (GeDa). Secondly, the gestural condition did not produce an image of the design. Therefore, the designers sketched their virtual design on paper after every gestural session (SkGe), including the movements of the sculpture if present. Both designers and dancers were asked after every session to indicate their satisfaction with the expression of their own creations in relation to the scent on a scale from 1-5 (very dissatisfied -very satisfied).

To answer the second question concerning the recognition of the expression of the gestures by an outsider, we engaged an interpreter, an artist/designer, to visualise her impressions of the gestures and dances in a sketch (SkInDe and SkInDa). She received the recordings of the gestures and dances randomised on videotape. Per design, she watched the tape twice for interpretation, during which she made the sketch, and a third time to verify her sketch. This process took on average three quarters of an hour per design. She was unfamiliar with the set-up and the scents.

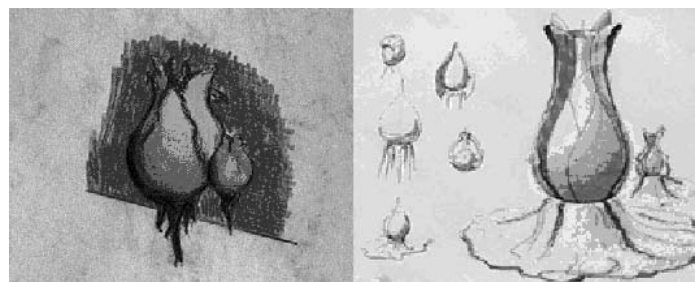


Fig. 7 Left: sketch made by the design student after the gestural design session (expressing Ligustral). Right: sketch made by Roselien after seeing the movie of the design student creating his sculpture expressing Ligustral.

3.2 The set-up of the matching experiment

Ten designers evaluated if the expression of the drawings made by Roselien Steur, the interpreter, resembles the expression of the sketches made by the designers of their virtual design created with gestures. Furthermore, we tested whether her interpretations of the dances were similar to the expression of these dances, according to independent designers.

The matching experiment consisted of two parts. In the first part, the subjects had to match the drawings made by Roselien of the design students gesturing, with the sketches which these students had created themselves of their virtual design made with gestures. This matching part had to result in 36 couples. The drawings made by the students were spread out on the table randomly. The subjects received the drawings by Roselien, placed in random order. They were offered as much time as necessary to make the couples. Afterwards, they were asked to give two to three catchwords to characterise the match.



Fig. 8 Left: The 36 drawings the designers made of their virtual design had to be matched with the drawings Roselien made when seeing the gestures of these designers. Right: The four dances performed by all four students had to be matched with the four times four drawings made by Roselien.

The second part consisted of four short sessions. In every session, the four dances by one student had to be matched with the four drawings Roselien made when watching this dancer performing. This matching part resulted in four times four couples. The subjects received the dancers in random order. Within a session, the drawings were randomly offered and the tapes were randomly distributed across the monitors. Again, the subjects were offered as much time as necessary.

4 The hypotheses

The two central questions were tested with five hypotheses, which are discussed separately.

4.1 Suitability of gestural sketching

Is gestural sketching suited, or even more suited than traditional sketching on paper to develop and visualise expressive ideas?

All designers indicated their satisfaction with the expression of their own creations in relation to the scent on a scale from 1-5 (very dissatisfied -very satisfied). If gestural sketching is more suited than sketching on paper to capture the expressive character of scents, than the designers should be more satisfied (= higher mark) about the expression of their designs created with gestures than with sketches. This leads to the following hypothesis, which was tested with a t-test ($p \leq 0.05$):

Designs created with gestures		Designs created with sketches
H0: μ Satisfaction	\leq	μ Satisfaction
H1: μ Satisfaction	$>$	μ Satisfaction

Table 2 Hypothesis 1: gestures are more suitable

4.2 Recognition of expression of gestures

Is an outsider, more specifically a designer, able to recognise the intense and extensive expression of the gestures (including dance) used during the design process?

The second matching experiment tried to answer this question by making a direct comparison between Roselien's interpretations and the original sketches and dances. Separate hypotheses were formulated for the matching of the drawings made by the designers with the drawings made by Roselien, and for the matching between the films of the dancers and the sketched interpretations by Roselien. Let me start with the matching between the two sets of drawings.

Matching two sets of drawings

All ten subjects matched 36 couples of drawings. The probability of a subject to have exactly k matches correct, can be calculated with the following formula (Loosen, 1985):

$$P(m=k) \sim 0.3679 / k! \quad (\text{for } n > 10)$$

k = number of correct matches

n = number of matches

m = number of matches

This means that, with a level of significance of 0.01, a subject has to have at least 5 matches out of 36 correct

($p \sim 0.003$), to rule out chance. However, we can also look at the separate couples. When we look at all 10 subjects and count the number of correct matches for that particular couple, then the following formula can be used to calculate the probability (Soest van, 1985):

$$\frac{n!}{k!(n-k)!} p^k q^{n-k}$$

n = number of matches
 k = number of correct matches
 p = chance of success
 $q = 1-p$

When we look at one couple, then the chance to make a correct match is $1/36 = 0.028$. With a level of significance of 0.01, at least 4 subjects have to make a correct match to rule out chance ($p = 0.0014$). This leads to the following two hypotheses:

H ₀ : Correct matches of drawings per subject	≤ 4
H ₁ : Correct matches of drawings per subject	> 4

Table 3 Hypothesis 2: An independent interpreter can detect the expression of gestures and produce a sketch which is considered to be similar to the original sketch by the designer.

H ₀ : Number of subjects that made a correct match for a couple	≤ 3
H ₁ : Number of subjects that made a correct match for a couple	> 3

Table 4 Hypothesis 3: An independent interpreter can detect the expression of gestures and produce a sketch which is considered to be similar to the original sketch by the designer.

Matching drawings with films

We use the same argument for the matching of the films by the dancers with the sketches by Roselien. All ten subjects matched four sessions containing four couples of drawings. The probability of a subject to have four matches correct within 1 session is $1/24 = 0.0417$. Again, we will test both the ability of subjects to make correct matches and the 'quality' (similarity) of the interpretation made by Roselien of the four dance students. Let us first look at the individual subjects. When a subject is able to make correct matches beyond chance ($p < 0.01$), then the formula:

$$\frac{n!}{k!(n-k)!} p^k q^{n-k}$$

indicates that a subject has to have at least 2 sessions correctly matched ($p = 0.009$). This means that he has to have correctly matched all four drawings twice. When

we look at the series of one dancer, then at least three out of 10 subjects should make a correctly matched session ($p = 0.006$). This leads to the following two hypotheses:

H ₀ : Correctly matched sessions per subject	≤ 1
H ₁ : Correctly matched sessions per subject	> 1

Table 5 Hypothesis 4: An independent interpreter can detect the expression of gestures and produce a sketch which is considered to be similar to the original dance.

H ₀ : Number of subjects that match a specific session correct	≤ 2
H ₁ : Number of subjects that match a specific session correct	> 2

Table 6 Hypothesis 5: An independent interpreter can detect the expression of gestures and produce a sketch which is considered to be similar to the original dance.

5 Results

Hypothesis 1. The first hypothesis H₀ cannot be rejected, because there is no significant difference between the satisfaction of the designers of their own sculptures made through sketching or through gesturing, see Table 7.

	Designs created with gestures	Designs created with sketches
Mean:	3.7	3.8
Standard Deviation:	0.849	0.533

Table 7 The results for hypothesis 1: the satisfaction of the designers about their design.

Hypothesis 2. Table 8 shows that the subjects amply exceed this number of four correct matches. The table also shows that three subjects (nos. 01, 08 and 09) are extremely good compared with the other subjects. Therefore, H₀, 'the number of correct matches per subject ≤ 4' is rejected.

Hypothesis 3. Table 9 shows all 36 couples, together with the number of subjects who made a correct match per couple. Only 6 out of 36 couples score less than 4 correct matches. This means that in at least 83% of cases, Roselien captured the expression as intended by the designer, so, for which H₀ can be rejected.

Hypothesis 4. Table 8 shows that 3 subjects correctly match more than 1 series (nos. 01, 03 and 04). Only for these three subjects, the H₀, 'the number of correct matched sessions per subject ≤ 1' is rejected.

Drawings & drawings		Drawings & dances
Subject	Correct match (N)	Correct series (N)
	Total couples: 36	Total couples: 4
01	31	2
02	18	1
03	24	2
04	21	2
05	23	-
06	21	1
07	21	-
08	30	-
09	31	1
10	22	1

Table 8 Number of correct matches per subject.

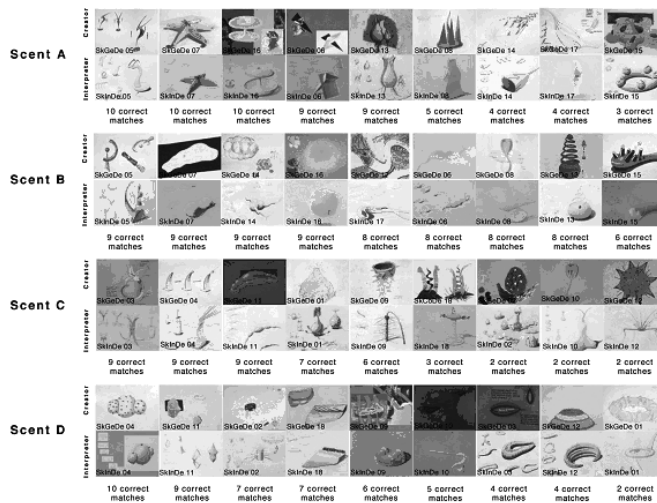


Table 9 Number of subjects that made a correct match for a couple 'drawing – drawing'

Hypothesis 5. Table 10 shows that only for the last series by dancer 04, H0 'the number of subjects that match a session correctly ≤ 2 ' is rejected. When we look at the correct matches of the three competent subjects together series (nos. 01, 03 and 04), then every series is scored at least once correctly.

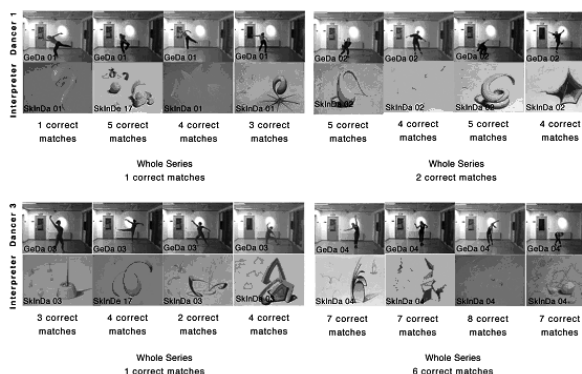


Table 10 Number of subjects that made a correct match for a couple 'dance – drawing'

6 Discussion & conclusions

We started this study by raising two questions:

1. Is the expressivity of gestures subtle and extensive enough to capture the expressivity of ideas? More importantly than that, do gestures surpass even the expressive possibilities of sketching on paper, currently the favourite method of designers?
2. Is an outsider, more specifically a designer, able to pick up the subtle expression of the gestures used during the design process?

This study answers the first part of the first question and the second question in the affirmative. However, we were unable to answer the second part of the first question in the affirmative.

First question

The experiment shows that in general there is no significant difference in expressive quality between traditional sketching and gesturing. Although the results do not support our hypotheses, gestural sketching should not be automatically written off.

Firstly, our hypotheses were very strict. We disregarded all extenuating circumstances, like the inexperience of the designers with gesturing and the lack of feedback. Taking these circumstances into consideration, the evaluation of the sculptures by the designers themselves is hopeful. Secondly, we focused on expressivity in general and limited our set-up due to the complexity of the problem. Therefore, we asked the design students to develop expressive dynamic sculptures without any specific functionality. It turned out that focusing on the spatial, dynamical character of sculptures is not enough to show that gestures are beneficial to sketches. This does not come as a complete surprise. We stated that expression and designing aesthetic interactions is one of the major advantages of gestures. Therefore, we have continued our gestural research with a special focus on aesthetic and engaging interactions. A few of these projects and results can be found in other publications [10, 13].

Second question

Our matching experiment shows indisputably that Roselien was able to detect and capture the expression of both gestures and dances. Thus, an outsider, at least a skilled artist/designer, is able to pick up the subtle expression of gestures, which was one of the main questions of this study. Nevertheless, the dances

appeared to be far more difficult to match correctly. This might partly be explained by the fact that the dynamic sculptures that the design students made, somewhat referred to an object that was created, whereas the dancers expressed the scent with their entire body. In the first case Rosalinde could pick up aspects of the virtual object that was created. In the last case she had to transfer the expressive movements of the dancers into an object.

Hypothesis 4 shows that not everyone can detect the similarities in expression of the dances and the drawings made by Rosalinde. This means not only that Rosalinde has to capture the expression correctly, but also that the subjects have to have the affinity to detect the expression. If we look at table 8, we see for example that subject 01 is good at matching pairs of drawings, as well as matching drawings and dances, subject 08 is good at matching pairs of drawings, but not at matching drawings and dances, and subject 04 seems to feel relatively more affinity for matching drawings and dances.

If we look at hypothesis 5 then we see differences in the results per dancer. It means that Rosalinde was able to detect and capture the expression of all dancers, although her drawings of the first three dancers were less convincing than those of the last dancer, or three out of four dancers were less distinct in their expression.

We would like to finish this paper with a beautiful example of the expressive wealth of gestures. The three stimuli depicted show the expressivity of body movements and the synaesthetic relationship between shape, colour and movements (see Figure 8). When we saw the films of dancer 2 (Sjoukje Philip) and designer 17 (Wing-Ken Cheung), we were struck by the resemblance between the expressivity of their movements. It was even more striking to see the sketches made as a result of these movements. All three sculptures were highly similar in terms of shape and colour. This is all the more striking, because the sketch which Rosalinde made as a result of Sjoukje Philip's dance was based on a black-and-white film. It was the expression of her movements which inspired Rosalinde to make the sculpture green. The resemblance between the sketches was not only noticed by us. The other matching experiment that was published previously [9] showed that well over 80% of subjects judged all three sketches as being created for scent A. The beauty of this kind of example strengthens us to continue our search for a movement-based design tool. Therefore, our

next step will be the coupling of (1) physical involvement in interaction (2) dynamic quality of interaction and (3) expressed and experienced meaning of interaction, as Klooster [8] suggests in her 'choreography of interaction'. This coupling should make it possible to formulate guidelines for a gestural design tool.

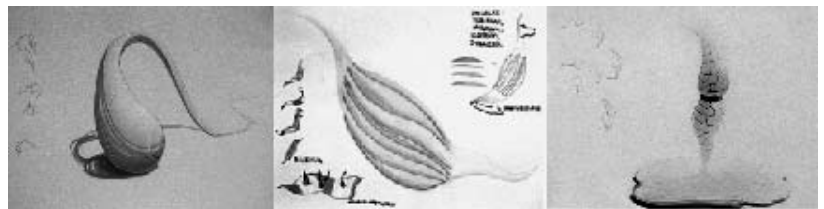


Fig. 9 The impression of the interpreter of dancer 2 for scent A (left); The sketch of designer 17 of his virtual sculpture for scent A made through gesturing (middle); The impression of the interpreter of the gestures designer 17 made for scent A (right).

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Talking to the hand – The interactive potential of shape- behavior in objects and tangible interfaces

Abstract

Technologies that might be utilized to perform shape-change are currently being pursued. The vision behind this effort is to construct adaptive and responsive envelopes through shape-change. In terms of interactivity such vision might hold immense potential. What is the extent of this potential?

Looking at what is absent from the experience of the virtual in comparison with that of the physical, like the extraction of contextual meaning from shapes and relations between shapes, 'tangible information' perceived by the body and omnidirectional reception from the surround, Shape-change, as a physical phenomenon, can bring to interactions with the virtual some of those missing qualities.

This paper summarizes the findings of a one-year thesis on the above hypothesis, named Talking to The Hand, done as part of the masters program in the Interaction Design Institute Ivrea and advised by Heather Martin and Yaniv Steiner. It reports the exploration process of shape-change as an interactive medium through iterative prototyping, and the various design proposals for objects and interfaces incorporating such behavior that concluded it

Keywords

Shape-change; product behavior; interaction; design;

1 Introduction

Research and development of technologies and design concepts that utilize some sort of shape-change is buzzing in a growing number of labs, commercial companies and academic institutes. The idea of morphing drawn from nature life and inspired by fantasy world is coming through in few fronts simultaneously. Dynamic structures based on Shape Memory Materials, Ferro-magnetic fluids and Micro Electro Mechanical Systems, are already performing elementary shape-change in commercial, military and space applications as well as in art installations. Other emerging technologies as Electro Active Polymers, 'Claytronics' (programmable matter composed of nanoscale robots) and reconfigurable structures demonstrate some of this potential in labs.

One ambitious concept is the 'morphing air plane' program sponsored by DARPA and NASA. This concept aims at building flying machines based on aerodynamic principles similar to those used by birds. When in high speed a morphing airplane would elongate its fuselage and pull in its wings to reduce drag, it would do the opposite when in low speed.

The 'Morphing airplane' program emphasizes the advantage of an adaptable design over others, and reveals it as the major drive for the realization of shape-change concepts. The ability to adapt a given geometry to changing environmental conditions or task profiles, would allow morphing entities to maximize their performance.

The approach to inflatable structures, in the early 1960's, was similar. Inflatable technology new at that time held an appealing charm, it could assume a pre-programmed shape in an instant. Radical architecture groups experimented with lightweight, temporary structures that could be deployed on demand and fit a more flexible personal mobile life style¹. Similar aspects were highlighted at the Expo 70 exhibition in Osaka, on the theme of inflatable architecture. Big scale projects planners advocated the adaptability of inflatable structures and their ability to supply a deployable solution in a wide range of scenarios².

In his Afterwards collection (2001), the fashion designer Hussein Chalayan follows a similar thought, how ever more poetic. In this collection all the cloths and accessories the models wear transform into furniture. A table becomes a dress, an armchair morphs into a suitcase. Chalayan, relates his work to his immigrant background³, and explains that immigrants are in a constant state of transience always taking into consideration the need to move here as well, the furniture transforming into a cloth is adapting to fit a task profile.

From the above it is evident that shape-change is a powerful inspiration, and almost an obvious concept when considering performance. However, an adaptive and responsive envelope that interacts with the environment, points at intriguing behaviors as well. Could shape-change offer additional functions other than optimization of performance?

A relevant association that jumps in mind, When thinking of such envelope, is a coral reefs fish knick-named by the Bedouins of the red sea 'Abu Nafcha' (Puffer fish) literally – "the inflatable one". The 'Abu Nafcha' owes his name to the tactic he use to deter a potential attacker, when threatened it inflates by filling his extremely elastic stomach with water until it assumes an almost spherical shape. Fully inflated it is seen by the attacker much bigger, signaling that it might not be a good idea to mess with. The 'Abu Nafcha' case shows that an act of shape-change can also function as a form of communication rather than an optimization of performance.

Similarly, facial expression and body language are a form of natural 'shape language' humans use to express ideas, identify the other side intentions, or evaluate social statuses.

Looking at the design practice communicating through shape is a founding thought. Some cognitive theories suggest that the environment is perceived not through an abstract mental model but directly from its appearances. In cognitive psychology this concept is known as affordance, a term that describes the visual clues provided by the various elements of certain environment, which explain or inform a spectator on their properties.

Physically speaking visual clues as such convey a scheme of constrains and operating forces, hence appearances in the physical world are in essence the things them selves. Virtual entities and digital devices lack this physical context. In fact, missing as well from their appearances are textures and other clues generally picked from any occasion environment. It can be said that the appearances of virtual entities and digital devices are detached of their essence.

The background chapter discusses what's between the physical and the virtual, and specifically point out to what is physically absent from the digital world. To summarize it is clear that the experience of a physical dimension so crucial to our understanding of the real world is missing from digital environments.

2 Background

Perception is the overall process in which the information gathered by our senses is converged into an understanding of the surrounding environment. In this process the data channeled from the various senses: vision, hearing, touch, smell and taste is analyzed, weighted, compared and so on, in a sequence not fully understood. The outcome of perceiving the environment is action, taken in various forms, moving, speaking, and so on⁴.

This gap between reception and action was the entry point the to the exploration; how could an interaction take the short route leading from reception to action? It seemed that some objects are Talking to The Hand, in the sense that the way such objects give out information almost calls for instinctive action somehow bypassing other processes. Intuitively, it seemed, with no objective proof, that the looks of things evokes a sensation or response in our hands, which in turn, 'evaluate' the potential of holding or touching such an object. It appeared reasonable that this is a natural capacity for humans, to understand the surrounding through our palms.

¹ Topham, Blow-up, 55-79

² Topham, Blow-up, 49-53

³ Goldstein, Time magazine, Vol. 156 No. 15

⁴ Wikipedia, Cognitive science, 3.6.

2.1 Affordance

Looking into cognitive theory one idea that immediately stands upfront in that regards, is the concept of affordance. J.J. Gibson, the American psychologist, suggested that the perception mechanism leading from reception to action is not necessarily situated at sensation, and claimed that the environment itself holds information that 'explains' the circumstances and possibilities available in that environment⁵. His approach favored the direct realism theory developed by Thomas Reid, the 18th century Scottish philosopher.⁶ In short the theory of direct realism claims that an object image is not projected onto the brain in the form of sensations and then processed to form a perception of that object but rather exists outside of the brain as part of this object or at least as part of the environment that contains that object.

Gibson's concept of affordance refers to 'a property of an object, or a feature of the immediate environment, that indicates how to interface with that object or feature'⁷. It holds many practical implications in the field of design in general and to thesis - Talking to The Hand in particular.

2.1.1 Natural, silent language

Gibson's approach and the theory of direct realism suggest that for humans the appearances of the physical world are deeply familiar. It might be said that we read the environment through a language; objects are not only placed in a location and carry an arbitrary appearance, but they are related to a scheme that in turn is related to another scheme, and together they form a greater scheme that represents the environment in total. A scheme is interpreted as a sum of operating forces and constrains all conveyed by visual signs and symbols. Morphological features, textures, and projected physical vectors serve as those signs. We see then that a physical environment is embedded with layers of meaningful information, and that appearances in the physical world are not at all superficial, but rather derive from substances, properties and inner mechanisms.

2.1.2 An acute design consideration

The relevancy of the idea of affordance to the field of interaction design and to my thesis in particular, is great. In his book *The Design of Everyday Things*, Donald Norman one of Gibson's assistants claims that 'well-designed objects are easy to interpret and understand. They contain visual clues to their operation.'⁸ He identifies the way things look as functional

communication, 'clues to how things work come from their visible structure- in particular from affordance constraints, and mappings.'⁹ And ads, 'Visibility acts as a good reminder of what can be done and allows the control to specify how the action is to be performed.'¹⁰

2.1.3 Inherent physical qualities

Designed objects that use the visual language of affordance, can become efficient and intuitive for use by cutting the need to evaluate through analysis the potential interaction with that object to then respond with the desired action.

In practical terms, to design an object with the right affordance is not always a straightforward act. Mechanical objects for example, adhere to the above quotes from Norman, in regards to their visible properties and derived action. But, modern digital objects might not provide many inherent visual clues, as there are simply no meaningful structural affordances apparent. If there are any affordances, other than those referring to the general shape, they usually relate to interface elements controlling various functionalities.

Shape-change objects could be imagined as ones that adapt their shape to 'output' a certain affordance Talking to The Hand suggests that although a mechanism is not required for the pure function of a digital object, a mechanism might still be required to generate visual communication. Metaphorically, it will serve the object as a generator for facial expression or body language. Through the use of the 'natural' language of affordance, these objects will form a familiar exchange of information with a spectator or a user.

2.2 Bodily clues

The concept of affordance explains how an appearance is meaningful, and how might an object 'talks to the hand' in an iconic manner, like a sign or a symbol that carry a meaning. But Talking to The Hand covers as well other types of knowledge like qualities of touch, as texture and weight (pressure), or mechanical properties as freedom of movement, balance, etc. All those are considered in an interpolated calculation to produce a perception. It is crucial to identify a possible mechanism with which the hands could generate this kind of perception.

2.2.1 'I am my body'

In his aphorism 'I am my body', Maurice Merleau-Ponty, the existential French philosopher, pointed to the fact

⁵ Wikipedia. Perception. Perception and reality.
⁶ Wikipedia, Philosophy of perception, 4.
⁷ Wikipedia, Philosophy of perception, 4.
⁸ Norman, *The Design of Everyday Things*, 2.
⁹ Norman, *The Design of Everyday Things*, 12.
¹⁰ Norman, *The Design of Everyday Things*, 22.

that human experience cannot be separated from the human body.¹¹ He describes our cognition, in 'The Phenomenology of Perception', as a dependent interrelation between the 'use of the mind' and the physical nature of our body which 'thinks' and 'perceives'. Our actions taken in the form of movement or our interaction with the physical world are a process of the body as a whole 'familiarizing' with the environment. Merleau-Ponty called this process habituality and explained it as a form of knowledge that exists in the hands, not accessible without a motoric purpose.¹²

One good example to the workings of this mechanism is the case of parking a car. As we lead the car into the empty space, we do not calculate distances or probability, we simply feel where the car begins and ends. We get that from our eyes looking at the mirror and out through the windows, but also from the hands in contact with the car through the steering wheel and from the buttocks situated on the driver seat. When we do not get these bodily clues from the environment, like for example in the case of driving a car in a video game, our sense of the car's physical environment is absent and as a consequence our driving performance is reduced. Similar, between aviators, it is a custom to talk about the buttocks as the place where the right way to fly a machine is felt.

In his book, *How the Body Shapes the Mind*, Shaun Gallagher, professor of philosophy and cognitive science, brings the example of communicative gestures. Gallagher suggests that gestures are motoric actions originating from an embodied experience, in the sense that we do not only react physically to the focus of communication (someone or something) in the form of hand movements, but also interactively iterate the movements as part of the communication and use them to support our thinking.¹³

It is hypothesized in *Talking to The Hand* on the relevancy of habituality as a concept to shape-change behavior, that a design acting physically within its environment (changing its shape) through the course of an interaction within this environment can provoke a better understanding of the purpose of that interaction and the situations along its course.

2.2.2 Tangible knowledge

Merleau-Ponty doesn't overlook other mental processes, the experience of perceiving a physical environment is

comprised of abstract information and tangible know-how - the process of our body as a whole familiarizing with the environment.¹⁴

The phrase 'the body as a whole' does not necessarily imply a total immersive experience; but rather indicates the overlap between the various perceptions available through the body and the actions those perceptions evoked. Going back to the example of the parking car, the experience of the driver is of overlapping input; the hands on the steering wheel with the movement of the car as it felt in the buttocks, the spatial feeling of the car interiors and the distance from other cars, or from the pavement, channeled through the eyes.

This also concerns with our ability to substitute sensorial information. The phrase 'seeing is touching with the eyes' suggests that in the physical environment the way things look corresponds with what we expect to feel when we touch them.

The relevant insight here is that we often describe such an experience as 'natural'.

In that case, if a virtual environment could provide a user with simultaneous multiple feedbacks in a course of an interaction that corresponds to an overlapping description of the same entity, touch and sight, hearing and touch, hearing and sight. This environment would be experienced as more 'natural'.

Laura U. Marks writes in her article 'Haptic Visuality: Touching with the Eyes' that ancient Greek philosophers, described perception as contact between the perceived object and the person perceiving it. In Marks words 'haptic looking: we touch the object with our eyes'¹⁵. Shape-change being both tactile and visual, is a medium that might provide such experiences.

2.3 Peripheral awareness

The periphery in our awareness, describe events and occurrences we are aware of without putting them in the highest priority of attention or the center.

Mark Weiser and John Seely Brown who pioneered the work on peripheral awareness in the context of technology while in Xerox PARC, give the example of driving: 'ordinarily when driving, our attention is centered on the road, the radio, our passenger, but not the noise of the engine. However, an unusual noise is noticed immediately, showing that we were attuned to the noise in the periphery, and could come quickly to attend to it.'¹⁶

¹¹ The Internet Encyclopedia of Philosophy, Maurice Merleau-Ponty, 2.

¹² Merleau-Ponty, *Phenomenology of Perception*, 144.

¹³ Gallagher, *How the Body Shapes the Mind*, 123.

¹⁴ Merleau-Ponty, *Phenomenology of Perception*, 144.

¹⁵ Marks, *Haptic Visuality: Touching with the Eyes*.

¹⁶ Weiser & Brown. *Designing Calm Technology: The Periphery*.

The periphery is only a hierarchy of priorities, which might change when circumstances change. It does not suggest that the things in the periphery are less important, since what was before a background noise or at the periphery can become the center of attention.¹⁷

2.3.1 An integrative experience

The experience of the physical environment is comprised of a stream of parallel simultaneous experiences that take place in the entire scope of our awareness, center to peripheral. We often describe that stream as a 'natural' experience, as it provides a sense of integration with the environment.

One possible reason as for why the physical environment provides a sense of integration is the feeling of 'being in control' that follows the action of diverging the focus of our attention to an event that takes place in the peripheral.¹⁸

On the contrary, the virtual experience is not as multi dimensional. Most interactions with virtual entities address the center of our attention, this experience is often considered stressful.

2.3.2 'Calm technology'

Weiser and Seely who coined the term 'Calm technology' already suggested this insight on the nature of technology in the context of awareness. It describes designs that 'live' in the peripheral space of our awareness, and suggests that digital technologies usually lacking a peripheral dimension in their interaction with users could become less stressing through being able to address our attention not only through the center.

One famous peripheral design that falls under this definition is Natalie Jeremijenko's 'Dangling String', a plastic wire that was suspended from a small electric motor and connected to an Ethernet cable. Each time a bit was transferred through the network the motor rotated an increment, the outcome behavior was some sort of twirling, the more traffic went through the Ethernet cable the more it twirled. By using the tactic of embedding information into users surrounding environment, it kept people aware of network traffic. This tactic strongly relates to Talking to The Hand, which suggest that shape-change behavior acts, in environments of information technology, as a medium that can generate peripheral experiences.

3 Frame work

The background chapter constitutes the thematic framework of Talking to The Hand. It proposes as central, three interactive potentials of shape-change:

Shape-change in relation to the concept of affordance, how can the change of appearances or shape, in specific those that describe the interactive qualities of an object, communicate.

Shape-change in relation to the idea of habituality, referring to the way our perception derives from the body as a whole, and how might interactions with overlapping inputs, such as visual and tactile provided by shape-change, familiarize virtual entities to users.

And last, shape-change in the context of the periphery, how can shape-change bring into interactions with virtual environments and digital devices a peripheral dimension, to produce a 'natural' experience.

The next sections will report the iterative prototyping part of the exploration set to verify these proposals. It will describe the morphological and semantic issues that appeared in the process of developing shape-change designs, illustrate the decisions taken along that process and summarize the findings of each iteration session.

The various prototyping sessions were performed under three themes drawn from a preliminary mapping of shape-change properties. Section 4 focuses on the visual aspects of shape-change. Section 5 looks into the tactile realm of shape-change and section 6 with the adaptive quality of shape-change.

Section 7 describes the working demos that were developed at the end of the process as a summery.

4 'Body language' for objects

In every system, at any given time, there exist multiple statuses in which the system might rest. Only in transparent systems that consist of only their visible structure, are those statuses obvious to the observer. In order for a spectator to realize the actual system status, a clear indication of this status needs to be displayed; however, a straightforward design to meet this requirement is not always possible, as often the status is hidden, or not always self-explanatory. For example, the

¹⁷ Weiser & Brown. Designing Calm Technology. The Periphery.
¹⁸ Weiser & Brown. Designing Calm Technology. The Periphery.

simplest light system, consisting of a light bulb and a wall switch, can assume four statuses. Only one is apparent and absolute - the 'light on' status. The other status, 'light off', although it might be obvious at first glance, could, in fact, be mistaken with 'bulb burnt' status or 'switch contact detached' status. To verify which is the relevant status, a logic procedure of debugging is required.

A morphing light system [Fig. 1] suggest how the physical structure of a light bulb could use a shape-change behavior, dependent on the status of the system, to provide explicit affordances that indicate its hidden statuses, and point at required action, in the 'bulb burnt' status, replacing the burnt bulb.

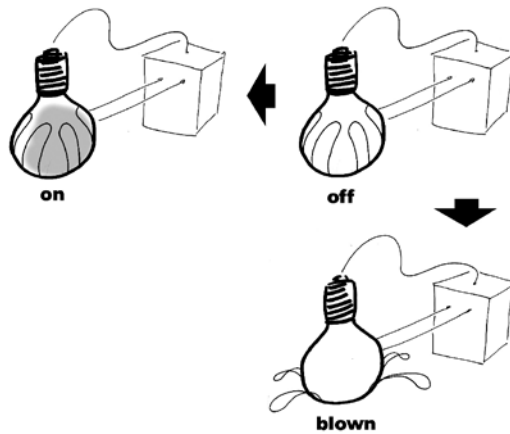


Fig. 1

4.1 Gestures, surfaces and textures

As previously discussed in the background chapter, shapes and textures form a 'natural' language. Talking to The Hand suggests that shifting between shapes can use this model to construct a new shape-change based language, in which lingual elements are source shapes, deploying features performing animated gestures are put together to produce phrases.

Few principle questions appeared before actual design work could have been done:

- What are the borders for a motoric-action to be conceived as shape-change
- How does the actual appearance of an object (skeleton Vs. envelope) effects the perception of a shape-change

To set the perimeter of the coming exploration it made sense in a practical manner to sum up those questions as tangible properties that would serve visually as a reference point for actual prototyping, all relating to a single design

criterion, what acts better as the agent of communication?

- Feature vs. Body, moving organs or shifting an entire body?
- Texture vs. Structure, transforming overall geometry or occurrences on the surface?
- Gesture vs. Posture, animation or still?

4.2 'Morphing cube'

'Morphing cube' attempts to hint at an initial vocabulary a sort of ABC of shape-change transformations. It was confined to a brief as follows: 'Construct a simple object representing a digital device, which conveys three operation modes or statuses through shape-change', and followed a process of tangible prototyping iterations.

The digital device selected as a vehicle for investigation was an external hard drive. A quick survey among intense users brought up three statuses reported as primary:

- Volume status, how much space is available on the hard drive?
- Activity status, is it ok to disconnect the hard drive from the computer?
- Synchronization status, to what extent is the backup on the hard drive synchronized with the computer?

Five prototypes were produced in total; three of them were develop into a video scenario illustrating the proposed interaction.

4.2.1 Prototype I: Volume

Initial sketches revolved around the property of size as a direct mapping to the amount of data inside the hard drive, most of them dealt with an expanding or growing envelope. It was clear though that an animation of growth as a mere gesture is inaccurate as, for example, it doesn't give out the same reading for more data or less data, since there is no real reference point for comparison. [Fig. 2]

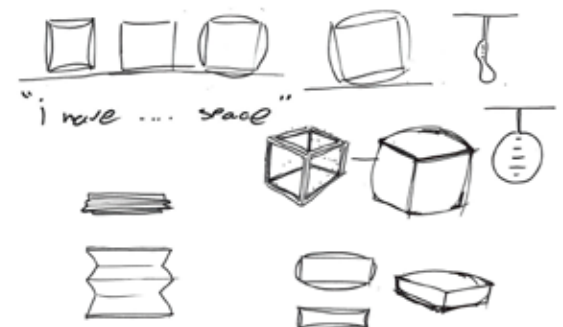


Fig. 2

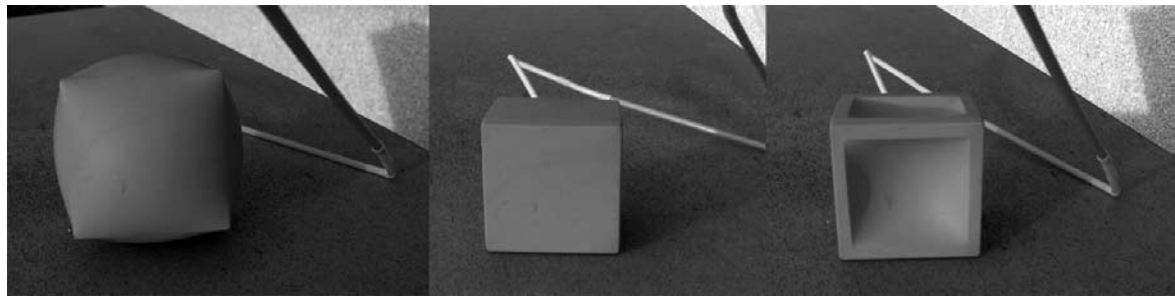


Fig. 3

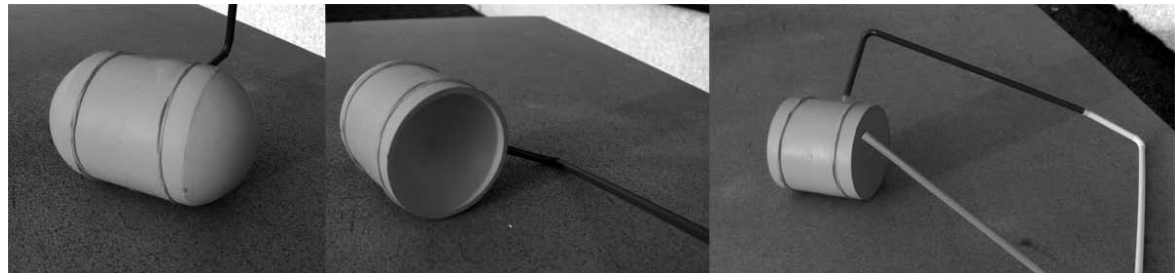


Fig. 5

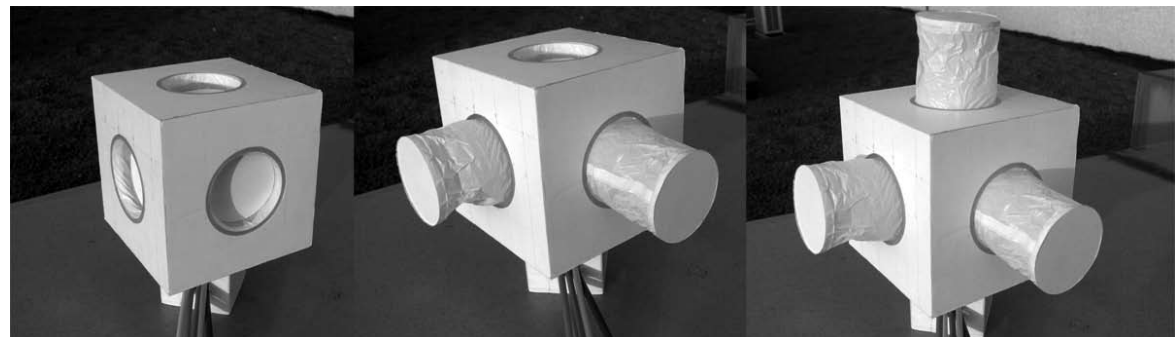


Fig. 6

The next set of ideas and the final object for the video prototype were composed of a skeleton structure, apparent along the animation of the shape-change, and understood intuitively as an reference point to compare the potential capacity with the current outline. [Fig. 3]

4.2.2 Prototype 2: Activity

Initially I thought that the hard drive might be able to indicate the 'what can or can not be done', as I was trying to follow the way animals are being understood by us through their body language. [Fig. 4]

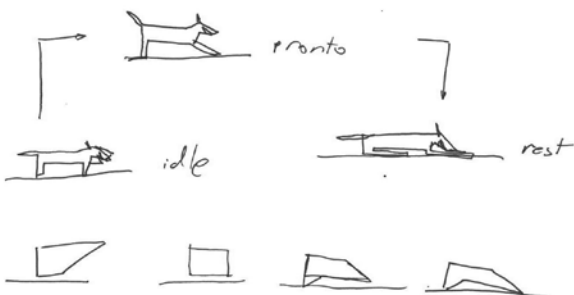


Fig. 4

How ever, as I developed the idea further it seemed more relevant to show whether the device was generally 'occupied', rather than indicating through a dedicated posture each of the various tasks it could perform. My

assumption was that in any case, while a certain process is undergoing, 'what can or can not be done' follows intuitively, and if the process or activity are evident the user will respond accordingly.

This behavior was demonstrated in a 'breathing' prototype [Fig. 5]. As activity undergoes it increases or decreases the rhythm of 'breathing' up to a stop when activity ends.

I further sketched objects that reflected internal process on their exteriors, by deploying tentacles, or rearranging geometrical hierarchy.

In one particular prototype that dramatically deployed large inflated tentacles, the scale of transformation or action was un-proportional to the content of the message, making the overall behavior seen as grotesque. [Fig. 6]

It led to me to believe that patterned occurrences, almost in a texture scale, on the outer surface of the hard drive, could would be more relevant shape-change behavior. The video prototype featured an object with a surface that was able of inflating bubbles in a pattern corresponding with a specific activity. [Fig. 7]

4.2.3 Prototype 3: Synchronization

The idea of an object getting in or out of sync builds on the convention and expectation that man made objects should be aligned to something in the space. Everything refers to some sort of origin, the gravity, the hand or head

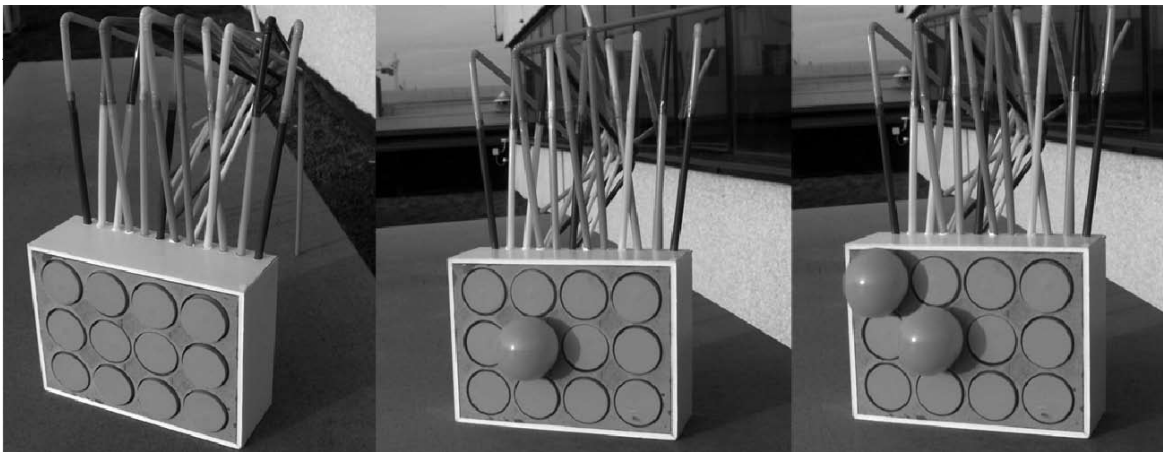


Fig. 7

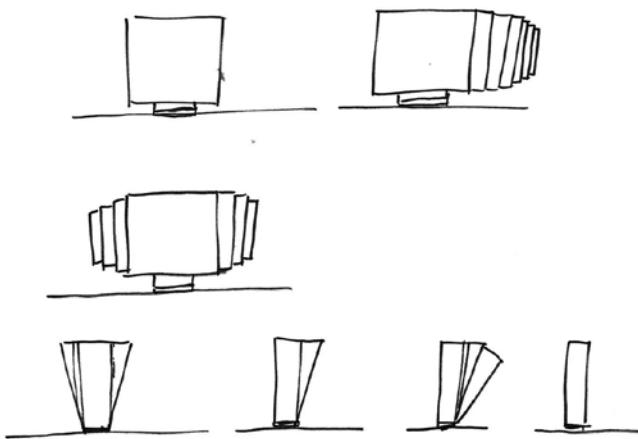


Fig. 8

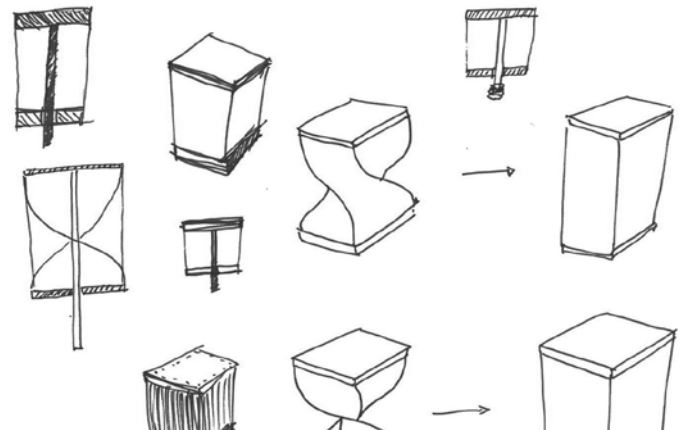


Fig. 9

or foot, and so on. I wanted to play with this idea and use this paradigm to state the relation of the content inside the hard drive with the one it originated from. While sketching I searched for way in which an object could express weather it was in sync or out of sync.

I was initially looking at symmetry, but came to think it delivered other misleading messages, such as 'out of balance', or pointing 'this direction'. [Fig. 8]

Again, as in the case of the 'Volume' prototypes, the issue was where to place the reference point. This reference point had to be self-contained generating a message independent of other objects that could be understood only through looking at the object itself. [Fig. 9]

Following this line of thinking, the prototype was referred to both itself and to the external surface it was standing on, in order to express the out-of-synced position. Two of the prototype adjacent planes were sliding in parallel to each other, causing the envelope to twist in a way that appeared as if the cube lost its alignment. As it was going out of sync while standing on a table, the prototype lost as well its expected stable posture further expressing the status of un-synchronization. [Fig. 10]

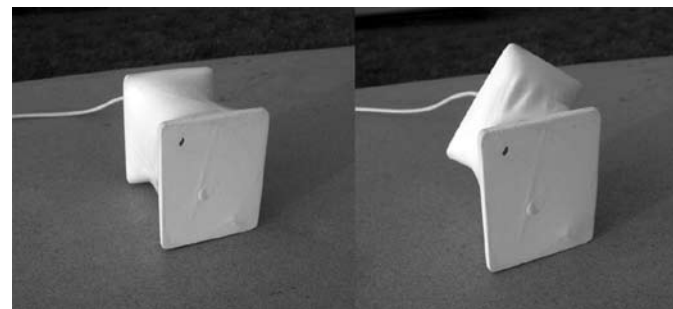


Fig. 10

4.2.4 Findings

Through the implementation of the 'Morphing cube' prototypes, I found answers to most of my initial questions that were not categorical, and seemed to be valid with in circumstances of the specific design.

The importance of a reference point in which a change could be measured was crucial. In order for a spectator to predict the physical potential of a certain entity, the design must hint at its entire capacity. I conclude that a shape-change can only be made measured and mapped through the existence of an internal skeleton, which the change could be referenced to.

The gesture language of 'Morphing cube' prototypes could not communicate more than few 'phrases' contained in the design. The lack of nuances in this gesture language led me to the next exploration, looking into occurrences on the texture level, as a sort of surface relief, their potential to communicate more elaborate messages and conduct more complex interactions.

5 Tactile experience

In this phase of the exploration I focused more on surface transformation and textures like shape-change. Zooming into the surface level resulted in tactile aspects becoming more dominant in the design process as the scale of transformation was now much smaller. Working and thinking about touch-interfaces meant dealing with cognitive problems and limitations, of perception related to the sense of touch, that were later identified through user observations. The outcomes of this process were two interfaces based on a shape-change surface, and scenarios that demonstrate the context in which those interfaces could be used.

5.1 'Blind tests'

In our everyday experience of the surrounding, touch plays an important role.¹⁹ We experience everyday shapes and textures through small and big skin deformations, changes in boundary temperatures, and, localized and distributed vibrations at the skin surface. It allows for a particular exchange of information with the direct surrounding world, and contributes greatly to our sense of awareness. Designing for touch has hidden qualities. Mostly, fully sighted people experience touch, in the pure sense, vaguely.

In order to test to what extent a user can read shapes, a shape reading 'blind test' was conducted in cooperation with Victor Szilagyi a fellow student that investigated location based media in his thesis work.

We assumed that through 'blind testing' the tactile parameters could be isolated from other parameters, and since 'blind testing' is a method used to evaluate efficiency of physical interfaces, we anticipated that any performance displayed on a 'blind test' is due to increase in fully sighted conditions.

The aim, from the design point of view was to develop an interface for location-based information that would allow

a primary mapping of available information in a specific location without engaging vision.

We view this interface as an alternative, or rather complementary, to visual based interaction. Thematically it seemed to fit the concept of peripheral awareness mentioned earlier, and also allowed us to experiment with idea of 'haptic visuality'.

5.2 User observation (1)

The set up for the observation was a box into which our participants could reach with their hands, unable to see what was inside. Inside the box the participant could feel by touching a surface of pins (three-dimensional pixel display) a series of shapes and composition of shapes. [Fig. 11]



Fig. 11

In the first stage of this iteration the participant was requested to read:

- Single basic shapes.
- Compositions of various basic shapes with similar sizes
- Compositions of various basic shapes with varying sizes

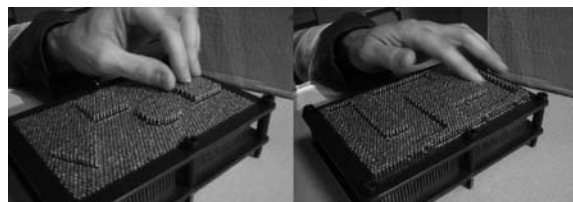


Fig. 12

All the singular shape compositions appeared to the participant embossed, and the basic shapes were always squares, triangles and circles. [Fig. 12]

In the second stage, the participant was requested to read:

- Single paths (continues depressions)
- Composition of paths

All the paths compositions appeared to the participant engraved. [Fig. 12]

¹⁹ Pasquero, Stimulation of the Fingertip by Lateral Skin Stretch

This testing process brought up several insights into the perceptual mechanisms being triggered, when understanding a three dimensional array only through touch. The first insight concerns the 'big picture'; the participants lacked the instant general understanding of the environment. They tried to recreate the three-dimensional features in their mind as they were feeling the terrain. The main obstacle they encountered, however, was their lack of prior knowledge as to the possible forms and layout. This made clear that since sight is medium of light, it covers great distance, as oppose to touch that requires 'no distance'. It made apparent that prior knowledge of the unfamiliar surface possibly a metaphor, or an inventory of participating features in the design, has to exist in order for an interface to work equally efficient with sight and touch. Another aspect of this issue was the physical size of the object, and its relation to the scale of the hand / finger, and the overall size of the display. A match between those sizes would allow participants to map the entire area of display onto the palm of their hand, and by doing so get the 'big picture'. We anticipated that keeping this kind of proportion would result in reducing stress, disorientation and effort reported by some of the participants.

Looking into the specific of hand motoric, the finger work, we saw that participants 'previewed' the terrain quickly and were akin to boundaries more then morphology. This was made obvious through both the lack of overall boundaries that define the perimeter of 'feeling' and the actual reading of a shape by following its edges. However, due to the granular nature of the pin surface raster, those edges were interpreted ambiguously. We discovered that smooth transitions having less of an edgy quality, were more suited to be displayed on the pin surface.

On another level, the basic demand to call a shape by its name seemed to be a methodological misconception. It was made clear through comparing participant's response to the engraved composition that could be generally described as 'Paths', as oppose to the embossed compositions generally described as 'shapes'. Participants could easily draw the outlines of a single path or a composition of paths, while exhibiting great difficulty when doing the same for compositions of shapes.

5.3 User observation (2)

The second iteration was focused more on identifying design opportunities for the interface mentioned earlier. It used the same 'box' setup as in the previous iteration. On the first stage of this iteration, going from light to heavy, the participant was requested to read smooth compositions of shapes and paths. Some compositions appeared to the participant embossed, while others engraved. [Fig. 13]



Fig. 13

In the second stage of this iteration the participant was requested to read animated transitions of various smoothed shapes along the surface of display. Animations appeared to the participant to vary on their behavior - continues, jumpy, abrupt, and so on. As well as their approach to the hand – longitude, latitude, circular, slalom, and so on.

This testing process brought up several concrete insights into the nature of that interface. As it was expected from the conclusions of the previous iteration on the granular quality of pin surface as the display medium, participants were much akin on grasping smoothed compositions.

As to the issue of a big picture, the boundaries of all compositions match an average hand size, and consequently participant's movement's pattern on the display area seemed much more oriented. However, the actual reading of the composition has not improved dramatically, and moreover it seemed that in terms of interaction, transformation of such a composition would introduce constant effort in just realizing the change, let alone acting upon such feedback. When asked to imagine the possible representations of those terrains in interfaces, participants referred to this question in either a direct mapping like for example – a stadium map, the solar system model. Or to the direct affordance of the pin surface to be pushed, hence buttons.

On the other hand the results of the second stage were more encouraging. All the participants responded sharply to animated transitions of shapes. It seemed that to follow through touching only the moving shape, as they were asked to do on one task, was natural and serene. It also matched our prior knowledge of the affinity of human's to movements in their environment, (the instinctive motoric response to movement exhibited by newborns for example).

The second task, of identifying and distinguishing between behaviors and approaches of the animated transition, also proved highly potential as all participants were able to identify, easily, quickly and accurately, all five exemplars they were introduced with.

We concluded that the real opportunity for a valid interface based on shape-change surface, was animation.

5.4 The Tacto-phone

The Tacto-phone is a detailed video scenario of a cell phone interface that allows for interaction with location-based information. It does so in an 'on the go' and 'in the pocket' fashion. By that I mean not having to stop walking, or moving through space, in order to interact with the device and through it, the relevant information. And also, being able of performing initial interaction, like preview, without taking the device out of the pocket.

The Tacto-phone uses a touch sensitive morphing surface to display and interact with animated shapes. It is suggested that the surface would be placed on the backside of a cellular phone, complimenting its screen. The surface together with an audio channel provide a preview and initial interaction with information placed in a specific geographic location, without using sight. [Fig. 14]

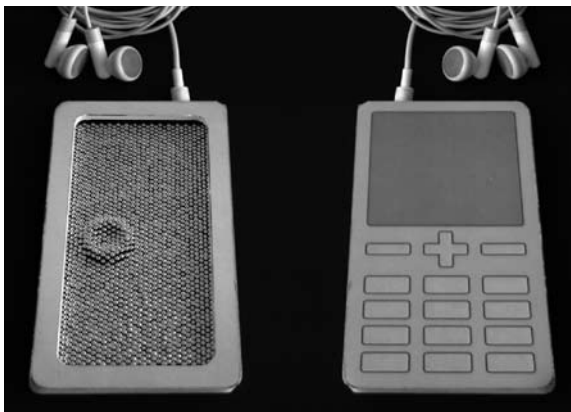


Fig. 14

Shape animations, called Tactons, are the basic interface element of the Tacto-phone. As concluded from the user observations, these animations, structured from combinations of shape, behavior, and approach to the hand, provide a hierarchical vocabulary large enough to map animation to information, similar to the way icons function in a GUI. [Fig. 15]

Tactons can be used for example, to distinguish between information that refers to people, from one that refers to content, or one that refers to events.



Fig. 15

As the animation is dynamic, the display area is mapped to a certain physical size that represents relative distance from the actual geographic position of the information, in reference to the spatial context. For example in a city, the mapping would be linear and related to a street. It provides basic navigation functionality as well as sensitivity required to filter all available information. The bigger the distance threshold is, the more information will be displayed.

5.5 Findings

The Tacto-phone highlight was with no doubt the response of users to animated occurrence on the pin surface. It emphasized the understanding of what we are attuned to effortlessly, as well as its potential as an opportunity to use this behavior as an interactive communication element.

6 Bodily experience

The work on the Tacto-phone brought up few interesting directions to peruse in the next phase. In particular the idea of adaptation as it has evolved through the Tacto-phone iteration seemed intriguing - as the environment changed, the animated rippling occurrences on the shape-change surface transformed. The Tacto-phone literally adapted its shape in reaction to environmental input;

however, this adaptation was obvious, the environment changed because the Tacto-phone is being navigated along the streets of a city. I was wondering whether there could be other adaptations not dependent on actual movement through space.

6.1 Adaptation in a digital environment

Drawing from nature, where adaptation is some sort of ongoing interactions between a living creature and the environment I defined for methodological purposes the components of a hypothetical digital environment for a certain interface. In this environment, the possible 'stimuli' on the interface can be considered and mapped. The environment map of a peripheral PC interface is composed of hardware, software, applications, other interfaces, information and users. When considering this environment in the context of an adapting interface, it points at the information component to be different in characteristics than the others.

All components introduce into the environment a 'stimuli' that might require adaptation, for example if the hardware is upgraded the interface might need to be replaced to be compatible with the new system requirements. However, such adaptations occur rarely. On the other hand, the information being interacted with changes frequently, not in terms of substance but in structure. All information is organized in some sort of a databases that although similar in principle are practically structured differently one from each other.

A good example for the diversity of databases is seen on the Internet. Although all websites are in essence databases each one is structured dramatically different, a fact most clearly evident through web page designs.

6.2 'Habitual interaction'

Following the digital environment adaptation analysis an adaptable interface reflects an ever-changing structure of information by adapting its appearance to the new circumstances. I hypothesized that by doing so, hidden qualities of the structure of this information (the database), would be exposed. I also assumed that manifesting this adaptation through physical action, the exchange between the user and the interface would enhance the user 'habituality' of with the virtual environment in which the information is situated, making the user more familiar with this information.

6.3 InfoTerrain web interface

InfoTerrain is a prototype with morphing interface that follows the approach proposed above. The interface superimposes three-dimensional, tactile maps onto existing web pages and therefore represents hidden qualities of this website. Since the main interactive feature of web page is a link, a super imposed webpage would simply illustrate the hidden aspects of that link. This would serve as new affordance of the link, thereby exposing the organization of the web site. It could expose the way in which the web page is connected to other websites, or the ways in which other users refer to it.

The interface suggests that information presented on a web page has depth, and that only a tiny portion of this depth is currently presented in webpage design. The iceberg metaphor better explains the hidden aspects of a link on a webpage; it could be seen as the tip of an iceberg that pops out of the water while the major part of its body is submerged. [Fig. 16]

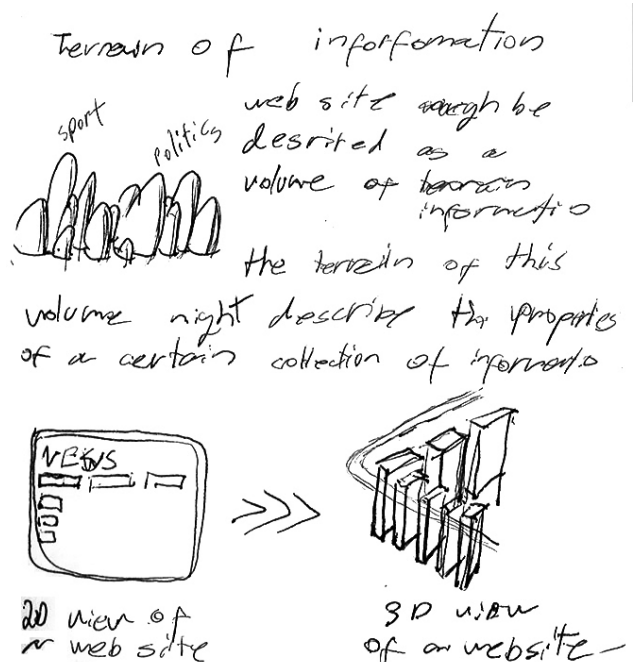


Fig. 16

Such three-dimensional tactile map is displayed on a morphing surface. A user laying his hand on the interface feels the surface morphs as he moves the mouse-pointer around on the screen. The interface acts as a peeping hole into the three-dimensional tactile map that corresponds with a certain 'hot area' surrounding the mouse-pointer. The three-dimensional output depends on the 'rating' of

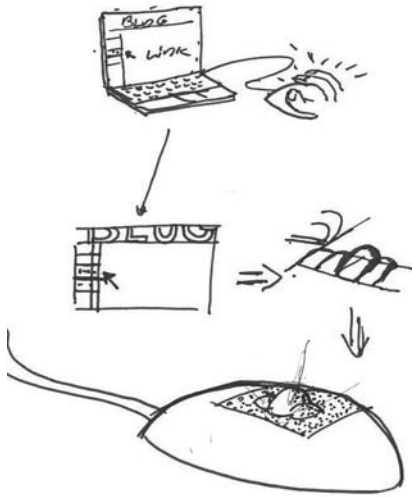


Fig. 17

a particular link within the 'hot area', the more 'rating' the link has, the higher the bump becomes. [Fig. 17]

Those tactile maps could display various potential ratings: Interconnectivity - It shows how big is the interconnection of the source behind a link and other sources. This might expose a cluster map of information sources, and potentially point to community sharing the same interest and interrelated through different websites. [Fig. 18]



Fig. 18

Popularity – a map that shows how a link is ranked within a certain reference group. For example del.icio.us link sharing. [Fig. 19]



Fig. 19

6.4 User observation (3)

In order to quickly evaluate the concept, I prototyped a rough version of the interface that would somehow convey the experience of a three-dimensional tactile superimposition, and get an initial feedback from users on the experience of such interface.

Due to technical limitations and time concerns I decided to use an existing pin surface and install under it a mechanism that actuated three Ping-Pong balls using servo motors. The mechanism received actuation commands from a screen application that was tracking the mouse-pointer over a faked webpage. Whenever the pointer was hovering over a link, the motors in the mechanism were updating the ping-pong balls height to match with 'value' of that link.

As the user laid his left hand on the pin surface (the right was moving the mouse) the three dome-like bumps would constantly change their height pushing against the users fingers up, or letting them fall back to natural posture.

The mapping between the interface and the webpage attached the mouse pointer to the middle bump. The other bump on the left was attached to the nearest link to the left of the link being pointed at by the mouse pointer. The same applied to the right bump.

On-screen those links, which were mapped to the pin surface, were dynamically highlighted with a different color while the mouse pointer was moved around the screen.

[Fig. 20]

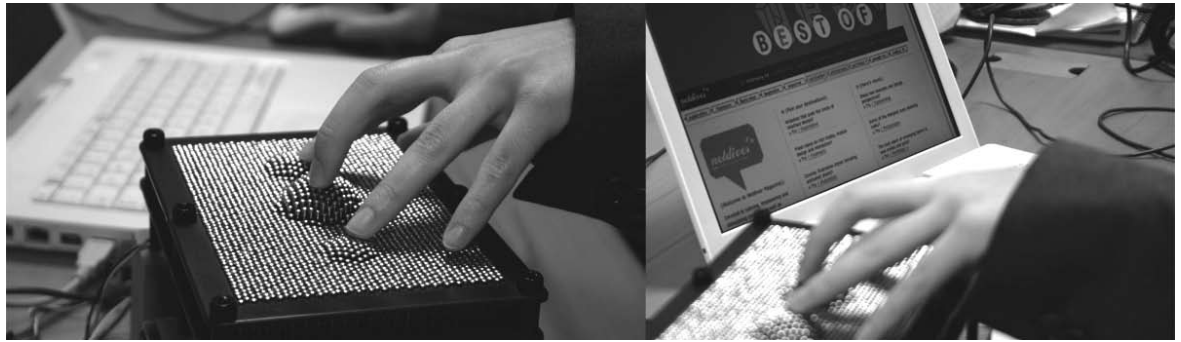


Fig. 20

The prototype brought about several interesting insights:

- Disorientating triphonic input, eye and two hands were causing the user to loose focus
- Animation of the bumps on the pin surface in relation to the mouse-pointer movement on screen wasn't continues, obstructing the mapping between what's on screen and what's under the fingers
- The mapping between the fingers touching the bumps and the link the pointer is pointing at is diverted (which finger represents the pointer).
- The Bump array dispersed on the surface was bigger then the normal hand size over straining the users both physically and mentally, trying to find the right location on the interface (playing a piano)

6.5 Findings

The most valuable finding from The InfoTerrain prototype was the understanding that information requires a dynamic representation, as it is most likely multi-dimensional and cannot be fully understood through only one trajectory. It seemed more relevant, that physical interfaces should reflect that in the same manner that screen interfaces do.

7 Final demos

To round up the exploration process I selected, from the three main sessions of explorations previously presented, two prototypes. I chose those, which were the most intriguing in their interpretation and explanation of shape-change behavior, to be further developed into working prototypes, that could demonstrate some of the proposed experiences, and provide an evaluation of their potential for future research.

7.1 InSync external hard drive

This prototype is an upgrade of the previous 'Morphing cube' prototype 3, which indicated how well a backup is synchronized with its source. It was composed of two plates connected together through a motor, and a flexible Lycra like fabric stretched between them. [Fig. 21]

The interaction however, was this time, bilateral, utilizing shape-change behavior for both input and output. The hard drive, cubically shaped, always displays the validity of the backup it contains (how well it is synchronized with its source) by misaligning its parallel two plates. The angular disposition between the two plates represents the difference (%) between the file structures of the source device and that of the backup on the external device. The bigger the difference is, the more InSync twists on it self. A synchronization utility can be initialized by physically enforcing the plates towards alignment a small fraction of the way, or otherwise, clicking a button on the screen interface. [Fig. 22]



Fig. 21



Fig. 22



Fig. 23

Interesting issues came up in the design process, concerning the proportions of the plates and the distance between them. One consideration was that the visual output of disposition is optimized when the plates are closer together, while the affordance of the required twisting action was optimal when the plates were further apart.

7.2 'Morphing mouse'

The 'Morphing mouse' refers to the previous 'Habitual interaction' concept and is taking of from the InfoTerrain prototype, exploring another potential for interaction with screen interfaces through a morphing surface peripheral. The interface is a sort of a hybrid between a mouse and a touch panel, merging the mouse essence of hand to pointer-on-screen mapping, with the finger function in a touch panel interaction.

Moving the 'Morphing mouse' repositions the mouse-pointer on-screen. When a GUI-screen-object (icon), or link on a web page, enters a hot-zone surrounding the mouse-pointer, the pin array morphs to display a "button" corresponding with the screen object/link. [Fig. 23]

The "button" that appears allows clicking on the screen object/link, while exposing its qualities, through shape & behavior. For example, a "button's" height can represent the size of a folder, or the score of a link in google. While a rhythmic up N' down movement might indicate the current beat playing in an Internet radio station the link is pointing to.

7.3 Design considerations

The realization of this prototype drew many efforts. The initial idea was to develop a matrix of actuated pin which all carry a stretchable membrane in a similar construction to the way poles hold a tent. The idea was, that this surface with a very basic resolution could generate ripple like effects and animate them. The advantage of this approach was that it could display more than one screen-object thus providing continuous tactile experience of the objects array displayed on screen. However, This attempt failed as the components and mechanism required for making such working interface were out of reach due to schedule and budget concerns. [Fig. 24]

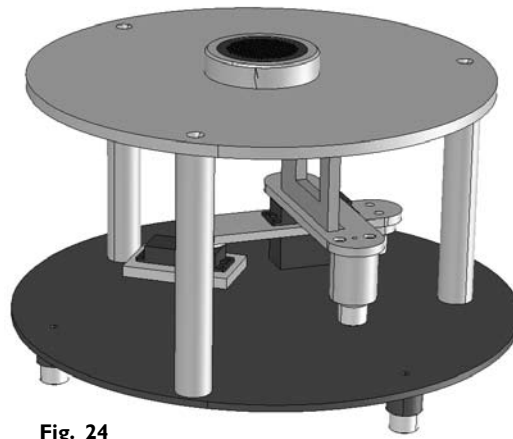


Fig. 24

Finally, the approach selected was to build a device that can emulate a shape-change behavior using a robotic arm with X and Y freedom of movement, which could place a spherical head anywhere under a pin surface. This device was able of displaying and animating the relative position and direction of flow of a screen object on the pin surface with high resolution. It was also able to provide a much richer tactile experience through a variety of motion behaviors the arm could output. [Fig. 25]

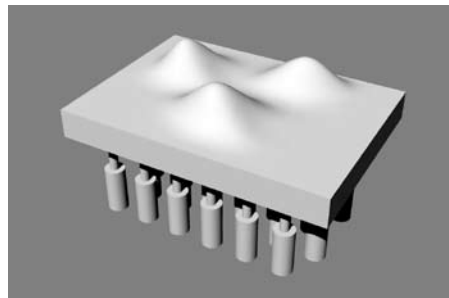


Fig. 25

7.4 Feedback

It was certainly an easy task to identify on a demonstration that users quickly catch the InSync interaction. This was also a simple explanation since the animation and what's behind it are strongly connected through the twisting metaphor.

The 'Morphing mouse' however lack the action needed to complete the experience, when a "button" appeared the loop wasn't closed through clicking on the bump. This self-explanatory action was evidently missing when observing users response.

8 Summery

Talking to The Hand builds upon three external ideas, affordance, habituality and 'the periphery', all of which support, although not categorically, three design proposals. For example the 'Morphing cube' prototypes might fall under affordance as well as 'the periphery'.

The first proposal is the idea of a 'body language' for objects based on the concept of affordance. It envisions digital artifacts that produce communication by adopting

an informative posture, through shape change. Objects as such can provide the spectator with deeper understanding on their status and inner processes.

The second proposal is a body-oriented interaction, that relates to the concept of habitualization and embodied perception. It suggests that intangible information is greatly familiarized through multiple sensations of shape change occurrences on surfaces embedded in digital objects. The point here is that the more parts of our body participate in a certain interaction with the virtual the more this virtual becomes familiar in the perceptual sense.

The third proposal focuses on a peripheral experience, it draws from the unexploited potential the periphery holds, in the context of interaction with digital environments, to reduce the interactive load, make existing interactions more efficient, and increase our capacity to process information. It suggests that through shape-change, virtual entities can address both the center and the periphery of people's awareness. Shape-change being a physical phenomenon perceived as part of the physical environment of the interaction, enables physical intervention in this environment.

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Towards sustainable use: An exploration of designing for behavioural change

Abstract

This paper reports on research aiming to identify, apply and evaluate design-led approaches for behavioural change to reduce social impacts of mobile phone use in public places. The paper presents the findings of the literature review; design-led approaches identified; analysis of existing design concepts; and the methodology and results of the application of these approaches in a design activity carried out by Industrial Design Masters students. The paper concludes by discussing the outcomes of this activity within the context of existing research in this field and proposing a framework for the development of appropriate resources to assist designers in incorporating behavioural concerns into their design process.

Keywords

Sustainable, Design, Behaviour, User.

1 Introduction

The lifecycle of a product consists of design and development, manufacturing, distribution, sales, use and disposal. The use phase has been identified as having a significant environmental and social impact, which is largely determined by the consumers' behaviour [1, 2]. To reduce the impact of product use, technological innovation alone is not sufficient, a fundamental shift in behaviour is required [3] a shift which could be initiated by innovative product design. Designing for behavioural change however, remains a relatively unexplored field by designers.

2 Literature Review

2.1 Societal Impacts of Mobile Use in Public

In the past, telephone conversations always took place in private in a fixed location, 'mobiles' by their very design, remove these boundaries. They are free of spatial restrictions and fixed societal constraints, allowing the user unlimited interaction in a range of situations and spaces. The rapid assimilation of mobiles into everyday life has modified cultural norms and practices altering society's definition of acceptable behaviour within the public domain [4, 5]. Spatial boundaries are constantly renegotiated to suit individual desires [6]. Mobile phones act as an extension of the user, amplifying their abilities and projecting their virtual presence whilst signifying status, wealth and lifestyle to others. Inert until activated the mobile is "deaf... blind and completely depend[ant]... on the user to manage its state" [7] yet its autonomy is apparent in its ability to fixate, enrage and pacify its user [8].

Despite the abundance of user guides and voluntary codes of conduct for appropriate mobile phone etiquette, society has yet to develop any effective methods by which to deal with emergent impacts incurred from mobile phones presence. The architecture of the phone box once acted as a physical signifier to others that the caller had moved out of public territory into private space [9]. With the proliferation of mobile phones these physical and architectural signifiers have become largely obsolete. For the most part, the obligation is placed on the user to

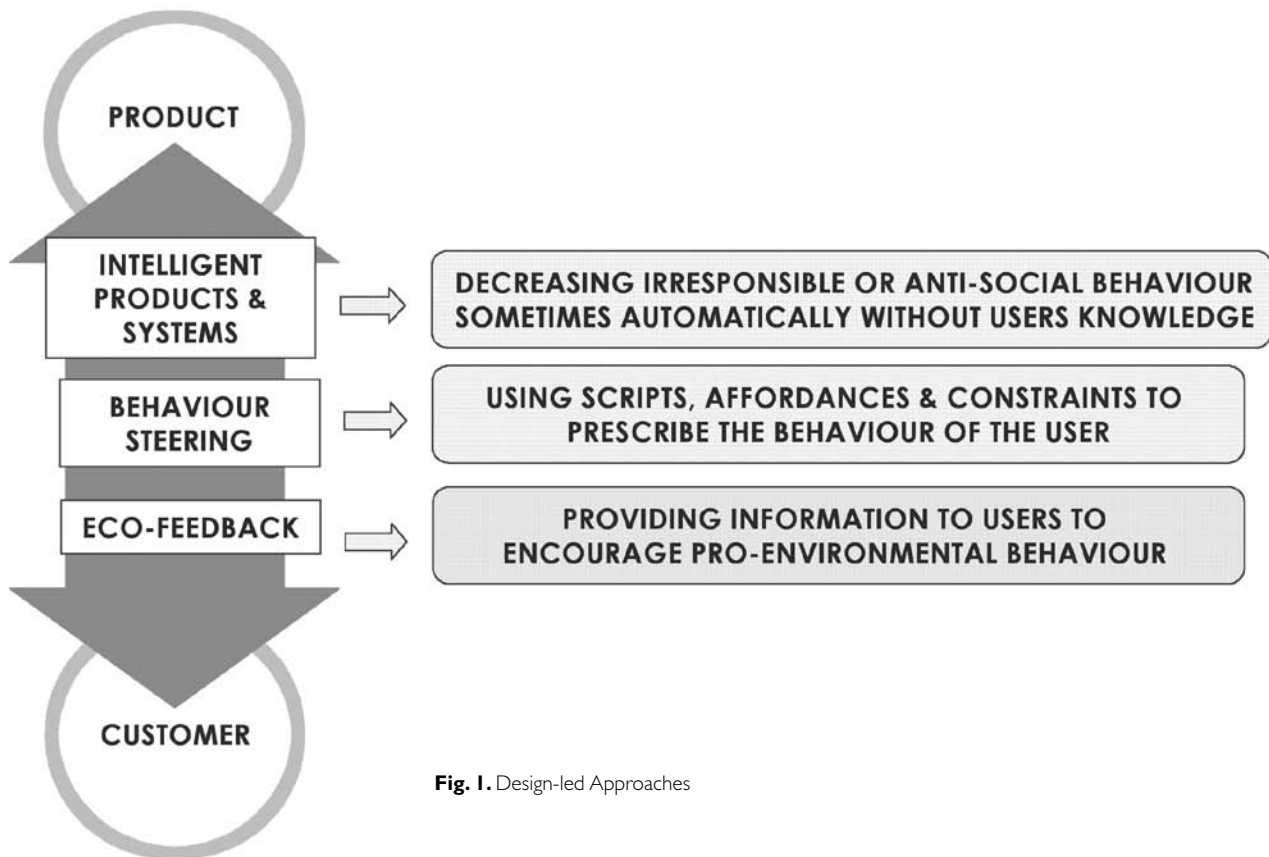


Fig. 1. Design-led Approaches

use their phone appropriately [10]. Users negotiate their own rules of engagement [11] and it through this process of appropriation and assimilation that the impact of the product is enacted to a greater or lesser degree [12].

2.2 Designing for Behavioural Change

Findings of a prior literature review identified the following approaches for designing behavioural change; eco-feedback, behaviour steering [scripts, affordances and constraints] and intelligence.

2.2.1 Eco-Feedback

Eco-Feedback, grounded in Feedback Intervention Theory [13] aims to provide consumers with information to enable them to make more informed choices. The Kambrook Axis kettle illustrates how eco-feedback works. Analysis of a previous Kambrook kettle revealed a high use impact particularly in terms of the energy used for heating and re-heating water. User centred research showed that a typical user often boiled the kettle, walked away to do something else, then re-boiled the kettle on their return [14]. Eco-feedback features were employed to counteract these rebound effects, “a thermostat and a temperature indicator on the handle [was added] to show when the water was still hot enough to use” [15]

2.2.2. Behaviour Steering

‘Behaviour steering technologies’ or ‘scripts’ encourage users to behave in certain ways as prescribed by the

designer [16]. Through the inscription of incentives and rules, designers can encourage desirable behaviours whilst blocking undesirable ones (ibid). Ingram points to the correlation between ‘scripting’ and the notion of affordances, “in design practice, perceived affordances are made evident... in the scripting of product use” [17]. The notion of affordances conceived by Gibson [18] was transferred into the design arena by Norman [19]. In Normans terms, perceived affordances inform the user of the potential actions and functions which could be taken while constraints place limitations on what actions can be performed. The use of affordances and constraints together enable the user to determine an appropriate course of action. Research into how scripts can facilitate sustainable use appears to be minimal, Jelsma and Knots work [20] is a notable exception.

2.2.3. Intelligence

‘Intelligent’ products and systems seemingly address the limitations of the previous approach by circumventing the users decision making function and arguably decreasing the potential for irresponsible environmental or social behaviour. In figure 1 each approach has been placed on an axis of influence indicating the degree to which each approach empowers the consumer or delegates responsibility to the product.

Eco-feedback is located towards the user end as this approach provides the user with information to make informed decisions autonomously; intelligent products however retain a greater degree of influence and control.

2.3 Existing Design Concepts

The impact of unrestricted use in public space has yet to be addressed commercially in the design of the mobile phone or within society at large. There are, however, some examples of conceptual designs which attempt to address the various social and environmental repercussions of mobile phone use.

Taylor redesigned a mobile phone to “encourage people to exercise polite mobile phone manners” [21]. Taylor’s concepts are in the most part designed to automatically mitigate, control or block unsustainable or inappropriate behaviour by users. The exception to this approach is ‘too-loud talking’ which provides eco-feedback as a means of encouraging the user to lower the volume of their voice. Taylor has, through design features, embodied the phone with a sense of self. It becomes indignant when the user behaves in an improper manner; it reprimands the owner by ‘shouting back’, it panics when left unanswered and scrambles messages and caller ID’s to discourage use in inappropriate places. Figure 2 below depicts the process instigated when the phone is left unanswered. The phone begins to panic; the ring volume increases and the caller identification display becomes confused. Its continued distress causes the battery to run down and eventually, exhausted by its panicked state, it ‘passes out’. When recovered, the phone reprimands the owner, informing them of the consequences of their actions.

Norman suggests the possibility of refining mobile technology “so that it better affords politeness to others” [23]. Early telephones fed a small amount of the person’s voice back into the receiver enabling them to adjust the loudness of their voice to an appropriate level. Mobiles eradicated auditory feedback. This, Norman argues, reduced the user’s ability to mediate the volume of their voice. To assist in reducing noise disturbance Norman suggests the use of noise-cancelling technology to minimise the level of the speaker’s voice whilst still capturing and directing the sound, this could be combined with the reintroduction of feedback. In addition, voice cups could be developed to mask and diffuse the speaker’s voice to avoid disturbing others. Norman’s concepts span both product-led and technological intervention approaches. He suggests providing feedback to the user to enable them to change their behaviour, yet through the introduction of noise-cancelling technology and voice cups, he also advocates taking a technological approach. The Massachusetts Institute of Technology (MIT) Media Lab are working on developing a context aware mobile phone [24]. An intelligent mobile phone which could, through a Global Positioning System (GPS) for example, establish the user’s circumstances and automatically assume an appropriate profile for use. In this case the decision-making process associated with determining appropriate use is automated, and control ceded to the phone.

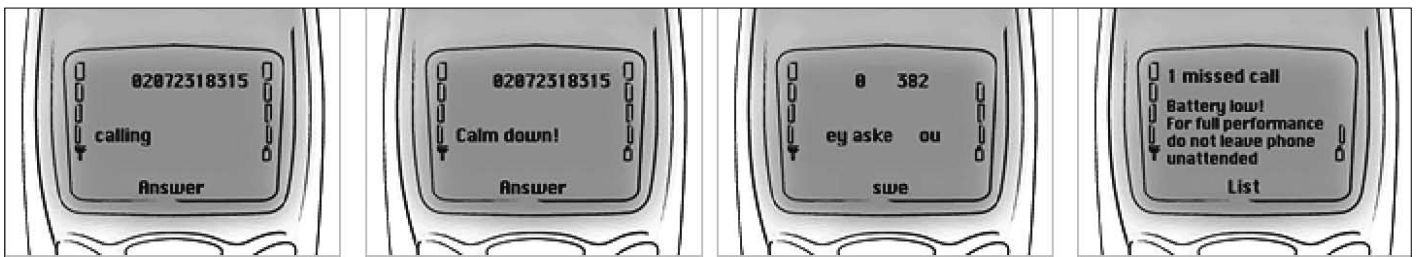


Fig. 2. ‘Leaving the Phone Unattended’ [22]



Fig. 3. 'The Electric Shock Mobile' [28]

As discussed previously, mobile phones are inert until activated by the user and are dependant on the user for survival, yet users often become psychologically dependant on their mobile phone. Using DeVaul and Dunns work as inspiration, Durrant exploits this co-dependency, exploring the possibilities of developing a mobile phone which is charged "by energy created by exaggerated body gestures made in effort to use them" [25]. Potential activities to generate energy may include; gestures, hand movements, body heat or breathing. Scenario-based testing, using an adapted self-charging dynamo torch, revealed that the user has to continuously move to maintain a viable connection. The user is forced to negotiate his or her level of need to be connected versus the effort required to do so. This approach could be termed as eco-feedback, as the level and duration of movement on the part of the user directly correlates with the provision of energy to operate the phone. These devices can be used to educate users about energy use by providing real-time feedback, which is critical in ensuring the information provided is integrated into the user's decision-making process [26].

IDEO's Social Mobiles project presents five exploratory and arguably controversial prototypes that "modify their users behaviour to make it less disruptive" [27] through design features which discourage socially unacceptable conduct. IDEO use a variety of different approaches in the design of their Social Mobiles range; the catapult phone allows the user to disrupt other people's conversations if they deem them to be inappropriate or offensive by launching sounds designed to interrupt their call. The electric shock mobile determines an acceptable speaking volume and delivers an extreme form of eco-feedback in the form of an electric shock if the user exceeds this level.

The speaking mobile affords silent communication by enabling the user to respond using simple expressive sounds. The knocking mobile enables the caller to indicate the urgency of their call by knocking on the phone; the recipient hears the knock and can use this information to determine an appropriate response. Finally, the musical mobile constrains inappropriate use by forcing the user "to play the tune of the phone number they wish to call" [29] this encourages them to consider the appropriateness of their actions.

2.3.1. Analysis of Existing Design Concepts

The design concepts discussed above informed the research by providing examples of design-led approaches for behavioural change within the context of mobile phones. Through analysing these examples, the approach taken by the designer[s] can be correlated with one or a combination of the design-led approaches identified in the literature. However, few design case studies extracted from the literature establish a research context for their concepts. Nor has it been possible from examining published work by these designers to determine their design process. In order to successfully integrate behavioural concerns into design practice and develop appropriate tools or approaches for designers, it is essential for this research that designers are observed and that their motivations, research methods and design practices recorded. This realisation prompted the need to instigate a product specific design study.

3 Design Study

3.1 Introduction

A design study was devised for an Industrial Design Masters module at Loughborough University. The students were set the challenge of identifying and addressing a social issue resulting from the use of mobile phones in public space using a design-led approach for behavioural change. The main aim of this study was to observe the designers' response to social issues identified and to record their research and design processes. This aim was broken down into a series of objectives which were;

- a. To determine their understanding of design-led approaches
- b. To discover if, how and at what point in the design process these approaches were applied
- c. To explore their perceptions of the effectiveness of these approaches in changing user behaviour
- d. To record and analyse their design outcomes

3.2 Methodology

A design brief was generated, comprised of three elements; research & development, redesign and presentation of final concept. The students were given a preparatory lecture to introduce the design-led approaches discussed above and a selection of design case studies which emerged from the literature. The R&D stage required each student to carry out user centred research in order to identify social issues resulting from the use of mobile phones in public. In the redesign stage the students were asked to select one design-led approach from the lecture and apply it within their design process. The students were required to submit a logbook detailing their research process, idea generation, design development, and final idea and to give a short verbal presentation. The duration of the project was two weeks. In terms of data collection, two main methods were used;

- A. A facilitated group discussion was held directly after the individual presentations and a short questionnaire dispatched via e-mail after project completion.
- B. Using a predetermined assessment criteria the students' logbooks and presentation slides were analysed to extract evidence of;
 - The method(s) of user centred research carried out,
 - Design process adopted (e.g. reflective, iterative, solutions-focused),
 - Application of research findings to design work generated
 - The students' level of understanding of the three approaches
 - Application of this understanding in product design ideas
 - How this concept addresses social issue(s) identified

3.3 Results of Design Study

3.3.1 Research methods & application of research

Analysis of the student's logbooks and presentations revealed that most combined primary research (product analysis, interviews with users and observational studies) with secondary literature reviews. The secondary literature focused predominately on the social impacts of mobile phone use, few students actively sought out additional product design case studies as inspiration for their own concepts. Of those students who undertook observational studies, most co-located their photographs with explanatory notes, scenarios and stories to illustrate the different types of behaviour observed in different contexts. Points of analysis included; body language, type of function carried out (e.g. texting, listening to voicemail), the location of the user in relation to others, the characteristics of the user (e.g. proficiency, age etc) and other people's response to behaviour displayed. Some students captured user behaviour using sequential photographs which were particularly useful in illustrating the series of actions taken by the subjects observed.

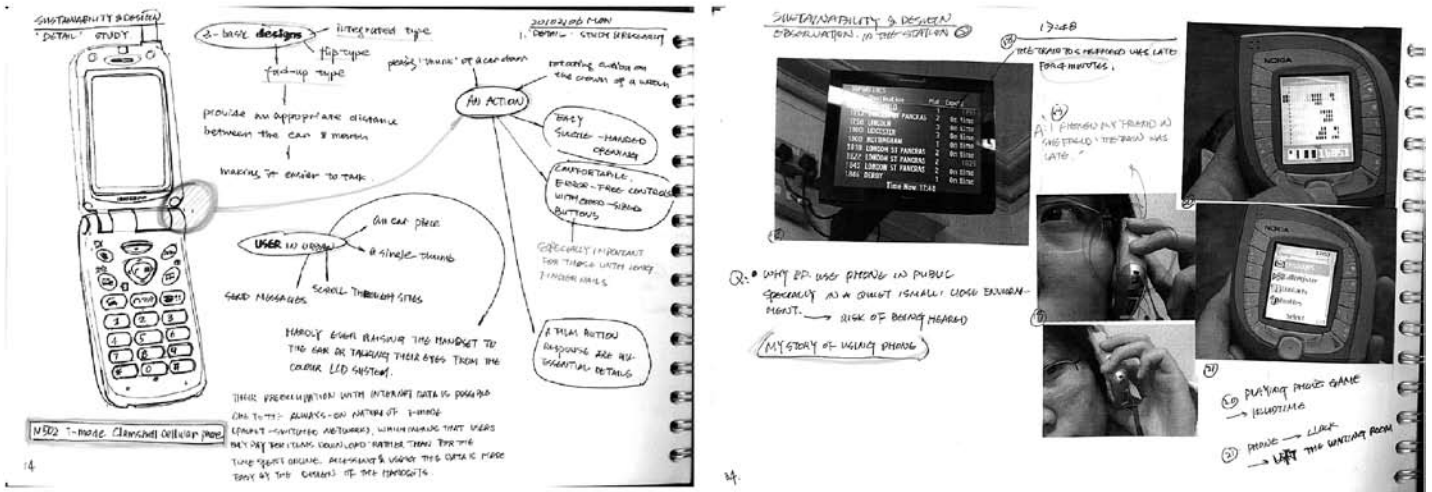


Fig. 4. Pages from Student Logbook, © Loughborough University, 2005

Most students analysed and reflected upon the information gathered from the literature and combined this understanding with their own user centred research findings to frame their chosen design problem. Some students, having established a direction for their design, redefined the brief to clarify the problem identified and to communicate their design intention e.g. how they intended to solve the problem.

For the most part evidence of how the research findings related to conceptual ideas generated was not explicitly recorded in the logbooks yet it was, in some cases, articulated in the verbal presentation. An exception to this was Student 5 who co-located his design ideas next to the research that inspired them, clearly demonstrating the links between the research undertaken and the design solutions generated.

3.3.2. Application of Design-led Approach[es] for Behavioural Change

The value of using a combined approach to analyse the students design process became apparent when reviewing their logbooks. In most cases it was difficult to assess the student's level of understanding of these approaches from the logbooks. It was also unclear which approach was chosen and how it was applied. Yet this understanding was, in many cases, demonstrated in the individual presentations.

Some of the students found it difficult to distinguish one approach from another. The use of case study examples to explain each approach helped in some way to clarify their meaning and how they could be applied; "The examples such as [the] Kambrook 'Axis' Kettle explain these concepts very clearly" (Student 3). Most found eco-feedback easy to understand, but found behaviour steering hard to define. To some, the boundary between behaviour steering and intelligence was undefined and this made

distinguishing one from the other quite difficult. Student 3 created a matrix, table 1, to classify the user behaviour and solutions according to the three approaches in order to find the best way to solve the social impacts she had identified.

CRITERIA	Eco-feedback	Behaviour Steering	Intelligent Products
Effect on the user behaviour directly	1	2	3
Feeling of being controlled	3	2	1
Design work space	2	3	1
[Will] work with [existing] technology	1	2	3
TOTAL	6	9	8
CHOICE	x	✓	x

SCALE: 1 = weak 3 = strong

Table 1. Comparative Matrix

Using this table she drew out and compared the practical, moral and ethical dimensions of applying these approaches against a specific set of criteria; her perceptions of the resulting effect on user behaviour, the degree to which the user would feel controlled, the design work space and compatibility with existing technology. Each criterion was rated against each approach on a scale of impact from weak to strong.

In terms of applying these approaches, most of the students advocated a 'mixed' approach, combining two or more approaches. Few students used the approaches as a starting point, preferring instead to apply one or more approach as part of their idea generation process to provide "a direction to think about the problems" (Student 5); as inspiration for concepts; or as a means to develop design ideas. "They are not only the lamps to my feet during the idea generation but they are helpful to understand what kind of solution can effect what kind of user behaviour during design development" (Student 3).

3.3.3. Perceived effectiveness of design-led approaches

Eco-feedback would, some felt, not be as effective in changing ingrained anti-social behaviours. Intelligent products were seen as having greater potential for effecting change. However, some students felt that the balance of control may be weighted more heavily on the side of the product therefore users may feel controlled or restricted. It was felt that the consumers should be given the choice to behave in the 'right' way, only if they failed to do so should the product take action to prevent their behaviour. The students concluded that preventing choices straight away would annoy the customer and possibly cause a reduction in sales. Interestingly, only one student sought to analyse of the downstream effects which may arise through the use of his redesigned mobile phone. His work is discussed below in Case Study 1.

3.4 Design Outcomes

Analysis of all ideas generated in sketch form and those detailed as final solutions revealed a range of approaches to solving the various social issues identified, however some commonalities could be observed in the type of solution proposed. The following commentary offers a brief overview of those typologies identified. A more detailed analysis of individual design case studies produced then follows.

1. Constraining or affording actions through the product form;

The examples below extracted from two different students logbooks illustrate the way in which the product form can be used to constrain or afford certain methods of use or behaviours. Student 1 observed users lack of concentration when using their mobile phone in public places and the resulting neglect of 'real conversations' to prioritise virtual ones.

In this concept, figure 5, the mobile phone creates a physical sensation to provoke a response from the user. The hole sporadically tightens around the users thumb to remind them of where they are and to ground them in the 'real world', thereby attempting to address the problems caused by user's lack of attention when engaged in virtual interactions.

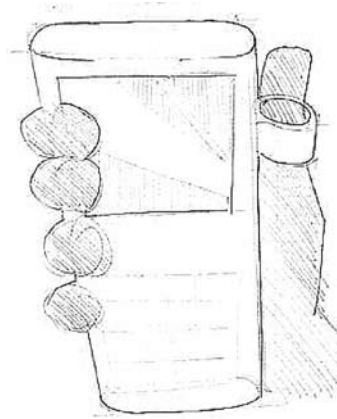


Fig. 5. Thumb Squeeze Concept, © Loughborough University, 2005

Student 2 used his observational studies as inspiration for one of his design concepts, figure 6. Having observed some discreet users cupping their hands around the mouthpiece of the handset to mask the noise of their voice, he designed a mobile phone featuring four pressure points. These points must all be continuously depressed by the user to maintain the connection. The location of the four pressure points deliberately encourages the user to adopt a specific arrangement using both hands to shield the phone and conceal their mouth.

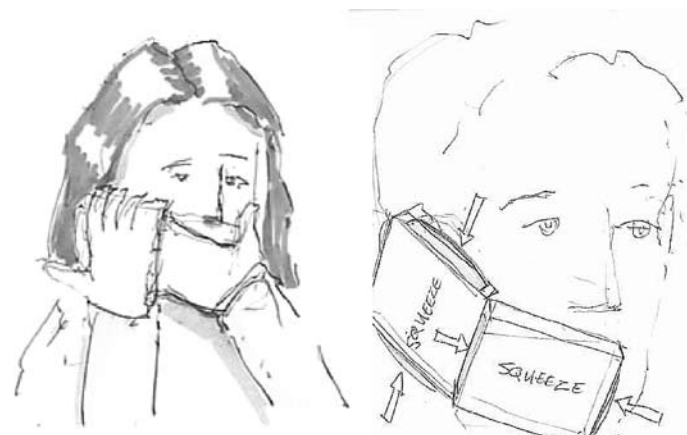


Fig. 6. Four Point Squeeze, © Loughborough University, 2005

2. Constraining or affording actions through the product function

Some of the design concepts featured limited functions represented as quick keys or shortcuts to enable rapid access. Student 3 designed 'fast keys' which are displayed in a simple keypad to enable fast and efficient use of basic functions such as listening to voicemail and sending texts. One of the 'fast keys' enables the mobile phone to respond to incoming messages or calls with a pre-prepared text message if it is in silent mode. This function also enables the user to press the button to indicate that they are busy.



Fig. 7. Fast Key 'Busy', © Loughborough University, 2005

3. Eco-feedback strategies

Several design concepts which attempted to educate the user or influence their decision-making process through the provision of information were identified. The type of information provided typically included; the 'called' status, location, and proximity to others. In many cases this was realised through the introduction of a supportive technology e.g. Bluetooth or a Global Positioning System (GPS). The information provided was, in many design concepts, depicted as a scale or symbols which illustrated the level of appropriateness or suitability of the call according to the environment. In most cases an over-ride facility was included for emergency situations. These concepts are similar to MIT's work in developing a context aware cell phone described in section 2.3. The student's concepts mostly focused on developing a user interface to provide

information based on an assumption of technological capability, MIT's work is concerned with establishing a viable technological system to enable this process to operate.

4. Supporting devices and systems

Some students chose to introduce supplementary devices and/or locate the product within a system which controls user behaviour. These systems typically consisted of a series of networked devices located in a public place which detect all mobile phones in a designated area. These devices send a signal to all active mobile phones to either; notify the user of appropriate conduct, switch the use profile of all mobiles automatically or disable function immediately.

5. Wearable devices

Wearable devices were designed to address problems arising from incessant ringing of mobile phones left by their owners; situations in which users neglect to turn the phone off in public places; or instances where the ring tone is set too loud.



Fig. 8. Wearable mobile phone concept, © Loughborough University, 2005

The rationale described by some students who had devised wearable mobile phones was that by wearing the device the user's ability to hear the phone ringing would be increased and this would hasten their response reducing annoyance to others. It was also felt that wearable devices would allow the silent vibration mode to be used more effectively as an alert mechanism. Student 3 designed a mobile phone which the user wears on their wrist. The screen interface and keypad pivot on a fixed base attached to the wrist strap.

6. Emotional response

One student developed a series of sketches exploring the potential for the mobile phone to produce an emotional or physical response to actions taken by the user. Two of these concepts are shown below in figure 9. The first (on the left) is a concept for a mobile which would automatically slide shut should the user's voice or the duration of the call exceed an acceptable level, terminating the offensive conversation for a predetermined length of time. Development of this concept led to the inclusion of an indicator to show the user the length of time left until the phone became operational. The concept shown to the right contains spikes which protrude when activated by an excessively loud speaking voice this is a particularly aggressive tactic on the part of the mobile phone. This theme is continued in his final design solution detailed in Case Study I below.

Design Case Studies

In this section the work of selected students is presented in the form of design case studies to illustrate the diversity in approaches taken in response to the design brief and variety of solutions generated.

Case Study I: Caller Hegemony

Student 1 took the concept of caller hegemony as his starting point. Caller hegemony [30] explores the dominance of the Caller over the Called. Having recognised the current imbalance of power between the Caller and the Called, this student sought to generate a solution to inform and guide the Caller and Called as to appropriate action to be taken in different social and environmental contexts.

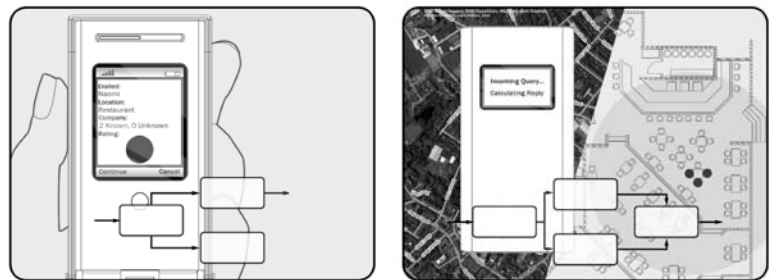


Fig. 10. An Intelligent mobile that can advise the user;
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This concept is based on a combination of two designed approaches for behavioural change; eco-feedback and intelligence. When placing a call, the Caller's mobile phone uses Bluetooth and GPS technology to inform the Caller as to the Called's current location, proximity to other users and volume of company, figure 10. The Caller can then make an informed decision to continue the call, or call back. Should the Caller wish to continue the call, the Called's phone then vibrates or rings based upon information provided.

As a secondary layer of complexity the mobile phone makes a decision as to the appropriateness of the call based on its context of use. Should the Caller or the Called continue the call despite information provided to indicate the call is inadvisable; both handsets display their embarrassment at being made to behave in an inappropriate way. As part of his design development the student explored the ways in which the mobile phone could indicate its emotional state. These ranged from

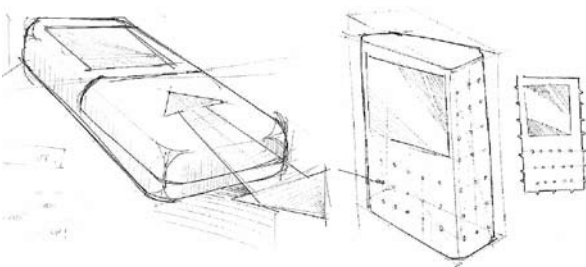


Fig. 9. 'Slide Shut' (left) 'Spikes' concept (right), © Loughborough University, 2005

highly disruptive e.g. deleting content, delaying downloads in progress, or terminating the call to slightly less confrontational ideas e.g. shaking, stammering or vibrating. In the final design the phone displays its embarrassment by emitting a red light which disables functionality for a fixed period enabling the phone to calm down, figure 11.



Fig. 11. The mobile can display its embarrassment,
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Student 1 acknowledged potential downstream social effects which could be caused through misuse of the product;

- The phone could be used to keep track of where people are and who they are with. Parents, for example, could check if their child is at school and companies could monitor the movement of employees.
- Those who wish their activities to remain a secret from others may purchase mobiles which are not Bluetooth enabled to allow them to hide their location from others.
- Finally, it may be possible for someone to purposefully disable another user's phone by deliberately raising their voice to trigger a shutdown.

Case Study 2: Quiet Mobile Phone

Student 4's research into the social problems caused by mobile use in public led to the identification of the need to talk quietly or softly; to restrict the use of ring-tones in certain public places and to provide private space in which to interact. The mobile phone must, she concluded, afford clear conversation and restrict noise pollution by incorporating adequate sound insulation. To investigate how to provide these features, she drew inspiration from two seemingly unrelated activities; the communication practices adopted within the deaf community and the sound-proofing properties of ear protectors used by

contractors on building sites. Using this research as inspiration, she related her findings to solving the social problems identified and translated the technology, materials and principles of use to her design ideas. Her final concept consists of two distinct features; a Text to speech function and a Sound-proof Cover.

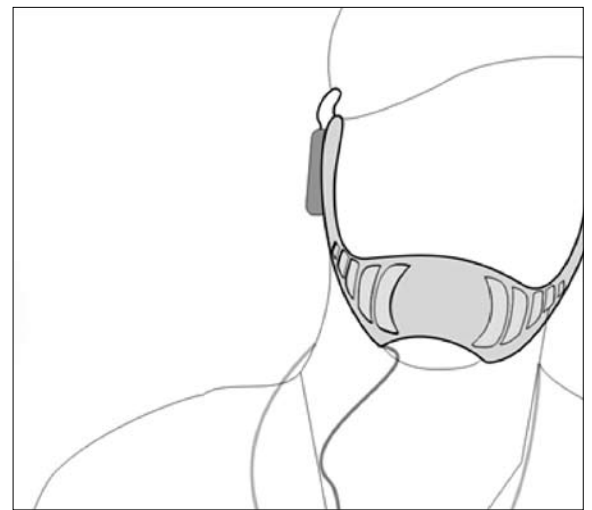


Fig. 12. Sound Proof Cover; © Loughborough University, 2005

'Text to speech': research indicated that deaf mobile phone users tend to use the SMS function as a means to communicate via text instead of speech. The 'text to speech' concept developed by the student allows the sender to type an SMS message which the recipient can then hear as spoken word.

Sound-proof Cover, (figure 12): using a high-elastic polyester material originally employed within ear protectors for construction workers, Student 4 adapted this material for use in her concept development of a sound-proof cover featuring a moulded mouthpiece and integrated earphones which allows the user to converse without disturbing others

Case Study 3: 'Eyes off Road' Time

Student 2 explored problems caused by 'eyes off road' time, such as when users walk whilst texting. His observational studies showed that when texting, the user's line of vision is directed towards the handset display; this makes it more difficult to avoid physical hazards. This (he observed) often resulted in people traversing the pavement in a haphazard manner; slowing down the flow of pedestrians and blocking the path of others.

To solve this problem, he devised a handset featuring real

time video streaming, figure 13. When the handset is open and in motion the forward view is projected as a screen saver behind any text improving awareness during eyes off road time. By providing eco-feedback the user is made aware of their surroundings and encouraged to change their behaviour accordingly.



Fig. 13. Concept for safer texting,
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This student not only considered the product itself but took the brief a step further by discussing the design implications for the environment in which the product could be used. Having observed people's impromptu use of street furniture to create temporary zones in which to use their phones, he built on this observation by designing booths for mobile phone use which boost the signal of the phone. The mobile choreographs the movement of mobile user, directing them to the nearest available booth through pedestrian traffic.

4 Discussion

4.1 Reflections on Literature Review Findings

Academic research dedicated to investigating mobile phone use in public places tends to focus predominantly on social issues regarding use. Particularly the impact of mobile phone use on societal practices and norms [31, 32, 33, 34, 35, 36]. These investigations are often instigated by researchers belonging to social science disciplines and typically involve the use of qualitative, user centred, ethnographic and observational research techniques. There were some similarities in the research methodologies adopted by the students and those described in the literature review papers. Primary research carried out by the students was predominately qualitative, user focused and observational in nature. The way in which this data was recorded, and subsequently analysed, however, differed. The students built scenarios of behaviours observed by co-locating their photographs with explanatory notes, stories and sketches. They established links between the product design and particular aspects of user behaviour for e.g. user's difficulties in avoiding physical hazards when texting due to their line of vision being directed towards the handset display. The students thought process was not linear in nature; they displayed an ability to see things differently and through combining different elements together generated novel solutions to the problems identified.

4.2. Comparison with existing design concepts

The design concepts discussed in section 2.3 were instigated by designers actively seeking to address social and environmental issues associated with mobile phone use. These existing design concepts were mostly presented as isolated solutions with little or no supporting contextual research. Those who set out a brief context to the design problem did so without indicating how they had arrived at these conclusions. Most tended to focus on the solution not necessarily how the solution was developed. Without this information it was difficult from a research perspective to identify and analyse design intentions, methodologies or processes adopted. The students engaged in this design study drew together empirical research findings from the literature and combined these with the results of their own user centred research. They used this information to construct a problem space in which to engage. They applied

developed and refined approaches for designing for behavioural change appropriated from other disciplines through engaging with these approaches in their design practice. Their reflections, difficulties, thought processes and design decisions were, in most cases, recorded in their design logbooks. The range of design case studies generated as part of this research takes existing knowledge an important step further. By observing the designers it was possible to record their responses to social issues arising from mobile phone use in public; how and when they applied design-led approaches and their perceptions of the effectiveness of these approaches in changing user behaviour.

4.3 Reflection on design-led approaches

It is interesting to compare the student's perceptions with those of the authors. The student's debate concerning the moral and ethical issues inherent in designing for behavioural change reflects those of the authors in a previous publication [37]. In both discussions concerns were raised regarding the level of control or influence which designers or manufacturers should ethically integrate into the product design. This debate was coupled with discussion relating to the effectiveness of design-led approaches in changing user behaviour.

Eco-feedback was understood by most students and was arguably the easiest approach to apply within the product design. However, the students questioned its effectiveness in changing ingrained user behaviours due to the potential for the user to ignore the feedback provided. Eco-feedback approaches provide users with information to enable them to change their behaviour, however, information does not necessarily lead to action as the consumer must be able to link their behaviour with the long and short terms consequences. Behaviour steering was the least understood approach, yet this may be due in some respects to the lack of tangible examples of how this approach could be applied within product design. Intelligent products were seen as having the greatest potential for effecting change. However, some students felt that if the product continuously regulated behaviour it would not encourage people to learn from their 'mistakes' and could result in the user feeling controlled or restricted by the product.

Most students appeared to favour a combined approach which is a particularly interesting development especially as the brief originally stipulated that only one approach be used.

5 Conclusions

To successfully integrate behavioural concerns into design practice, and to make this process repeatable, appropriate information and tools must be developed and incorporated into the design process. The findings of this design study have provided an insight into the type of information required by designers to consider these issues and appropriate formats for conveying this information. A further outcome of this study has been to inform the authors of potential ways in which design-led approaches may effectively be configured to maximise their effectiveness in addressing user behaviour.

5.1 Type and format of information

The findings of this study indicated that designers need to be made aware of potential problems caused by user behaviour through introducing the concept of designing for behavioural change as a design challenge. In terms of the effectiveness of these approaches in aiding the design process, it is interesting to note that rather than using these approaches as a prescriptive method or tool, the design students viewed them as inspiration for concepts or as a means to develop or evaluate the effectiveness of design ideas. It has, therefore become clear that any outcome of this research should focus on providing potential directions or approaches, rather than prescriptive methodologies to follow. The provision of existing design case studies not only acted as a stimulus for approaching the problems identified but also helped to clarify the design-led approaches introduced. This finding is supported by those of Lofthouse [38] who identified "that ecodesign information should be presented visually using case studies and examples" "to encourage, inspire and educate" designers and "support idea generation". Taking into account these findings, the next stage of the research will be to create an informative resource for designers explaining why they should design for behavioural change; approaches they could apply and inspirational case studies. This will be tested with a group of designers.

5.2 A combined, tailored approach

Drawing together a series of findings led the authors to consider two key issues; the potential ways in which design-led approaches may effectively be configured or combined and how the degree of influence or control could correlate to the seriousness of the behaviour enacted in relation to wider social impacts. The students indicated that the approaches introduced would be

most effective if they were combined. In addition, the authors have concluded that due to the different scales of impact associated with different use behaviours there is a requirement for a tailored strategy of product intervention using a combination of approaches. A potential strategy may be to design levels of intervention which are enacted in a sequential manner in response to the user's level of compliance and the gravity of the consequences of the action taken. In this scenario, the product would instigate a process in which the level of intervention would steadily increase tipping the balance of influence from the user to the product as depicted in figure 1. A higher degree of intelligence on the part of the product could result in an ability to predict patterns of behaviour, thereby circumventing actions before they are taken.

Overall this paper has shown that design-led approaches are useful and inspirational tools which enable designers to begin to address issues of use behaviour when designing mobile phones. Designing for behavioural change is, however, still a relatively underdeveloped research area in design and further work needs to be carried out using different product types. In addition, further research is needed to explore how theories and ideas from other disciplines may be transferred into the design process. Finally, 'behaviour changing' product ideas need to be prototyped and tested with users to evaluate their effectiveness.

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Product semantics: sophistry or success?

Introduction

This paper presents the summarised findings of an unpublished PhD study on product semantics carried out in the late 1990s (C. Brown 1999 *Product Semantics: the style of the information age?*). It should be noted here that this topic was approached from the point of view of the design historian rather than the practising designer. The investigation was stimulated by the much heralded emergence of product semantics in the 1980s (McCoy 1987; Siltavuori 1988) and the marked variance in critical opinion over the validity and efficacy of it as a 'design theory' in the years that followed, leading to a notable decline in debate about the idea, apparent in the design press, in the early 1990s. The study therefore sought: to establish the reasons for the emergence of the theory of product semantics in the 1980s; to examine the various theoretical principles upon which the theory is based; and, to analyse the way in which these theoretical ideas were put into practice. As well as a review of the available literature, a field study was also undertaken to: establish the extent to which design practitioners in the UK were aware of the concept; establish the extent to which it had been adopted by design practitioners in the design of industrial products; identify any viable, consistently efficacious methods that allowed the design of easy to operate and symbolically meaningful products; and the extent to which it was valued as a design theory. Ultimately, the aim of the study was to assess the validity of the theory of product semantics and by providing an

overview of attitudes towards the concept among design practitioners within the UK, assess its future role, if any, in the design process.

Product Semantics: sophistry or success?

The design concept of product semantics that evolved in the 1980s was a theory whose 'time had come', a genuinely original response to a set of new, problematical conditions facing design that were the culmination of developments in technology and culture. Although several aspects of the theory had previously been considered (Friendlaender 1984) [Figure 1], it was the first time that many previously disparate elements had been brought together in order to try to formulate them into a unified workable approach that would consistently produce the elusive functional and symbolic qualities inherent in many design 'classics'. It is perhaps not surprising, therefore, during this period of methodological uncertainty in the design world that this timely development should have been so eagerly seized upon by designers and manufacturers keen to differentiate their products in an increasingly homogeneous market. Indeed, it should be remembered that much of commercial industry's initial enthusiasm for product semantics (Freedman 1987) was due to the fact that it was widely touted by its advocates as a replacement for what was increasingly being regarded as the straitjacket of Modernist methodology [Figure 2]. However, a lot of the inevitable hype that accompanied this latest 'great white hope' of design undoubtedly also

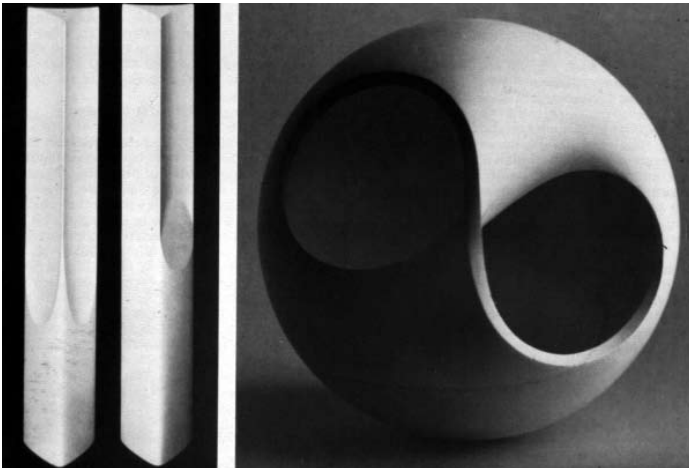


Figure 1 form studies, Reinhardt Butter, Hochschule für Gestaltung, Ulm 1958/59

Figure 2 the 'black box' problem of Modernist methodology

contributed to its misappropriation and subsequent discreditation in many quarters of the commercial design world. Yet to merely dismiss product semantics as the 'wiggles and waves' style [Figure 3] or just another 'buzzword' of the 1980s (Aldersey-Williams 1988), as many of its detractors have done, would be to do it an injustice. Its theoretical principles provide firm evidence that it was a serious study and was certainly more than just a stylistic response to the cultural climate.

However, it would also be fair to say that product semantics became something of a theoretical 'bandwagon' propelled by a relatively small clique of design academics and outside of this dedicated circle there was by no means universal concord over the validity of the concept. Indeed, there are many proposed aspects of the 1980s theory of product semantics that can perhaps be criticised for being unrealistic or even unattainable. At the user-product level, for instance, the idea of using product semantics to make products easier to use seems plausible. Moreover, the evidence of the field work suggests that designers regard operational self-evidency not only as a desirable, but also a generally attainable goal [Figure 4]. But the whole idea of imbuing products with symbolic function at both the user-product and culture-product levels is far more problematical and it is here that there is far less consensus of opinion both in the literature and the field work [Figure 5]. The fundamental fact remains that the meaning of all objects is dependent not only upon the context in which they are perceived, but also upon the individuality of each user's interpretations. Critics, particularly those using Barthes' literary theory (Richardson, 1993 p.36), have been keen to point out that product semantics as proposed in the 1980s must inevitably fail on these grounds. Yet the design theorists (Gros 1984; Krippendorff & Butter 1984; Krohn & McCoy 1984; Lannoch 1984; Rheinfrank 1984;

Butter 1989; Krippendorff 1989; Lannoch & Lannoch 1989) behind product semantics were of course aware of these paradoxical problems and attempted to resolve them through the creation of a 'new design language' [Figure 6]. But while it cannot be denied that this linguistically-based approach to product semantics led to some undoubted successes, it must also be acknowledged that far too many attempts to deliberately imbue products with symbolism through such methods, often resulted in needlessly expressive designs that relied upon a stylistic vocabulary [Figure 7]. The lesson to be learnt from such experiments is that knowing the words does not necessarily make for a stirring speech. Indeed, the net result of these many overt and obvious 'one-liners' was a picture of a design approach that seemed to inevitably end up caricaturing itself, which only gave succour to claims that the whole concept was in fact sophistry.

What is also apparent, both from the literature and the field work, is that one of the main problems of the 1980s theory of product semantics was its failure to translate ambitious theory into practicable method. Undoubtedly the goal of creating 'readable objects', by transforming complex linguistic theory and intuitive aspects of the design process into easy to apply methods (Lannoch 1984; Athavankar 1989; Krippendorff 1989; Lannoch & Lannoch 1989), was a laudable one. But rather in the same way that describing consciousness is not the same thing as being conscious, it would seem that it is possible, with enough thought, to formulate linguistically-based methods which can orchestrate an element of intuition in the design process, but which cannot in themselves guarantee to incorporate the appropriate intuitive responses with any amount of consistency, let alone generate them. Certainly this is true of the few 'systematic methods' that can be identified in the literature, which, while interesting

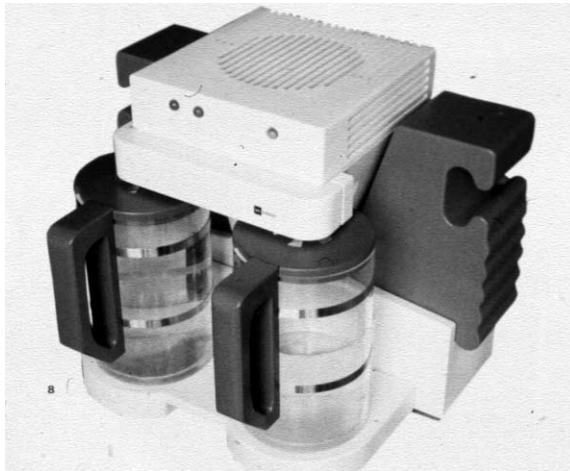


Figure 3
The 'wiggles and waves' syndrome of product semantics in 1980s



Figure 4
Lisa Krohn's 'Phonebook' 1987: operational self-evidence

experiments, can be rightly criticised for being somewhat pedantic instruments ultimately lacking in efficacy. It is, for instance, significant that no such linguistically structured methods were discovered to be employed by those designers who took part in the field work, supporting the notion that it was an inappropriate approach for tackling the myriad problems associated with meaning in design. Rather those product semantic 'methods' as such discerned in the field work, though effective ones in achieving satisfactory results, were found to be far less theoretically structured and more flexible approaches than those cited in the literature. Indeed, what is clear from the study (Brown 1999) is that where designers understand and use product semantics, it is regarded, not as with the 1980s initiative as some kind of 'magic bullet' doctrine, but rather as an important part in the overall design process, a flexible tool, one of many available to the designer.

Thus while the paucity of reliable 'systematic methods' identified by the study may be viewed as a failing of the 1980s product semantics lobby, it should not necessarily be taken as evidence of the sophistry of the basic concept. While it remains true that "...There are no blank slates for designers to begin afresh on, no tabula rasa in culture..." (Dormer, 1988, p.16), the innovative and award winning designs [Figure 8] revealed in both the literature review and the field study demonstrate that it is possible for designers to successfully imbue products with intended semantic meaning within certain boundaries at both user-product and culture-product levels and in a more subtle and successful manner than many of the experiments of the 1980s would indicate.

Indeed, the findings of the field study also suggest that in terms of achieving consistently successful results, there are genuine benefits to adopting a constructive approach to

the semantics of a product rather than simply relying on 'happy accidents' to fulfil these criteria. Positive awareness of such matters, it would seem, would not only inform the designer, but can also enthuse clients and other practitioners in the design process. Furthermore, if the opinions of those designers, who in the study adopted a product semantic approach, are to be believed, then the widespread integration of product semantics into the design process is not only desirable but also essential for the development of the profession. Certainly those examples of successful product semantic design [Figure 9] proffered by designers in the field study support the view that product semantics could be as important as ergonomics in the design process (Krippendorff & Vakeva, 1989, p.52).

It is argued, therefore, that product semantics can be seen as a valid approach that does, when utilised in an appropriate manner, provide a useful theoretical framework for certain aspects of the design process. Some fifteen years after its emergence, the study suggested that product semantics remained as an 'umbrella term' for a loose collection of associated ideas and not as a single, coherent theory, which was undoubtedly a major cause of its original dissipation. However, the theoretical developments of the 1980s in this direction have been valuable in generally raising awareness of the need for designers to understand an object's function at both user-product and culture-product levels. Indeed, the study suggests that while product semantics may not have radically changed design in the way originally hoped, it did have an impact upon a significant portion of the design community (approximately 25-33%) and users of the concept see it as a genuine enhancement. This legacy would seem to be visible in many successful and innovative products in recent years [Figure 10]. But this is still clearly

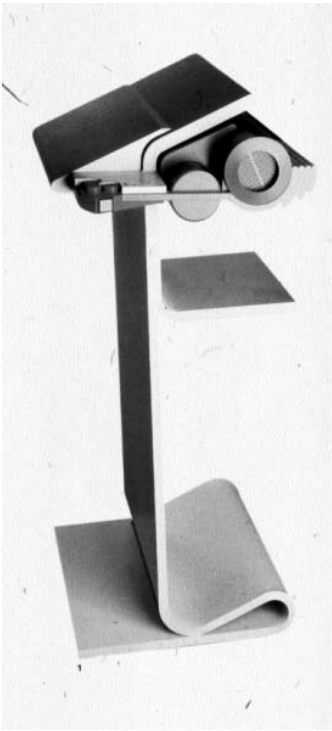


Figure 5 Technology Design's 'Elaine' printer: problematic symbolism

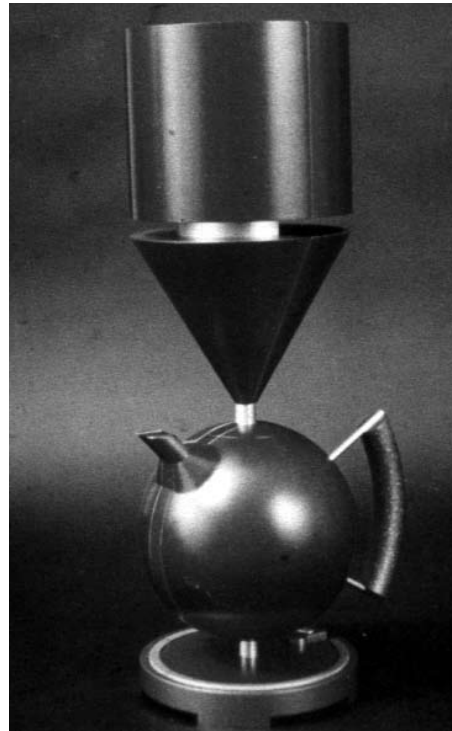


Figure 6 Cranbrook prototype 1988: new design language

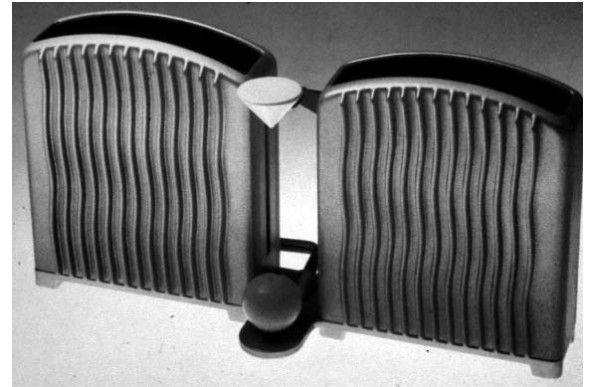


Figure 7 Cranbrook prototype 1986: stylistic vocabulary

a minority view and greater awareness of the concept is needed if product semantics is to play a more significant part in the design process in the future, as many of those who use it clearly think it will.

Conclusions

What occurred in the 1980s with the theory of product semantics was a fresh initiative at an old idea, revamped and neatly labelled but insufficiently refined for the practicable purposes of use in the day-to-day design process. This inability to answer designers' demands for a new and reliable methodology led to frustration with the concept and eventually its rejection in many quarters. Indeed Krippendorff (Capitello 1991) blamed an 'untheoretical design profession' for the rejection of the concept of product semantics and the field study indicated that generally designers do not value academic theories as particularly useful for everyday design practice. Indeed, one of the more surprising findings was that even those designers who adopted a product semantic approach were not particularly aware of the subject specific literature.

However, calls for more expressive and communicative products in the market place still persist. Such admonitions suggest that the attempts in the 1980s to formulate a theory of product semantics were worthwhile, since these are precisely the issues that it tried to address. However, it also confirms the findings of the study that the ideas central to the theory were not properly understood or disseminated by a large enough section of the design world.



Figure 8 Philips 'Roller Radio' 1987: innovative and successful semantic design



Figure 9 Random Product Design, EEV Argus Thermal Imaging camera



Figure 10 PSD Associates,
Swatch DECT phone

If lessons are to be learnt from such an historical overview as provided by this study, it is that product semantics as a design concept will have to be content with playing a supporting rather than a starring role. The overly-theoretical and misplaced emphasis in the 1980s on 'what is the message', which ultimately led to the rapid rise and fall of the concept's popularity, will have to be avoided. Indeed, the successful examples of product semantic design revealed in the field study highlight some important lessons for the future based on the mistakes of the 1980s. Firstly, while a degree of consensus in meaning can be achieved in nearly all cases, there can be no certainties and so the more narrowly defined the target user group for a product the more successful the 'communication' is likely to be. Secondly, humour is transitory and so semantic 'messages' that try to be too blatant in their communication are apt to become wearisome for the user and rapidly hackneyed in design terms, especially in those cases where there is simply not a lot to tell the user. Ultimately, if the theoretical developments of the 1980s are to have value for the designer, it is to promote product semantics as a discreet tool which can facilitate that part of the design process concerned with the need for communication in the object-user relationship.

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Form confusion in public spaces, or: how to lie with affordances

Abstract

One of the designers' responsibilities is to make the product communicate to its users what it affords to them. Repeatedly, designers, design researchers, journalists and people at parties relate examples of mistakes that have been made; some have produced directions, approaches and guidelines to improve this practice. In this paper we report a small study in which a number of examples were collected of products miscommunicating their intended functions and use. The examples are discussed, and some underlying themes are highlighted, addressing issues of the meaning of automation, the limits of influence that the designer has, and the need for a wider study of form pragmatics, next to the venerable form syntax and established form semantics.

Introduction – confused...

All of us have had tedious encounters with products, in which we had to spend a lot of effort to find out what a product can do for us, and how we bring it to doing so. It can take a lot of time, trying out, asking advice, decyphering manuals, and plain random pushing of buttons, to get to know the product. Since Norman popularized the Gibsonian notion of affordances, it has become an acknowledged duty of the designer to express to the intended user what the product was intended to afford him or her, and how he or she can attain the state of fulfillment. Often this comes down to telling the user 'which button to push'.

Although there is a growing skill and knowledge base that helps in educating new generations of designers, there is still a way to go. Many products still need 'fixes', such as the handwritten signs and small notes fixed to doors, water taps, that we encounter in daily life, especially in public spaces and 'dirty' industrial work situations. In our homes, and often in office work situations, we tend to eventually learn how we can get our VCR to turn the TV on and off, how to switch channels, and which buttons to ignore (Fig. 1). Life mainly becomes difficult when we accidentally hit one of these buttons, end up lost in some menu dialogue, and have to fight our way out of it, sometimes by performing a hard power-off reset. But in these situations, we establish a repertoire of routines, and notice the aggravation less. It becomes more noticeable in situations where we encounter a product for the first time. In public spaces, such as trains, and boats, and planes, and in hotel rooms (especially abroad), we have a multitude of first encounters of the affordance kind, which we fail to enjoy. It is here that miscommunication, lack of expressiveness, is at its most obvious. In this study, we collected a number of these encounters in public spaces, and use these examples to distinguish and discuss some relevant issues. Apart from collecting a few amusing anecdotes, we hope to illustrate some ways of approaching the expression of affordances that can help design students and practitioners better develop their designs.



Fig. 1. All alike. Left: We typically use a few buttons of our remote controls, ignore most, and learn to live with them. When using somebody else's toys, we're back to square one. Middle: One of these knobs can be turned to open the door to the lecture theatre, the other can only be pulled. Which is which? Right: A patch? ATM's often use rows of buttons whose function is indicated on-screen, which works for a flat screen, but creates problems of parallax for a recessed screen. To reduce these problems, small bars were added later to more clearly connect the button and the screen. The smudges on the screen are also a sign that many users expected it to be a touchscreen.

What theory there is

The need for products to express their purpose and operation has received serious attention from designers and theorists. Within the form semantics movement, there has been attention for emotional and functional expressiveness for a longer time, and for the expressive value of metaphors. In the late eighties, the Gibsonian notion of affordance was introduced to the design community, most notably by Donald Norman's influential books (Norman, 1988, 1992), and by academic design researchers working in a Gibsonian ecological approach (Smets, 1989; Gaver, 1991; Smets, Overbeeke, & Gaver, 1994). Especially in the emerging field of (computer-human) interaction design, educators, researchers, and practitioners paid explicit attention to this, driven by a need for finding expressiveness in an application area where increasingly fewer physical constraints could express mechanism and functionality. In part this led to a confusion in the usage of the term 'affordance', where its original meaning 'possible future events/actions that the product offers to a specific user' got mixed with 'expressing those possible actions'. For some, this led to a view that putting an icon on a button was equal to giving an affordance to an application. Norman clarified these issues in his Interactions paper (Norman, 1999). In this paper, we stick to the original meaning: affordances are events and action opportunities, and the designer has to express these through the design of the product. Gaver (1991) distinguished affordance and information, and explored the combinations of these two notions, each of which can be true/false for an action opportunity. A successful expressive design both has the right affordance and shows it, resulting in a perceived affordance; if the product is clear that it doesn't perform the function the

user desires, this results in a correct rejection.

Mismatches between affordance and information yield hidden affordances (the product can perform the function, but it is difficult to find out how to get it to work) and false affordances, or posing (the product suggests it can do something which it cannot).

Most discussions have looked at what goes wrong in individual cases. Darnell (1996-2006) has maintained a website of amusing and instructive examples, under the name of 'bad designs'. As one of the rare exceptions, Djajadiningrat (1998; see also Djajadiningrat et al, 2004) presents a design for a VCR that is wholly based on both enabling and expressing affordances through physical interactions.

Over the past decade a number of guidelines have emerged. Several authors have looked at which connections people can make, suggesting guidelines in the vein of the Gestalt Laws. Norman (1988) discussed the notion of 'natural mapping', e.g., suggesting which layout of the controls of a cooker best matches the layout of the four heating units. Wensveen et al. (2004) extended this to 'natural coupling', drawing attention to (mis)matches in time, modality, feedback, and feedforward.

An interesting limitation in current theory is that it puts all the responsibility, and all the blame, at the designer's footsteps, whereas the examples we present below show that the designer is often a few steps away from the user, and cannot control how the product reaches the user. We see therefore, that some of the errors are due not to the product, but to the way it is incorporated in the environment. And that many of the patches were probably invented by janitors and maintenance people in close contact with the users, rather than by the design

departments hidden in corporate agencies. This offers food for thought on the roles of all those involved in the design and application process.

Collecting confusion

Aim of this study was to generate a collection of examples of confusion that is large enough to be structured into categories. The examples were gathered by visiting public places, observing and recording confusion. Also, we were liberal in our method, in asking people for situations and products they had found confusing, and including some of our own experiences, especially from international travel, and from the literature. There was no lack of volunteers. Admitted, this is explorative rather than disciplined evaluative research. The method cannot find the worst designs (which are not noticed at all, so can't be remembered) and is likely to be biased toward the most annoying (and therefore best remembered) rather than the most confusing examples.



Fig. 2. Discreteness. Left: This toilet design has the flush button elegantly incorporated in its shape, so that it looks as a hinge, and finding the flush becomes a possibly embarrassing puzzle. Right: Public toilets show evolutionary stages due to the introduction of body proximity sensors. Some sensors look like buttons or ornaments, and don't express their sensing activity. After these sensors were introduced, signs were needed to tell people they didn't have to flush. Recently, we see the opposite: in some places where there are buttons, these look so similar to sensors, that signs are added that users had to 'please flush manually'.



Fig. 3. Doors, automatic doors, and blocked doors. Left: If a door is labeled 'automatic', does that mean (i) that it will open when you approach, (ii) that it will complete the opening action when

you start an opening motion manually, and/or (iii) that it will close unannounced (typically when you are queueing there to get out of the train). Dutch railway trains have all three meanings under one label 'automatic'. Right: Denying a door is a door: The post is placed in the doorway to prevent shoppers to take out supermarket trolleys. But when the door is shut, it's totally unobvious that this is a possible entry to the shop.

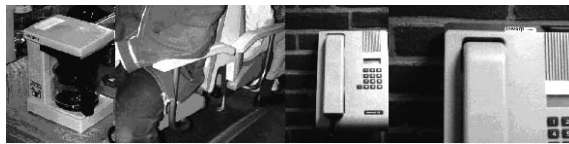


Fig. 4. Safety, hygiene, and visibility. Left: Coffee maker in an international hotel. To make coffee, the user must pour water into what looks like a heat ventilation slot in this electric device. There is no explicit indication, and pouring water into electric devices is to many people an action that is sound in a Darwinian sense. Middle: Luggage can be stowed under seat backrest in the train, but this is not apparent; also, people mistrust it, because they cannot see whether it's clean or not. Right: How far does the designer reach? This coin-operated phone was placed in pubs and restaurants, but its coin slot is at the top, invisible if it is hung too high on the wall. How does the designer anticipate and prevent this? How much control does the designer have in shaping the situation of use?



Fig. 5. Freedom. This hot air blower's nozzle can be directed down to dry your hands, or up to dry your hairs. How do you see that you can turn it? A sign 'turn here to make the machine blow up in your face' might at least amuse native speakers of English...

Results and discussion

One week of searching and photographing produced between 50 and 60 examples in the field (the count depends on how different the examples should be), some of which are shown in the figures in this paper. We tried to group and order the examples to different criteria, and thereby lay bare some considerations that were most salient in the collection. (Note: in the text below, we list frequencies of examples, but these numerical values should be taken lightly, as rough indication of size, not a precise measurement).

The first, most obvious, criterion was location: where was the example placed. Here, washrooms and toilets provided the most frequent examples (20 and 7, respectively), probably because these are locations and activities where errors often lead to embarrassment. Especially a hidden flush brings about awkward situations for the visitor of a toilet. The introduction of automatic sensors made life easier, and more hygienic, but was often carried out in such a discrete fashion that users did not know what to do, and had to look if the flush control was a hidden foot pedal, a chrome and plastic pushbutton, or an infrared sensor which looked identical to the former pushbutton (see Fig. 2). Other favorite locations were public walkways (10) and especially trains (7). In one instance, we observed an elderly lady waiting patiently in front of a door, which carried a sign 'automatic'. The lady didn't understand the door, waiting for it to open. The door didn't understand the lady either, it only closed automatically, after a fixed time (See Fig. 3).

Another criterion for classifying the examples came from considering the interaction between user and product as a scenario over time, rather than a momentary activation. Table I illustrates such steps, and gives examples of what needs occur in different steps. Gaver's notions of hidden affordances and posing also yielded 19 and 24 examples, respectively.

Conclusions: fixing the flaws?

In the figures and organizations presented above we found some specific categories which can be used as attention points for reviewing designs, or as starting points in idea generation. Especially the developments of automation and sensors require new ways of making products expressive; the example shows that a word as 'automatic' harbor different meanings. Moreover, we found some emerging themes, which have relevance for developments in the profession.

A recurring theme was the attachment of labels, either in the design, or in patches afterward. Norman (1988) already wrote "Bad design cannot be patched up with labels, instruction manuals, or training courses. Warning labels and large instruction manuals are signs of failure". Djajadiningrat et al. (2000) saw labels as misguided attempts of designers which "...sacrifices expressiveness to achieve a unified and aesthetically pleasing whole". But also, we see that many of these patches are not made by the designers during conceptualization, but by the janitors, facility managers, shopkeepers, and friendly neighbors who operate in the situation where the product is applied.

Step	Frequency	Comments
1. need		In user-product interaction, the user's goal/intention comes first. This is connected to the locations (toilets, washbasins, doors). We didn't use this as a category for counting, as it is not a source of confusion, at least not for the user.
2. function (what)	17	When the user seeks entry to a building, a door must advertise itself as offering that possibility (Fig. 3). A tap should be recognizable as a thing that can deliver clean water. A water reservoir should show how it can be filled (Fig. 4).
3. activating (how)	25	A user may recognize a door or a tap, but may not be able to find out how to get the door open or the tap running.
4. modifying (change)	6	During some interactions, the product can offer degrees of freedom, e.g., temperature of water, or direction of dry-blower for drying hands and hair (Fig. 5). This must be recognized.
5. completing (stop)	3	Some interactions need to be concluded, e.g., most people want to shut doors or flush the toilet behind them (Fig. 2). Seen as part of the interaction, these actions are completion.

Table I. Organized by temporal sequence in use.



Fig. 6. Unclassified. In order to help the blind cross over, 'tikers' have been installed at zebra crossings, giving sonic cues to the state of the traffic lights. The sound sometimes lead to complaints from people who lived next to them, which, in turn, led to a most curious design solution: the ticking information has to be requested by pressing a button. How will the blind person find the button, or its function, the first time he or she comes here?

Maybe the most important lesson to be gained from this exercise is that it points to the need for a deeper understanding of the third part of semiotics, i.e., pragmatics of product use in the full context of the user's life, next to the understanding of the functions (syntax) and abstract expression (semantics). An example from linguistics hopefully helps to explain: regarding the sentence "It's warm in here," syntax addresses the form of a correct sentence (e.g., "warm here in it's" is not a correct sentence); semantics addresses what this sentence means in isolation, 'by the book' (e.g., "the temperature is higher than 30° C"); pragmatics addresses how we use it in the complexity of life (e.g., to tell someone to close the window). A focus on pragmatics by necessity broadens the context of user-product interaction to include a wider range of time, place, and people involved. In order to achieve products which function to everybody's satisfaction, our methods of informing the design process, such as contextmapping methods (Sleeswijk Visser et al, 2005) which have hitherto mostly been used to mediate between users and designers, will require a commensurately wider participation in the codesign process, in which users, designers and other players (e.g., facility managers, cleaners, distributors, installers, maintainers) work together to shape the context vision for future projects. This may be most visible in public spaces, but equally important in other product categories in our increasingly complex world. We'd like to end this presentation of confusions with the example in Fig. 6, which we could not fit into any of our schemes, or in our thinking. We leave it, just as food for thought.

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Can HCI inspire dynamic design?

Abstract

By nature, computational systems are temporal machines. For more than 50 years, the discipline of HCI or human-computer interaction, has explored how people behave with dynamic objects like buttons, scrollbars or more recently tangible interfaces and ubiquitous environments. In the same time, a significant and complex culture has emerged: digital affordances are now familiar for users. Can this culture be transferred to dynamic product design? This paper presents some of the insights raised by the HCI community, with a focus on interaction models and semantics. More precisely, it introduces the model of Instrumental Interaction created by Beaudouin-Lafon² and illustrates some of its properties with tangible and gesture-controlled objects.

Keywords

HCI, affordances, direct manipulation, instrumental interaction, dynamic design

1 Introduction

History of computer is closely link to motion understanding and representation. The first computational systems have been developed to monitor ballistic devices. After the second-world war, the evolution of radar technology led to the creation of interactive displays that visualized moving objects like planes for example. At the time, operators were using button panels and instruments called lightguns to interact directly with the screen. Later, these devices evolved

into keyboards, pens and mice, shaping the paradigm of the modern computer. Although they allowed a high level of text input, they were limiting physical expression, the body often being reduced as one dimension (click, keystroke) or two dimensions (mouse coordinates).

This context diffused an environment called WIMP for window, icon, mouse, pointer. The discipline of HCI or human-computer interaction, has created a model called "direct manipulation"¹ to describe this environment, inspiring the creation of software interfaces such as the Apple Macintosh desktop environment. Following these principles, a vast majority of today's software is based on objects such as scrollbars, menus, and icons.

Accordingly, a complex culture has emerged from these objects that are used everyday by millions of people. Their behaviors, semantics and affordances have become cultural references; in the same way that product design has informed our relation to the world. Like a chair affords seating, a scrollbar affords sliding, changing a value or a quantity. Computational devices have hence created their own codes, systems of meaning that are now familiar to the vast majority of computer users.

Many people live now in a world where they can reverse the time (Ctrl-Z), instantiate objects (Copy/Paste) or manipulate simultaneously different items (Select, Drag-n-Drop). These properties, like many other are described,

evaluated and generated through interaction models such as “direct manipulation”¹, or more recently “tangible interfaces”¹⁰ or “instrumental interaction”².

In the last few years, a new class of physical objects has appeared: they can change their shape, being animated or controlled by motion, gestures or physical interactions. They are now very similar to computational objects like icons or windows. Can we apply interaction models coming from computational systems to them? Can we transfer structures and practices from computer to these dynamic embodiments? In order to explore this issue we introduce the model of Instrumental Interaction created by Beaudouin-Lafon². Then we present two dynamic objects implementing some of its properties.

2 Instrumental Interaction

In 2000, Beaudouin-Lafon^{2,3,4} introduced a new interaction model called Instrumental Interaction that extended and generalized the principles of direct manipulation. For him, an interaction model is a set of principles, rules and properties that guide the design of an interface. It describes how to combine interaction techniques in a meaningful and consistent way and defines the “look and feel” of the interaction from the user’s perspective. Properties of the interaction model can be used to evaluate specific interaction designs. According to him, designing Post-WIMP interfaces that are more faithful to the principles of direct manipulation and that take advantage of novel interaction techniques requires new interaction models. To guide interface designers, these models should be:

- Descriptive, incorporating both existing and new applications
- Comparative, providing metrics for comparing alternative designs as opposed to prescriptive, deciding a priori what is good and what is bad)
- Generative, facilitating creation of new interaction techniques

For Beaudouin-Lafon, WIMP interfaces do not follow the principles of direct manipulation. Instead, they introduce interface elements he called “instruments” such as menus, dialog boxes and scrollbars that act as mediators between users and the objects of interest that he called “domain objects”. An interaction instrument is a mediator or two-way transducer between the user and domain objects. The user acts on it, which transforms the user’s actions into commands affecting relevant target domain objects.

Instruments have reactions enabling users to control their actions on the instrument, and provide feedback as the command is carried out on target objects.

A scrollbar is a good example of an interaction instrument. It operates on a whole document by changing the part that is currently visible. When the user clicks on one of the arrows of the scrollbar, the scrollbar sends the document a scrolling command. The feedback consists of updating the thumb to reflect the new position of the document. In addition, the object also responds to the instrument by updating its view in the window.

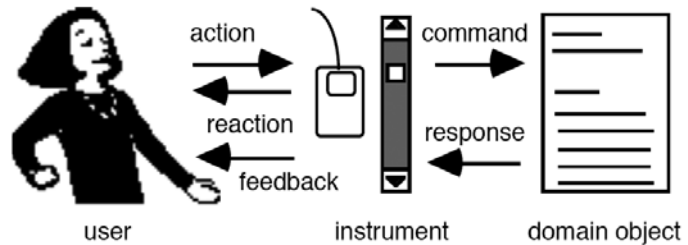


Illustration 1: Interaction instrument mediating the interaction between a user and a domain object

To precise his model, he isolates some design principles to support the development of large-scale applications and take advantage of recent research in new interaction techniques: reification turns concepts into first class objects, polymorphism permits commands to be applied to objects of different types, and reuse makes both user input and system output accessible for later use. One early example of polymorphism is the queen interactor of the Topobo system⁵, a 3D constructive set

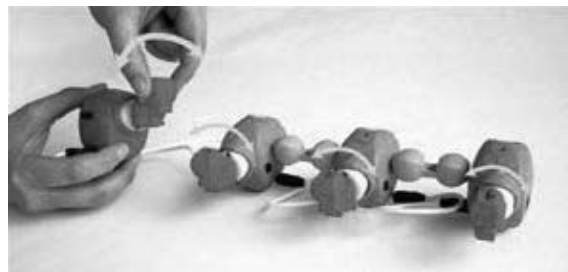


Illustration 2: Topobo Polymorphism: actuating one object commands many

And because interactive systems are open, they must therefore adapt to various contexts of use. What is critical is that we define interaction architectures that give more control to end users that are more resistant to changes in the environment, and that scale well. He calls these three properties reinterpretability, resilience and scalability. Reinterpretability is close to the concept of reconfiguration developed by Lucy Suchman in her works about situated action⁶. As an example of a situated and open system, the critical piece of Kelly Dobson, Blendie⁷, illustrates how an appliance could be triggered by the noise instead of classic buttons. You induce the blender to spin by sounding the sounds of its motor in action. This leads to a mode of interaction very direct where the user has to mimic the output of the device to be able to actuate it. As noted by Dobson, the action may also bring about personal revelations in the participant. The participant empathizes with Blendie and in this new approach to a domestic appliance, a conscious and personally meaningful relationship is facilitated.

3 Instrumental interaction in the physical world

As an example of transfer from the world of computer to the physical one, we present here two projects that try to reify the concept of sliding into a physical



Illustration 3: Blendie: A blender activated by outside noise, inciting you to develop your own language with it

object. As shown in figure one, the scrollbar is basically an instrument that allows modifying a value or a quantity by navigating through it. It could be actuated by its little arrows on the extremity or by grasping directly its handle. What could be a tangible scrollbar, how this instrument should be shaped and actuated in the real world? Would it be as meaningful for people that use it? As an exploration of these issues we introduce two objects: Tangicam⁸, a video camera for children and Telebeads⁹ an electronic jewelry system that can capture motion and interact with domestic appliances.

3.1 Tangicam: a tangible video camera for children

Tangicam, or tangible camera is a device that let children frame their world by simply pressing its handles. In an augmented reality context, children can use the body of the camera as a circular slider, allowing them to navigate through the video they took. Tangicam reifies the frame and the slider concept. It is polymorphic because it can controlled many objects in the same time and it is contextualized for it delivers different functions depending on its environment.

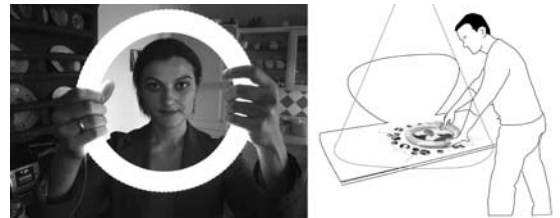


Illustration 4: Tangicam a circular videocamera that can act as a tangible slider

3.2 Telebeads: digital jewelry that interact with domestic appliances

Like the scrollbar, the movement of the ring (equipped with a miniaturized mems gyroscope) is changing progressively the state of an appliance. Here, scroll up means more quantity of water in the case of the tap. The lamp is gradually getting brighter as the ring gets higher, providing a simple and very natural feedback of the motion.



Illustration 5: Telebead: Moving the ring scrolls water in the tap or light in the lamp

5 Conclusion

This paper has introduced the Instrumental Interaction model of Beaudouin-Lafon and discussed if it could be used to inform dynamic product design. The early results of these investigations show that shape-shifting and motion-controlled objects are surprisingly similar to screen objects. They often offer one dimension interaction (e.g. buttons) or 2D (changing a value, scrolling). In this respect, they offer “instrumental” potential, they could then benefit from the model. It could be then interesting to explore how dynamic object reify HCI concepts, like Castiglioni’s switch reified in its time the concept of binary state. As early exploration, we showed how a scrollbar could be materialized as a circular slider and as a motion-sensitive jewel. Further works will consist in observing if this metaphor is meaningful for users in a domestic environment.

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Beyond Bionics

A tool of innovation and sustainability



Figure 1

Abstract

Formal and typological innovation and ecological sustainability are essential premises for “meaningful” products. Applying bionics to the design process is a valuable approach to convey those concepts. A didactic research led at the Department of Industrial Design of the University of Florence has tested its effectiveness.

Intro

When willing to charm a peahen, the peacock fans out its tail, fascinating not only her prey, but creating an image that has become the symbol of beauty. Its gesture, its change of status has a clear meaning: seducing her. Spirals: everywhere in vegetable forms of life. A tree's buds line up along a branch with a short pace, rotating around the axis, following a spiral line. This has a precise meaning: it allows the various elements to exploit sunlight

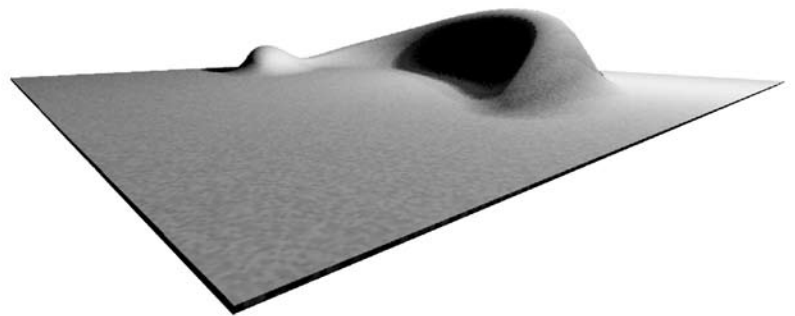


Figure 2

in the same way and enables the balance of weights, optimizing the use of materials.

These are just two of the infinite examples that we might quote, conveying the concept of meaningfulness in nature's “products”. This semantic effectiveness consists of various declinations: shapes and colours that tell their purpose and their function – formal and typological innovation – materials developed exactly for the purpose they are being used and constructions that optimize the size and the shape of the parts related to the solicitations they have to bear – ecological sustainability.

In every human era and in every historical period, the world of nature has always been source of inspiration for every artistic expressions. The derived objects are always triggering emotional and perceptive mechanisms. They respond to a very contemporary consumers' habit,

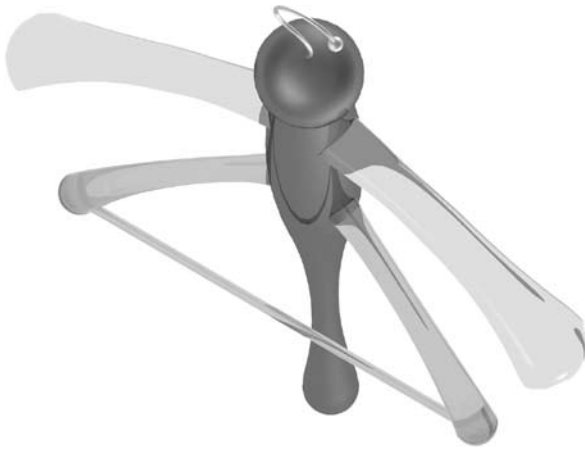


Figure 3



Figure 4

the so called “polisensualism” [Ref. 2] that is the search for a global involving of senses during the experience of consuming. In designing, the valorisation of formal components happens, nowadays, through the definition of a philosophy that is ecologically sustainable, integrating shape and meaning, emotion and rationality, intellect and feeling, technology and perception to obtain products whose decorative function is strictly linked with their meaning and performance characteristics.

State of the art

Bionics, in its primary etymologic meaning, is the science that studies the electronic systems able to simulate the behaviour of living organisms and their parts [Ref. 1]. In the design field, we extend this meaning to the science that studies the structure and the function of living organisms with the aim of acquiring inspiration to designing.

Bionics models very often represent precise cases of knowledge transfer from the world of Nature to the world of products. 3M is studying the microscopic structure of spiders’ paws in order to design post-it stickers that keep stuck although air humidity [Ref. 3]. The swimming suit Speedo Fastskin FSII emulates sharks’ skin structure to optimize the water flow around an athlete body [Ref. 5]. Design research takes possession of the formal qualities and the engineering logics existing in nature and it reinterprets them to become product design. Up to now, what has typically happened, is that designers and scientists have been focusing mainly on simulating the characteristics of natural materials or just the system of forms. The study of functional aspects, integrated with morphological aspects, is still a nearly unexplored field, and a huge resource of inspiration for designers. This is the final objective of Dacia Design Project.

Dacia Design Project

From October 2005 to February 2006, the Department of Industrial Design of the University of Florence has chosen bionics as the didactic approach for a six months assignment to first year students.

The project is named DACIA Design: Design Abitazione Complementi Innovativi Ameni – Design of Innovative and Pleasant House Fittings. The theme is the design of innovative products for the house, dedicated to contemporary users, which have to be positioned in the market of luxury and are able to respond to new behavioural trends.

Innovation, in a general sense, is nothing without a correct form conveying its value. How to explain this to the students? How to make them absorb this concept? As people working in didactics know, form-giving is a burning topic, with no possible scientific solution – standard methods are not available in this field. It is a question of finding good approaches, like keys that enable students to open their mind. Our concern has been testing whether bionics could play the role of a “mind-opener”.

¹ Thousands of pages have been written about this topic, with no general agreement. The authors of this paper are supporting that, being designing a process that involves a creativity quantum, it cannot be framed in a strict method. Bruno Munari reports in his book “Da cosa nasce cosa” [Ref. 4] a very effective analogy between designing and cooking: while the recipe of green rice, where every step is compared to a design process’ step, can be explained, the cook still makes the difference in the success of the overall dish.



Figure 5

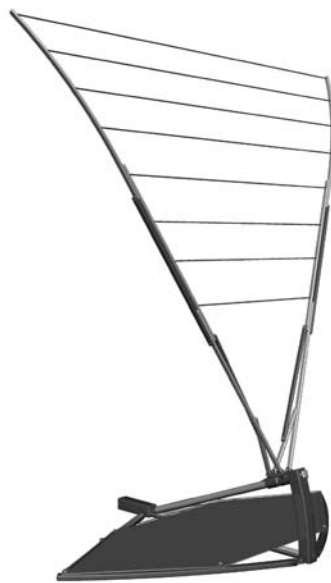


Figure 6

The Process

The students have been divided in groups and every group had an inspirational theme: insects, mammals, fish, flowers, leaves, carnivorous plants and dinosaurs.

Each group has studied formal qualities and functional mechanisms of its inspirational theme, pointing out the interesting phenomena that emerged from the research.

At the same time they have started questioning themselves about how the spaces they are living in their homes are responding to their needs.

“Are the proportions among the different rooms coherent with my lifestyle?”

“Are the objects that I find in my house useful?”

“Are there habits that I have – likely different from the habits of my parents – supported by products?”

“What products are missing in this habitat?”

They have thus been struggling and facing the concepts of personalisation of objects and spaces of the home living culture.

DACIA Main Outcomes

As shown by the design cases illustrated in the next section, Bionics has proven to be a very good approach to convey to students the concepts of ecological sustainability, formal and typological innovation.

During a design process, every time that designers need to verify the optimisation of the various aspects in a product, they discover that nature has already found the best solution, for example, requiring the minimum quantity of material or using the most appropriate section in relation to the efforts that the structure have to resist.

The concept of best performance with minimal effort illustrates to students what is ecological sustainability in products.

While learning to observe the changes in society and the emerging of new behavioural standards, students have also learnt to read and reinterpret nature, to use it as an inspiration for finding new solutions for the contemporary world of objects, innovating not only technologies but also forms.

Design cases

The changes of status or activities, such as flying/stand-by, attacking/stand-by, defending/stand-by, love season/stand-by are very fascinating topics of study. These dynamics present extremely interesting and inspiring formal and functioning characteristics, whose transfer in a product, make it effective and meaningful. These variations can be used in products to communicate to the user if the object is off, in a stand-by mode or whether it is working. It can also become a metaphor of the product life cycle: form can become an indicator of the utilization phase of the product.

The bionics concept of shape communicating status has led to formal innovation in Kirò [Fig. 5 – 6]: the drying rack has borrowed its kinematics from the bats’ wings to answer the increasing demand of space in the houses. When open, it is a capacious drying rack with a fascinating wing shape, when it is folded, it takes very little space. All final projects have been characterized by a high degree of formal innovation. Verminillo [Fig. 7] has taken inspiration both from the functioning, the shape and the texture properties of the caterpillar: it is a toilet bowl’s brush whose articulated joint, comfortable handle and hair distribution enable an effective and practical cleaning operation.

Komorebi [Fig. 1] has been influenced by nature poetics. It is an emotional lighting object, derived by form and consistence of vegetable cells, made of wood and a sandwich of fossil marble that contains leaves. It is combinable with other Komorebi pieces, to compose a net that enlightens spaces with dreamy forest-like light. Poetic is also Anemone [Fig. 8], an electrical insect killer, whose simplicity, formal elegance, and functioning are inspired by the sea anemone. As the aquatic animal eats hermit crabs, Anemone “eats” mosquitoes, after having seduced them with the light emitted by its tentacles. The simple and delicate cloth hanger Dragonfly [Fig. 3-4] mentions shape, transparencies and iridescences of the dragonfly. It faces the interesting theme of personalization for it becomes a practical home device which can be utilized in multiple ways: the long stick, that evokes cloth



Figure 7



Figure 8



Figure 9

hangers of old times, is actually an effective expedient to enable people with different bodies, heights, postures and mobility capabilities to utilize the object.

Zanza [Fig. 9] has observed the peculiar needle that mosquitoes use to suck blood. Its principle has been inverted to obtain a pipe where the water can drain after usage to keep the soap always dry. This has resulted in a simple bar soap holder, characterized by a high degree of ecological sustainability both in its usage – no soap is wasted – and in its construction – the project has minimized the quantity of material and chosen for recyclable corn starch plastics.

Sauro [Fig. 2] has stretched formal innovation up to a typological breakthrough. It aims to reinterpret the domestic space in a fluid way, offering a new informal and contemporary manner of relaxing that eliminates the border between seat and carpet. The shape suggests a prehistoric animal napping beneath its surface, which is asymmetrical and strongly characterised. It is targeted to the generation that has grown up with Hanna and Barbera's *Flinstones* and *Jurassic Park*, triggering an unaware process of fascination in the users, inviting them to take a liking to it and explore the multiple manners of using it, treating it as a social opportunity or as a lonely experience of a comfortable hug.

Conclusion and Future Developments

Applying bionics to the design process made the students assimilating the concepts of meaning and perception in products, taught them structuring mechanisms and linguistics of the design process and, at the same time, helped them in elaborating typologies of objects, which are new and also sustainable. Therefore, Bionics based design process has demonstrated its effectiveness. The scientific research progresses, which are enabling

longer lives and extremely differentiated functional frames, are resulting in an increasing complexity of needs and a growing variability of the consuming society. The theme of "changes of status or activities", mentioned at the beginning of the "Design cases" paragraph, has the potentialities to provide a structured approach to solutions and, therefore, to become a consistent and long term research project.

Table of Pictures

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3. Dragonfly, by Fabio Novelli
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Making role playing work in design

Abstract

This paper presents and evaluates examples from our work with role playing exercises in design, both in design education and in our own design work. First, rationales for the adoption of role playing in design are briefly reviewed. The following rationales are generally being given: communication within the design process, the increase of technological complexity, and the experience and empathy of designers. A fourth rationale is added: attentiveness to social change. The examples from our work are presented and briefly evaluated in the light of the rationales, and in terms of the practical problems of integrating role playing exercises in design teaching and in a design process. Careful consideration of the actor-audience relationship and sufficient preparation for the actors and other contributors aid the success of role playing in design.

Keywords

Role playing, improvisation, design process, education, social change

1 Introduction

This paper presents examples from our work with role playing exercises in design. Previously, I have reviewed the literature and examined rationales being given for role playing in design [1]. I identified the following rationales generally being given: communication within the design process, the increase of technological complexity, and the experience and empathy of designers. I added that there could be a fourth rationale for the adoption of role playing exercises: attentiveness to social change.

In this paper, I review the rationales that had been identified again briefly. I reflect on examples of work in which we made use of role playing in design. I look at the

practical problems of integrating role playing exercises in design teaching and our own design process, and reflect on their usefulness.

2 Rationales for role playing in design

From Burns et al [2], which was perhaps the earliest paper on role playing, to Buchenau and Fulton Suri [3], a concern that has led to the adoption of role playing techniques was the communication within design processes. Authors sought to find engaging ways to present concepts and to communicate about them “with peers, clients and perhaps users...”. (Burns et al, *emphases original*). A second rationale was to help designers in dealing with the complexities brought on by computerization and miniaturization. Simsarian [4]: “Projects often include new-to-the-world systemic and strategic brand issues as well as interactive systems that are highly nuanced and difficult to articulate verbally. (...) Role playing can work to bring it all together.” Jensen et al [5] use role play to research and re-introduce rich possibilities for tangible interaction that products used to offer. Burns et al [2] also thought that role playing “could allow designers to imagine better; (...) to empathise better” with potential users (*emphases original*). It seems that this needs to be achieved through an activity rather than through abstract, deposited knowledge. Buchenau and Fulton Suri [3] appeal to the “vividness of owned experience” that this creates for designers, influencing and guiding their decisions. Brandt and Grunnet [6] claim that drama can enable “bodily understanding.” Klooster [7] affirms this from her own experience of transferring insights from dance into the understanding of movements in human-product interaction.

This third rationale connects to a fourth rationale I have argued for [1]. Role playing could be useful as a technique

for designers to consider themselves and their actions positioned in a context of social change.

2.1 Attentiveness to social change

Krippendorff and Butter [8] argued that design had to start engaging with product use as a wealth of situated practices of living. To bring design activity and methodology up to date with societal developments, we need to investigate the “discursive tools”, as Jonas [9] termed them, that we employ in design. Rather than neutral analysts and synthesists of form, designers are increasingly recognized as being implicated and involved in the conditions of product production and consumption. Buckley [10] and Hjelm [11] argued that the long dominant concern for form in design could be read as part of a strategy for maintaining existing understandings and power balances in design. Who are designers? What are their experiences? What is their scope for experience in relation to product use? Role playing can be a discursive tool within design that promotes attentiveness to social change. The literature on Keith Johnstone’s ‘theatre sport’ [12] and Augusto Boal’s ‘forum theatre’ [13] shows that role playing has this potential. Nearly all design-related publications on role playing refer to either or both of these important innovators of improvisation techniques in the past century. But the design-related publications tend not to make explicit the potential of attentiveness to social aspects that improvisation techniques hold: they can be a vehicle for the exploration of actions that depart from norms. The techniques hold a potential for innovating on interactions: through surprises, through inadvertent actions, and through reflection on these. There are many organizational and civic arenas where improvisation techniques are already used for the very purpose of discovering this innovation potential.

Role playing exercises, set up with Johnstone’s and Boal’s ideas in mind, might be of use to designers in deconstructing their own ways of interacting, in exploring ways of interacting that are someone else’s, and in experimenting with interpretations of interactions. With that, role playing exercises may enable designers to reflect social changes in their work without having to do so in a very explicit and text-based manner. Having subscribed to this notion as a rationale for role playing exercises, we have gone about setting up a number of those exercises. We are now at a point where we can ask: in how far was our set-up of the exercises successful in enabling students

- and us - to reflect in-depth on interactions? This question is explored here. Previously, I have held some of our efforts up against all four rationales that were briefly reviewed above [1].

3 Examples of role playing techniques applied

We first adopted role playing techniques three years ago, as part of the curriculum for the new MSc course Design for Interaction at the TU Delft. The design project “Exploring Interactions”, in which I am involved as a tutor, challenges the students to design “everyday products (as) personal pathways that allow individuals to find and create their own experiences, (...) instead of operating a device to obtain a ‘commodity’ or function...” [14]. Our inclusion of role playing workshops in this project was informed by the rationales discussed above.

I monitored all of the activities described below from an action research perspective (as laid out by e.g. Robson [15]). I observed and recorded the activities, while also being substantially involved in planning them. I asked collaborators for peer review on the success of the activities, and I interviewed a few of the students some weeks later, after their final presentation.

In all examples presented below, the role playing exercises took place at the project stage where user research had been carried out in the form of interviews or observations. The step to be taken next, aided by the role playing exercise, was design idea generation.

3.1 Role play example 1: the Story Walk

The first role playing exercise in the MSc project “Exploring Interactions” was a combination of improvisation theatre techniques adapted by me for the course, and the Storyboardwalk developed by Saakes and van de Lelie, see also [14]. The combined workshop was called the Story Walk.

Twenty students in four groups took part in the workshop of one afternoon, in a studio.

Taking a situation from their prior research, they were asked to break it down into dramatic elements, improvise with the elements, then settle on a story, act it out, photograph that, print it out right away and lay it down in a storyboard collage.

Figure 1 shows the example of a collage by one student group. The story is about waiting at the station. The collage shows two alternative stories, with the top one depicting the involvement of a design intervention that brings the story to a happy end.



Fig. 1: Story Walk collage

Evaluation

The evaluation with the students showed that none of the four groups had actually experimented with an emerging story. All groups had taken a story they had previously sketched following their research, and played it through. They went away from the afternoon with a visual record of an interaction. This they said they valued. But on balance, it can be concluded that the students were mainly focused on dramatizing and presenting their story, rather than on the experience of being in that story, or on experimenting with unexpected interactions arising from the situation.

3.2 Role play example 2:

Quality of Interaction Workshop

A year later, a shorter workshop was held, for a larger group of about 30 students, in groups of three to five. In a short idea finding phase, the students were asked to use their prior user research to give a desired interaction a two-part name describing its quality. The technique hails from Hekkert and van Dijk's ViP approach [16]. Each student then asked their group mates to act out this interaction. Each student's design idea would be 'played back' to him or her as problem owner, with opportunity for adaption and discussion. In a sense, it was a mini forum theatre exercise [13].

Evaluation

The pictures in Figure 2 reflect the students' self-consciousness about enacting sometimes quite intimate kinds of emotions, in a workshop setting. Many had to suppress laughter when acting out the interactions, and

acted very fast. They did not seem to experience and direct the qualities of the interactions they were role playing much. Some decided to brainstorm instead, and one student commented: "We're designers, not actors, you know." It seems to be important to create a calm and somewhat secluded setting for such a workshop. And there may be a need to prepare students for the acting itself, to let them practice it and get a feel for it.

3.3 Role play example 3: Project "Organizing Things".

The third example of role play comes from an ongoing design research project of our own, in which we look at the integration of user research in the design process: the project "Organizing Things". Preliminary findings from that project are described in Boess et al [17]. We seek insight into our combined design and research activity as 'investigative designers'. In team meetings, we recalled to our attention actions that had been described and shown by participants of our prior research, and we role played some of those actions (Figure 3).

Evaluation

While we had found that team meetings were a good form of communication for research and design, the role playing did not fit into the meetings quite naturally. Only the three researchers were involved, in the secluded setting of an office with a meeting space. Yet when we filmed the actions, we also had to contend with self-consciousness which hindered the experiencing of the actions. Even in that intimate situation, we would have needed more structure or a more immediate way of visualising the role playing results.



Fig. 2: Quality of Interaction workshop. “Control-yielding curiosity” (left): fear of being approached with a sharp object. Design goal addressed injections at the doctor’s. “Controlled surrender” (right): dealing with fears as a patient being guided around in a hospital by staff.



Fig. 3: The check-out dance. A research participant described how, when leaving the house, he’d check on his clothing: “Let’s say in my pocket I’d check on my keys, the other pocket my purse, and in my breast pocket my mobile phone and mp3 player.” (top row of pictures). We re-enacted these actions later in an idea generating session (bottom row of pictures).

3.4 Role playing examples 4 and 5: Workshop “What is interaction?”

Two further role playing workshops have since been held. The first was developed for a semester course I held for product and communication design students at the HBK Saar in Saarbrücken, Germany. The second one was again part of an edition of the MSc project “Exploring Interactions” at the TU Delft. Both workshops had a nearly identical set-up and are discussed together here. The students were this time assigned roles. There was a group of actors, a group of observers, a group of scenario writers and a group of things makers. Each group of 4 to 6 students was given a written set of instructions about their role and given an hour’s time to practice, write, make, and prepare interpretations respectively. After an hour they all came together, and the scenario writers instructed the actors about their task, while the things makers provided things to act with. Short scenes were improvised by the actors before the audience of the other three groups. Inbetween and after the scenes, the observers led a discussion on what was seen.

Evaluation

While these last two workshops (the second one was actually three parallel workshops with 20 students each) are very recent and have not been fully evaluated yet, some initial notes can be made. Both times, the students set about the workshop tasks with great earnest and application. Following the scenes being acted, they held discussions in which in-depth themes about the first-hand experience of interacting with things emerged. The students worked almost self-sufficiently throughout the entire workshop. In the time that the students had been given to prepare, tutors could take the time for some brief coaching and explanation for each group, so that the students came back to the forum with some confidence about their role.

4 Conclusions and Further Work

Our examples have shown us that if we want to access the innovation through experience potential of role playing that was laid out by Boal and Johnstone, we need to be attentive to its set-up. While the first three attempts did not enable us fully to get to work on that, the fourth and fifth showed that more preparation for the acting

itself, and the creation of an actor-audience situation, increased the ability of the design students to accomplish an in-depth reflection and discussion on interaction.

An incidental observation from our exercises throughout these three years is that small role playing elements are 'naturally' present when people explain how they intend their design ideas to work out in human-product interaction. Such 'mini role-plays' do not yet have a place in design methodology, and have not yet been explicitly addressed by us. Yet it may also be helpful to develop these into a more explicit element in design processes.

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Meeting duet; challenging people into a body language of meeting

Abstract

With the introduction and incorporation of novel interactive technology in product design, products are increasingly designed as facilitators or mediators of interaction. This perspective opens the way to a specification of this focus, namely designing products as a motor of socio-cultural activities and events. Here the product's form and behavior should, more than ever, be designed with the intention to engage people in a form of contact with each other. In this paper we present an educational project that aims at designing a meeting event on the festival 'a camping flight to Lowlands paradise'. The project is based on the Design Movement approach, where products are designed for, and as part of, a Choreography of Interaction; in this case as part of a meeting event at Lowlands. In this paper we show how a product design originates from the creation of a social cultural event. Moreover, we show the effect of designing products from a choreographic perspective and with focus on people's body language and dynamic interplay.

Keywords

product, eliciting, event, meeting, contact, choreography, interaction, movement, body language

1 Introduction

This paper discusses the outcome of an educational project that was done at the department of Industrial Design of the Technische Universiteit Eindhoven (TU/e).

This department focuses on designing intelligent products, systems and services, which implies a strong focus on integrating the newest technologies in interactive, user-centered products.

The project we present here is an implementation and specification of this focus, involving the following two specializations. On one hand it concerns the design of an interactive product that facilitates and mediates a socio-cultural event; in line with the growing attention for social interaction [1]. On the other hand it is based on the Design Movement approach. This approach incorporates knowledge from the field of dance, namely dance improvisation and Laban's movement analysis [2]. In this approach a Choreography of Interaction is created, which involves the design of a product that motivates this Interaction Choreography [3,4].

In this paper we show how this project resulted in a product that was designed for, and was part of, a meeting event at the festival 'a camping flight to Lowlands paradise'. Lowlands is a three-day festival, attracting a wide variety of people, most of them relatively high educated. The visitors sleep at a camping adjacent to the festival area. The festival has a very open minded and tolerant atmosphere [5,6]. We illustrate how product design, when approached with a choreographic perspective and a focus on body language between people, can be seen as the design and motivation of an event



Fig. 1: The choreography of meeting: jointly explore the possibilities of increasing and changing the surface of touch

2 Meeting Duet

The project we describe was named Meeting Duet. The objective of the project was to design a new way of meeting that would especially fit the cultural context of the Lowlands festival. This design included a product that would motivate, facilitate and mediate this meeting event. Moreover, the product's form and behavior should engage people in a high quality and meaningful form of contact with each other, as part of the experience of Lowlands.

The project Meeting Duet was done by a team of five students, namely the first five authors of this paper. The project was coached by the sixth author of this paper, in order to support the choreographic perspective on design. The manager of the Lowlands festival, Eric van Eerdenburg, represented Lowlands' interest in new challenging events.

In the next part we introduce the designed event, the meeting that was choreographed as the reason and starting point for the design of the product. In the second part we present the product that was designed to motivate the choreographed meeting event, and we will explain how its characteristics are meant to do so. These two parts overlap, since the product design evolved from, and was part of, the creation of the meeting event.

2.1 Designing a meeting event for Lowlands

The meeting event for Lowlands was choreographed through a range of explorative iterations, where experimentation, experience and observation formed the basis for insights, discoveries and design development. These explorations were supported and refined through literature, experts and interviews. This process resulted in the following conceptual meeting event.

The concept of the designed meeting plays with the fact that people do not know each other on a festival. It challenges people to approach each other and to explore through interconnected body language. This meeting is based on physical contact and avoids prejudices that are based on visual appearance. Curiosity and fantasy, just like challenge and daring, are important drives which closely relate to the drives of the visitors of the Lowlands festival. This event might lead to a more open attitude between people and hence might enrich the Lowlands social cultural atmosphere.

The idea is to invite people to jointly explore the possibilities of increasing and changing the contact area between them (see fig. 1). They are enticed to constantly create new shapes of contact area. Their movement should express challenge towards each other: playing with being proactive or reactive; leading or following is constantly an issue. This way people explore each others attitude in a very direct and mutual body language. The movement is a continuous search and is fragmented at the moments when other parts of the body are introduced. Because this movement focuses on contact area, it involves spatial relations as well as play of forces. Most naturally, touch starts with small groping movements, only with hands and fingers. Gradually people may gain trust, and dare to decrease the distance between them. With decreasing distance the area of contact increases, together with the level of intimacy. They may dare to touch with and get touched by more and different body parts. The movements become bigger, and evolve into full body movement. Hence the form of touch changes dynamically.

During the development of this concept, first associations to product ideas started to rise:



Fig. 2 Several initial prototypes that are used to explore and develop both the choreography and the eliciting of the choreography.

Imagine a screen, with people on both sides. The screen prevents seeing other people pass on the other side, yet when someone touches the screen you see an impression. The only way to discover who is on the other side is by touching that impression. You can push it gently, stroke it, or hardly touch it at all. The person on the other side might react and shift his or her position. You can either choose to follow the movement on the other side or choose not to. After a moment, another impression appears, and yet another. To touch them all, you have to come closer to the screen, and use other parts of your body as well. You can also take the initiative yourself and create a new impression, by offering an extra body part. The closer you get, the more contact area you create with the unknown other side. It all feels very challenging but intimate, yet you are separated by the screen.

Another possibility to imagine is to break through the spatial separation between another person and yourself. When having certain surfaces on your body that match and react to surfaces on other people's bodies, spatial shapes can be composed, which for example could be translated in the composition of music.

2.2 Designing the challenger, mediator and motor of the meeting

These first associations were the starting point of the product design. This product design phase started as a natural reaction to the design of the event; in search for products that would fit and elicit the meeting event (see fig. 2).

The first ideas were further explored and developed with simple prototypes. These explorative iterations were once more the basis of further design development, again supported with study of literature and meetings with

experts [7]. Fine-tuning the choreography of the meeting event was still an essential part in these iterations and it evolved in connection with the development of the product. As a result of these iterations, both the concept of the screen and that of the connection points were integrated into the following, final concept that was prototyped to complete the project (see fig. 3).

This concept intends to evoke the idea of composition and transition of a shared contact area. The screen, which is made of flexible material, shows an impression when touched; an impression that might invite someone to touch back. The material has a thickness that allows feeling the other person by form and force, and in such level of detail that touching is excitingly intimate, but not too confronting.

In order to invite people to participate further in this meeting event, the tangibility was enriched with visual and audible feedback: to motivate touching the screen, the material shows a nap where it is stroked and a pattern that suggests areas and directions for movement. To make participants continue their journey of discovery the screen incorporates an irregular net of hidden points that are organised in the area of reach. Each point generates different music samples when touched on both sides of the screen at the same time. These hidden sensors may be active or not and trigger different samples over time. Hence a cooperative touch-search is stimulated through auditory feedback; it keeps the people in continuous mutual bodily search to discover new compositions of music.

With this appearance, this concept takes on the role to challenge people to meet in the intended touching manner. Its flexible and bounding screen mediates this

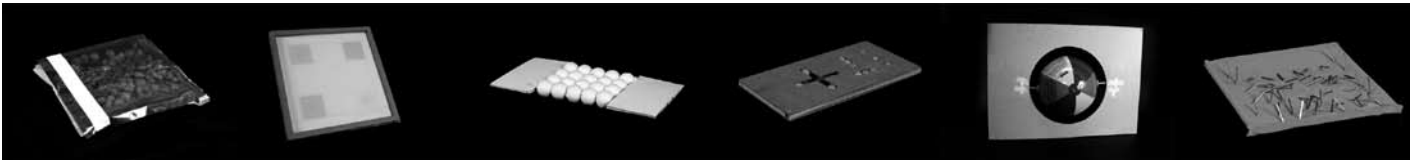


Fig. 3 The concept, a screen which motivates discovering each other by touch and meeting in a totally new way

daring touch-exploration, yet it simultaneously guards the possibility to move away if desired. Its hidden sensors puzzle people and keep them in search for different touch compositions, because these lead to new and exciting musical compositions. Having to be touched on both sides motivates a continuous leading and following search to find and compose music together. Its possibility to build music with samples might make people overcome their shame and go into full bodily contact and new body language.

2.3 Work in progress

Now that the product had resulted in a first prototype, the project was at an end. The design however is not complete. The next stage of explorative and iterative development of the meeting event should involve cycles of testing with groups of people and in context. This is a crucial phase to find out if it indeed motivates the intended form and experience of meeting. Each test will bring forward new discoveries and points of attention for detailing the event and product design. The development of the event hence continues into the last details of the product design.

Based on the interest from both Lowlands and the /d.search-labs at our department, and also the enthusiasm of the design team, it was decided to further develop this design of a meeting event, to find out the potential to actually bring it on the Lowlands festival and to use it as a case study to perform design research on Tangible Interaction and Choreography of Interaction. Eventually, this continuation should develop into both useful findings for design-research at our faculty, a good learning process for the students and a good time for the visitors of the Lowlands festival.

3 Conclusion

Since interaction is a fast growing design specialization, more and more design issues come forward that are considered to be essential in interaction focused design. In this paper we highlighted (1) an example of product design as the creation of an event, with (2) the potential of movement and human body language, as this brings forward a very rich vocabulary for interactive design. We literally moved through the project we presented in this paper. By doing so we iteratively developed insights and integrated discoveries. This congregated into a design that, again literally, incorporated many different interaction design issues in a 'moving' way.

We believe, based on our experience, that the human body incorporates a great source of undiscovered opportunities for design, especially when it comes to the design of interactive products. Our body language contains a vocabulary that links more directly to design than we might think, which can be read in many possible meanings of the words.

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Sensorimotor paradigms for design of movement and social interaction

Abstract

The human brain has evolved for governing motor activity by transforming sensory patterns to patterns of motor coordination. Movement, as a basic bodily expression of this governing function is shown to underlie higher cognitive processes and social interaction. There are three prevailing concepts of sensorimotor interaction that set up different frameworks for design of artificial movement. This paper focuses on the common coding [14] paradigm of sensorimotor interaction as justified by recent experimental studies on the mirror neuron system. It aims to provide a novel approach to design of movement interactions in an inter-agent setting.

Keywords

Sensorimotor interaction, mirror neurons, design, movement.

1 Introduction

The level of understanding of human behaviour and perception frames the borders for design. Movement and action (action is understood as purposeful movement) are the primary expressions of behaviour. Tracing the evolution of species, movement takes more complex and abstract forms. By humans, movement is grounding cognition, language, and social interaction. Interaction through movement and its implications for creation of social agents are discussed in an attempt to outline a new design framework. After reviewing the main

views on perception and action and the design concepts they can afford, we choose the common coding paradigm [14] as a basis for design of movement in inter-agent setting. The common coding is explained in concrete sense with the latest discoveries in neuroscience and experimental psychology. In particular, the discovery of the mirror neuron system in humans [4],[7],[9] have given new dimension of understanding the sensorimotor system and its interaction to a complex environment, including the interactions with another agents.

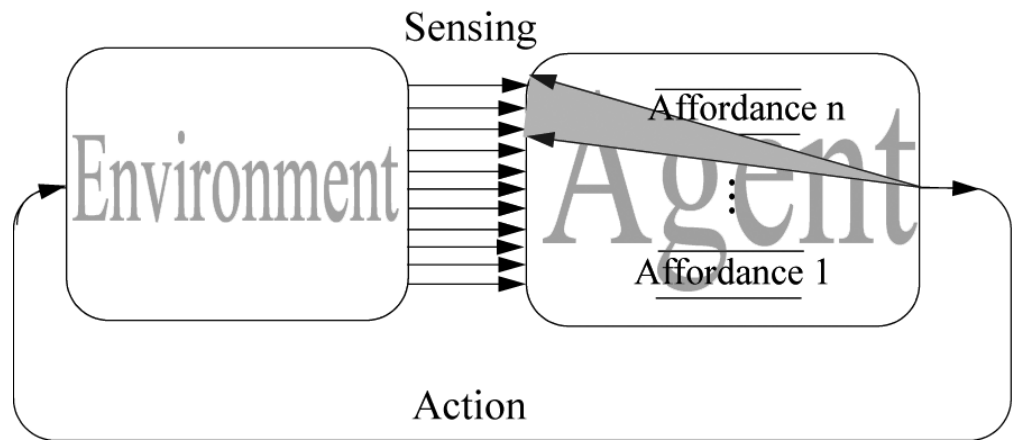
This paper is organised as follows. In Section 2 the three prevailing paradigms and their implications for design are introduced. Section 3 elaborates on the common coding theory, its biological background and its implications for design of movement and social interaction. Section 4 summarises the main conclusions and suggests a road for further work.

2 Views on perception-action interplay and implications for movement design

The commonly accepted views on perception-action interplay yield different paradigms and settings for accomplishment of a movement. During more than a century of research few major views on the interaction between perception and action have been suggested. They can be divided into three groups, depending on the determining factor in this interaction. Historically first comes the understanding that perception precedes and may provoke an action; a different view suggests

¹ As an agent is understood any object or subject that can express own behaviour; e.g. human, animal, or animat.

Fig. 2. The selection view suggests that any integrated action requires selection of relevant environmental (sensory) information. This sensory information is enhanced by the "right" perception by a top-down mechanism. Action selection is determined by affordances with different complexity.



that actions determine our perceptions; recently more evidence suggests the perception-action unity. The Information-processing view on the perception-action interplay postulates that perception precedes action. Even though it has been established more than a century ago by Donders [5] it remains to be a widely accepted methodological strategy for decomposing the stream of processing between stimulus presentation and response generation into a number of stages: first, perception is acquired, followed by an internal representations and processing, eventually causing an action. There is not a direct way in which actions and perceptions could interact, but through the environment. This view suggests that to design an embodied movement one has to go through stages of sensing, processing, and representing in a subsequent manner. Since a direct backward coupling between action and perception is lacking, the embodied design of moving agents is not intrinsically promoted. Figure 1 represents schematically this view.

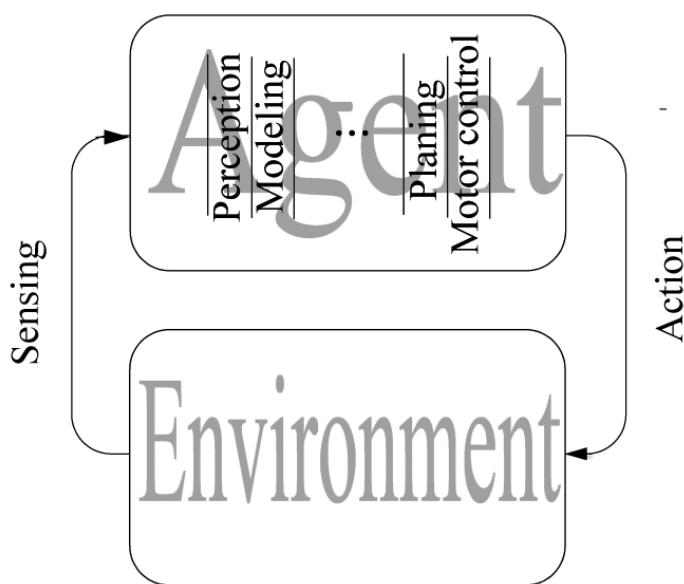


Fig. 1. Information processing view facilitates design of movements, actions, and behaviors as a linear system. The direct feedback link from action to perception is not possible.

On the contrary, Selection view advocates that actions determine our perceptions. Attention mechanisms account for various limitations observed in human performance. Thus, they are assumed to enhance or to inhibit the activity in the various streams and at various stages in the flow of information. The basic principle behind this view is that any integrated action requires selection of action-relevant aspects of environmental information, and at the same time ignore or reject the non-relevant aspects. For instance, we can think of our visual system as a gigantic hand that "palpates" the needed part of a visual scene. Gibson [6], Clancey [3], and Shaw and Todd [19] emphasize this relation between action and perception and regard the perception of things as a function of actions they afford. The metaphor of 'affordance' accounts for the direct link between perception and action, but still the action or the affordance for an action remains the determining factor. The selection view is represented in Figure 2.

The advantages and limitations of this approach are already explicit in its definition: perceiving affordances in the environment means that perception as filtered through the individual capabilities for physical action and through the current goals or intentions. This leads to the advantage to couple perception and action deep down in the sensorimotor control loop, providing an action-oriented interpretation of percepts in real time. In addition, affordances provide on a high granularity level a basis for agent interaction and for learning or adapting context-dependent, goal-directed action. However, the perception is filtered and restricted through an immediate action; in a real life scenario this filtering can bring to a very distorted and single-sided choice. Besides, the lack of representation (see Figure 2) is not a realistic assumption and certainly can not account for all cases of perception. In addition, although the selection view builds on the existence of a strong link between perception and action, it does not assume a reciprocal unity between perception and action, because it does not go further than taking a "black box" interpretation of the agent.

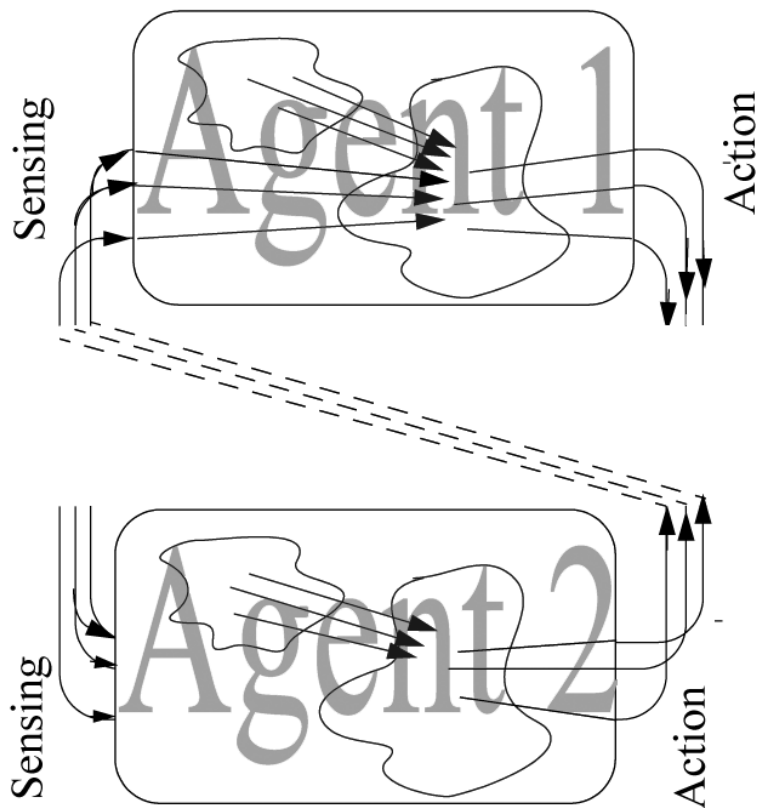


Fig. 3. The common coding theory shows that sensing and action activate the same internal representations. Moreover they can be activated by endogenous factors. If Agent 2 expresses an action the activation as by an own action will take place by the observing Agent 1.

While the information-processing view was unable to explain perception in many cases related to direct action, the selection view and Gibson's notion of direct perception failed to explain another group of phenomena like memory and imagination that can certainly originate an action by themselves. To address this problem, Neisser proposed an alternative which captures aspects of both approaches [13]. Based on neurological and cognitive studies, he proposes that there are two biological perceptual systems, one for direct perception and one for recognition. The direct perception system evolved earlier and explains Gibsonian phenomena. The recognition system developed later in evolution and uses memory, complex representations, and inference to distinguish instances of objects which have a semantic content. Neisser's view of direct perception and recognition as distinct perceptual systems has important ramifications for design of moving agents. It suggests that affordances will not be suitable for all behaviours. It also can be interpreted as suggesting that traditional

model-based techniques are appropriate for recognition-style perception. However, his analysis can be an origin of a hybrid approach that somehow should combine the positive aspects of the two theories. Although more realistic, the approach based on Neisser's view will not bring a compendious approach to design. An alternative direction is implied in the work of Shepard [20]. He suggests a way toward opening the "black box" in the Gibsonian approach. Shepard argued that, as a result of biological evolution and individual learning, the organism is tuned to resonate to the incoming patterns that correspond to the invariants that are significant for it. These patterns, according to Shepard, have become most deeply internalized (i.e., represented), and even in the complete absence of external information, the system can be excited entirely from within (e.g., while imagining). Thus, unlike Gibson, Shepard makes an explicit reference to internal representations and makes it possible to articulate the notion of resonance with that of motor representations.

The Common coding theory postulates real parity between perception and action [14]. Its core assumption is that actions are coded in terms of the perceivable effects (i.e. the distal perceptual events) that they should generate [11][12]. A growing body of behavioural and neurophysiological studies supports this theory. As a first evidence for a direct matching between action perception and action execution came the discovery of 'mirror neurons' in the ventral premotor cortex of the macaque monkey [15][16][17]. Mirror neurons fire both when monkey carries out a goal-directed action and when it observes the same action performed by another individual [18], i.e. the perception and the action are likely coded in the same way, by the same structure. More recently, it was found that a subset of these mirror neurons also respond when the final part of a previously seen action is hidden and can only be inferred [21]. Therefore, the observation of an action activates action representations to the degree that the perceived action and the represented action are similar [12]. Moreover, specific neurons in this region respond to the representation of an action rather than to the action itself. Further reasoning infers that observed, executed, and imagined actions are represented in a common code (Figure 3). Better understanding of this code will give insights not only for the nature of action and perceptual representations, but also gives a very efficient and novel way of designing actions that will not avoid any aspect of the perception, and still rely on a single design concept.

3 From movement to meaning and social interaction

The importance of motor patterns in the development of concept formation has long been elaborated. Not only making sense of the environment, but interacting with it has its roots in sensorimotor learning. The production of purposeful, goal-directed movement pervades all human activity like walking, grasping, typing, sports, dance, etc. Speech is also intrinsically a motor act. On a deeper cognitive level, eye movements, and body language go together as a subtle expression of complex mental processes. Besides the obvious involvements, movement as a part of the sensorimotor process underlies cognition and social interaction. Indeed, the human brain has evolved for governing motor activity with the basic function to transform sensory patterns into patterns of motor coordination. The reaction to changing environment is the first functionality that is mastered in human development.

By studying conscious motor imagery in humans, it has been shown that it is possible to access the action representation [10]. Motor imagery, which is thought to involve the activation of internal models of action, can be considered a first-person process of the participant "seeing" the execution of own action. A motor image is therefore an equivalent to a prediction for that action. Recently, Voss et al. have shown that internal model prediction occurs even in the absence of movement [22]. Therefore, due to common representation and internal simulations we are able to anticipate the consequences of our own actions, be conscious of and able to control our mental states.

Since the perception of an action can reflect the behaviour of a conspecific, the common representation and internal simulations are not necessarily directed to our own actions. Mirror neurons, found in ventral premotor cortex of macaque monkeys, are activated both when the monkey executes grasping actions and when it observes someone else (or another monkey) making grasping actions [8]. Following the discovery of mirror neurons in monkeys, there is increasing evidence that a large proportion of the human motor system is activated by the mere observation of an action [17]. In addition, observing an action affects the peripheral motor system in the specific muscles that are used in the action being observed [9]. Observing another person's actions also influences one's own ongoing movements. Recent evidence suggests that observing an action interferes with one's own actions when these are different from the observed actions [1][2].

4 Discussion

The three sensorimotor paradigms provide different possibilities for design of movements. The Information processing paradigm facilitates design of movements, actions, and behaviors as a linear step by step process. The direct feedback link from action to perception is not possible, therefore the embodied, and especially interactive behaviors are difficult to design. The Selection paradigm, based on the notion of affordances makes it possible to implement embodied movements and actions. However, movement interaction and prediction of its own actions are not intrinsic to this paradigm. The Common coding paradigm that accounts for a realistic unity of the perception-action process is shown to have the highest potential for design. Not only movement but also higher motor cognition behaviours

are within its reach, since a system that can predict its own actions can also be controlling them. Moreover, the social interaction patterns can naturally be represented within this paradigm.

Important questions for designing a movement lies in the respective computational role of each brain area that subserves the internal simulations and shared representations between self and others, as well as in a better description of what precise aspects of an action are actually represented. The temporal distribution of these representations is also likely to help understanding various mechanisms that in its nature are acts of motor cognition.

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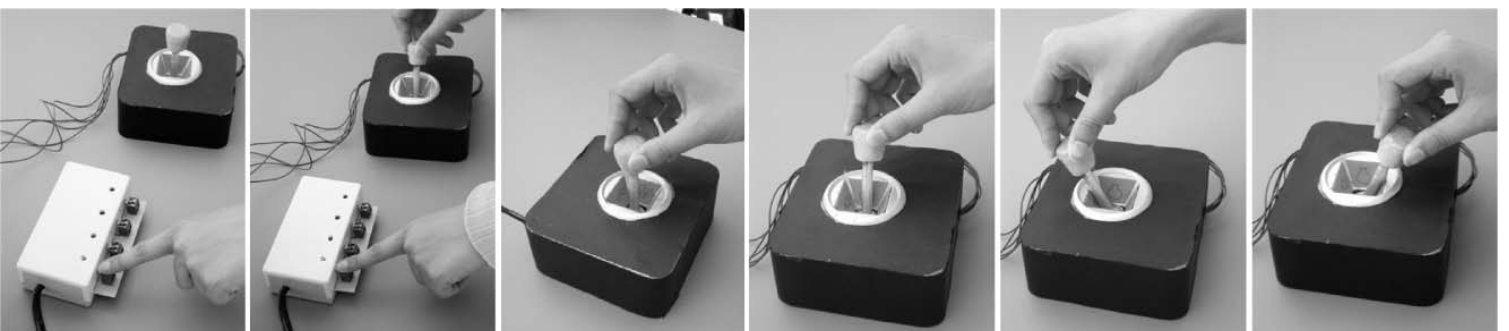
Designing tangible user interface for configuration practices

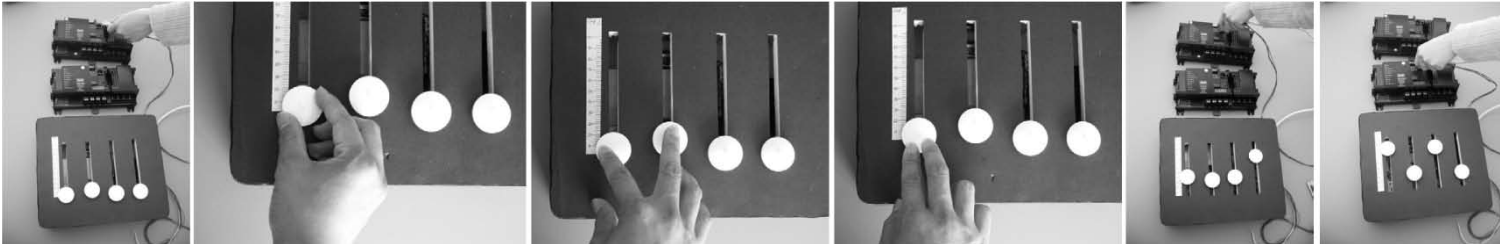
Abstract

In this demo paper, we present a project in which we explored interactional possibilities for designing a tangible configuration interface as an alternative to conventional input devices in the field of industrial refrigeration maintenance. Based on several ethnographic field studies and design workshops, we built three prototypes of three configuration interfaces. Each interface was built and used to explore issues that are dealt by users in their everyday work practice, namely manipulation of digital values, collaboration for effective configuration, and transparency of configuration.

The Pointer

In designing The Pointer, we were interested to investigate the qualities of a physical interface that support the collaborative aspect of configuration. It is designed so that the system controller can mediate two-person operation that can take place in two points of interaction: the controller and the joystick. The reason behind for having two points interaction is that often the controller and the configuration software are separated, located in two different places. The gap between the controller and the software makes it difficult for the technician to go back and forth in between. The Pointer in this sense allows the configuration duets, which consist of the assigner (the one who points) and the adjuster (the one who toggles using the joystick) to collaborate together in configuring the system, resulting in an effective and efficient process.

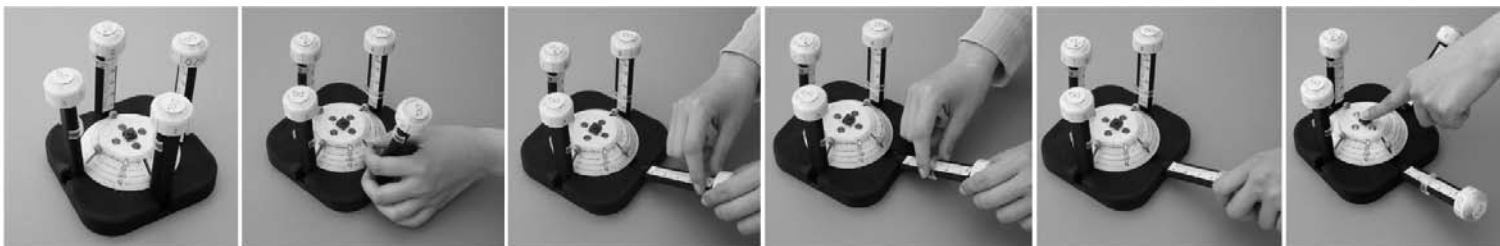




The Tuning Board

The Tuning Board is designed to investigate the possibility of physical interface as a device to configure interdependent and fluent values. In this case, rather than keying in a range of numbers, or using a mouse to scroll through a list of numbers, the user is able to adjust the value settings using a row of parameter sliders. With the Tuning Board, the need for both accurate adjusting

and comparison across specific parameters is solved by providing the user with four sliders, which allow users to organize relevant parameters that they need to compare across, or monitor for various kinds of situations. This configuration interface also nurtures the development of skills to organize various ways to configure (organizing which parameters should be interdependently configured, compared, and monitored).



The Compass

When designing The Compass, we focused on the need to make visible the performance and meaning of configuration actions. In order to do this we considered the space for body movement that seems to be constricted in by the current software application. By unfolding the layered and bulky configuration software into a spatially opened interface, we aim to support users in expressively perform the assigning, manipulating and re-adjusting of configurable parameters. The shape of the Compass guides the user in several different ways.

Before doing any configuration, the levers of the Compass are standing vertically on the base. In this state, the functions on the base become the center of perception. The movement of the hardware-chooser towards the lever guides the user to lower it and thus discover the capacity slider and its scale. The user can then configure the capacity of each hardware, which then guides him to locate a knob for sub-parameter of the hardware that can be configured at the end of the lever, for example the number of unloaders for a compressor.

Productality – Exploring how to create perceived personality in products

Abstract

Existing research into product personality, referred to in this paper as ‘productality,’ resides in the aesthetics or visual language of a product. However, by looking at human personality, in particular, relationships between people, inspired by movement, body language and gestures, we believe this will improve interaction, hence the user and product relationship. The behaviour of products can be designed to influence the perceived ‘productality’, thus fostering the way that we generate memorable experiences of products.

This paper is a positional statement by the Centre for Design Research concerning its current thinking about ‘productality’. It is written half-way through a year-long programme of explorative action research based on a review of literature and a cycle of two design projects developing and using new tools and techniques, where we hypothesise that encouraging rituals of use within a suitable context for products will enhance the experience and bond between user product and brand.

Keywords

Explorative Design Research, Flow, Concepts of Self, Philips, Personality, Product, Tools & Techniques

I Introduction

1.1 Background

There is a wide variety of literature related to user response to product appearance [1] but almost all of it is found to have some potential relevance to human perception of products. In this field Crilly reported that excellent work that was carried out by Crozier [2], Bloch [3], Mono [4] and Coates [5] offered new theories to understand how product design influences user response

but they have not been put into practice or reviewed in relation to existing work. Hence Crilly’s conclusion that literature has not been connected even when the ideas are complementary, and succeeding work has not properly referenced preceding thinking. This has led to the absence of a comprehensive literature review and models and frameworks have not been integrated to form a general and coherent perspective. There are other areas of research that appreciate the importance of growing the knowledge base within the area of design oriented product/user interface. For example, in the field of HCI, represented by the CHI conference series and there is a growing interest in making user interface design thinking more mainstream [6].

It is against this backdrop of incoherence and emergence that Northumbria University (NU), Centre for Design Research (CfDR), sponsored by Philips Design BV Eindhoven, has progressed its action research based on explorative design practice, to improve the quality and experience of users’ interaction with consumer electronic products. Also, that the collaborative research interests of NU CfDR, Philips and the Technical University of Eindhoven have developed over the last two years. The CfDR and the authors of this paper feel that the DeSForM conference acts as a showcase for this and other contemporary research being carried out concerning the interaction of people with electronic products. An important characteristic of much of the work presented at the first DeSForM conference was the explorative, empirical and practice-based nature of it. This work can be seen as a sincere attempt to address the situation described by Crilly et al, where theories have not been put into practice. However, the methodological basis of such work is that it is not theory driven but practice based to derive knowledge to support design practice,

which may then lead on to the establishment of appropriate theory.

In his book, 'The New Everyday', Stefano Marzano states: 'Within the next decade, we may find that any non-intelligent interactive objects or systems around us have been replaced by almost invisible, intelligent interactive systems – an 'Ambient Intelligence' that could soon form a natural part of our everyday lives' [7]. He also proposed that the challenge for designers, and everyone is to discover the new relevant qualities that products and services will need to have if they are to fulfil the aspirations and dreams of those who use them.' This challenge addresses the need for meaning and purpose in life, which is again, common to everyone, the only difference is, as Barlow stated; that technology changes the way it gets gratified [8].

1.2 Ambient Technology and Product Personality

The miniaturisation of technology now means that a product's form no longer needs to follow its function. Philips have long since recognised that design of the interaction between a user and the product is becoming increasingly important [9] and this is driving the collaborative research between Philips Design and the CfDR, which is the subject of this paper. When there are fewer constraints set by technology, the designer has greater freedom to create empathic modes of interaction and dictate the tangible elements of product/system interface [10].

Govers' 'Sample project: Product Personality', 2006 at TU Delft [11], examined the potential of defining the aesthetics of product personality using twenty human personality characteristics and concluded that there is no definition. Govers and Schoorman stated that it is 'that part of the symbolic meaning that refers to the physical product itself, and is described with human personality characteristics' [12]. Their discussion of product personality involves identifying products as symbols through an individual statement about the concept of self. The self-concept encompasses 'all ideas one has about oneself' [13]. Govers & Schoorman's hypothesised that as similar personalities are attracted to each other and the notion of opposites attracting is not a certainty, consumers are attracted to a product with a perceived visual product personality to match that of his or her own self-concept.

The importance of the self-concept encompassing all ideas of oneself is paramount because the once

commonly held view that our personalities have a single, stable 'Self' is being questioned. Kozlov described what ambient intelligence needs to understand about human personality: 'Personality is now seen not as a one-dimensional entity consisting of a core Self, but rather as a product of ongoing 'dialogues' between many 'I-positions', or narrating voices, which together make up our identity' [14]. He explained that each of these I-positions is characterized by a different set of attachments – to our body, to people, objects, events past memories and future plans. I-positions have their own life-stories, their own value systems and ways of acting them out [15]. Modern self-narrating strategies are actually stories that are not only told by many different I-positions, but the I-positions can relate to different value systems, so we can no longer talk about the value system of an individual but the existence of multiple and often conflicting systems within one personality. Such I-positions, or sub-identities, evolve over time, being shaped throughout our lives, in response to physical, cultural and social contexts.

1.3 Ambient Intelligence, Concepts of Self and Behaviour

This description of personality infers that to be able to respond to people sensitively, designers of Ambient Intelligence systems, including interactive products, need to consider the complexity of personalities based on a model of the multiple Self. At the simplest level of understanding; an individual can exhibit varying behaviours and 'voices' at different times and this should infer that the design of a system that can recognise such differences and react accordingly. Kozlov believes that; '...the manifestations, or enactments, of these I-positions may be more strongly evident in some contexts than in others. Contextual triggers may be spatial (different 'heres') temporal (various 'nows'), interactions with people (real or imaginary), or social institutions (rules, roles, rituals, etc.)' [16].

Whilst personalities can be seen as complex to consider, our first impressions of people can also be misleading because they might infer behaviour to the onlooker. An unshaven person may well give the impression that their behaviour is to not take pride in their appearance. Likewise, the appearance of an object can be misleading. The train designed by Raymond Loewy that looked really fast was, in fact, no faster than any other train [17]. Behaviour is shaped by innateness and experience [18]. At the moment, most products have closed behaviours, rigid and not easily modified by experience. Open

behaviour products have an innate (inbuilt) way of reacting, but are flexible and easily altered through learning. The Sony Aibo dog is one of very few products that have this inbuilt and adaptive way of reacting within a product. Aibo is given 'a puppy-like personality that develops as it is played with.' [19]. Interaction between a user and an object might also be classed as intelligent or unintelligent. The difference between these two is not in the intelligence of the object, but that of the interaction. 'We discover intelligence not in things (be they machines or animals) but in our interaction with them.' [20].

1.4 Previous work at the Centre for Design Research (CfDR)

The direction of the project described in this paper has been influenced by previous research in the CfDR to understand ways in which the characteristics and qualities of movement could be designed into products to promote greater empathy with users. The hypothesis of that work stated that 'introducing designed physical movements will enrich product behaviour' [21]. The intention of this project is to investigate the interactive element of product personality using the previously derived knowledge of designing with motion. An important point of emphasis of the work was that 'objects can't represent emotions in themselves; rather a person can experience emotion as a response to the combination of the static and dynamic ambience of the product. The user projects a persona onto the object and then anticipates a corresponding behaviour' [22].

Following a review of the previous research, the CfDR and Philips decided that the new direction of its collaborative research was to consider aspects of user perception and interaction on a broader polysensorial nature. The focus for this project was to investigate how brand personality might be portrayed through a perceived product personality. Philips naturally acted as the brand subject to contextualise the research.

Our methodology of approaching this research again referred to the tried and tested precedent of the previous work in the CfDR. We adopted an explorative action research method based on the continuous cycle of planning (including literature review), acting (design practice), evaluation (independent peer review) and reflection (correlating review feedback and on-going reflection with other literature). This research attempts to address a specific issue in the gap in knowledge identified by Crilly [23] by looking at it from the design

practitioner's perspective, rather than from a theory-based perspective to develop a theoretical model. It combines theoretical literature and case studies of design practice to derive tools and techniques and to identify robust strategies for their application in future project contexts by other design practitioners and researchers.

2 Branding through Product Personality

Traditional industrial design relies on marketing and branding to launch successful products. Branding used to be obvious. A company could stamp a symbol or logo onto the surface of its products but when products and technologies are becoming increasingly ambient, embedded or invisible, a new experience of the brand becomes necessary for companies to be seen to offer value [24]. We decided that we needed to investigate both brand personality and human personality as a starting point for our research to establish grounding in the subject matter. The expectation of our research is that understanding how to create desired anticipated behaviour might allow the designer to control the desired emotional outcome.

2.1 Understanding Human Personality

At this stage of our work we did not see a logical order in which to study brand personality and product personality or the nature of their relationship to the user. To understand product personality, the components that make up human personality must be made explicit. In the first instance, our project team, brainstormed the differences between emotion and personality and soon realised that emotions were just one of the many factors built into personality. We investigated various definitions of personality that use methods of differentiation and modelling and rely on natural inclination of personality types to behave and think in certain ways, e.g.: Myers Briggs [25], Eysenck [26] and the Big 5 [27]. However, as explained in 1.3, the complexity of human personality is such that we needed to simplify the scope of our study in its application to product personality to make it practicable. By researching different definitions that describe the components of human personality, we limited the study to key factors of; emotion, behaviour, appearance, habits and temperament [28].

2.2 Identifying Philips Brand Personality Traits

In order to begin to correlate human personality

definitions and characteristics with brand personality traits, we undertook a comparative analysis of where the Philips brand sits in the consumer market along with five other leading brands including B&O, Sony, Apple, Samsung and Alessi. The objective of this was to determine the unique factors that Philips has embodied in their company. After brainstorming the context of each of the companies, we came up with six personality traits that we thought summed up the Philips personality. These were Caring, Reliable, Under-standing, Supportive, Efficient and Playful. A review of these with the project design team at Philips showed that these traits were considered accurate from both its per-spective and the original market strategy statement of the company [29]. We then developed scenario mood boards around; 'what if Philips was a nurse or a butler', as a way to express the Philips personality, so we could see if the Philips personality could be used in a flexible manner.

Later on in our research we revised our thinking, on the basis that consumers prefer products that are similar to that of their own selfconcept (see section 1.2) the project team decided that 'productality' should be designed around the user rather than a company's brand personality traits. This does not mean that a company will not be able to develop or reinforce a brand character, simply that the starting premise should be based around the user. Naturally, the manner in which this is done ought to consider and reinforce the brand character, where possible.

2.3 Human & Product Personality Comparison – Notes on Language

In order to advance the study of product personality, we could not presume that it holds the same components that build up human personality. To remove preconceptions that might arise from the term; product personality, we decided that we needed to rename it as 'productality', which is how it is referred to throughout this paper. 'Productality' is the conjoined term of product and personality. Its conceptual defini-tion is that it should encompass all the factors in a product that provide it with character and behaviour including visual appearance and physical interactions. Further dis-tinctions were made between the language associated with people and products using less pejorative terms. Rather than human appearance we would use 'Product Aesthet-ics'. Personality trait could be referred to in product language as 'Productality Attrib-ute' and human behaviour extremes as 'Product Behaviour Limits'.

2.4 Ontology of User-Product Interaction

In the same way that a product cannot experience an emotion, a product cannot develop habits or portray temperaments; rather they are implemented through the innate behaviour designed into that product to be perceived by people as appropriate.

'The distinction ... is between syntax and semantics. For a machine, all that mat-ters is syntax. The meaning does not matter ... all that matters is the form and capacity to change that form into another form. For humans, what matters is not the syntax but the semantics, the meaning, what lies inside. Even if machines are able to imitate humans perfectly, it is unlikely, we think, that they will have a concept of semantics in a way that human beings do. Meaning lies not in our heads or in the structure of our language or in the structure of our problem solving capacities. Meaning lies in the social world. It is the social world that imputes things and phenomena with meaning. And in so far as machines don't live in a social world, they cannot have meaning' [30].

We decided to refer the components of 'productality' therefore to behaviour, where behaviour is 'the action or reaction of [or to] something' [31]. We need to understand how product behaviour might enhance an experience and how this experience might determine the relationship between user and product. Personality might be defined as the constant character that is formed over time [32] and we must therefore look at 'productality' in the same way as use over time. Take an old car for example. The owner might be the only person who knows its 'perceived temperament' on ignition hence a certain bond is formed.

3 Reviewing & Evolving Previous Work

The CfDR's previous work noted that industrial design practice uses many tools and techniques that facilitate the process of designing and communicating designs to oth-ers, e.g.: 2D sketching, CAD modelling or 3D soft and hard modelling [33]. These tools and techniques are taught to practitioners worldwide in their education and pro-fessional training. The previous research developed concepts, tools and techniques to enable the design of movement through one-way interaction of products. Our re-search reviewed and assimilated these in the context of designing two-way interaction involving the input from the user and the behaviour of product. The outcomes for each are explained below.

3.1 Qualities of Movement

Reviewing the previous work helped us to familiarise ourselves with the issues involved when deliberately designing a movement rather than movement arising as a by-product of the design process. We decided to take a step on from that body of work, by investigating and analysing the qualities that can make a movement appear to have character. We drew up a matrix of existing products that contain movement and analysed our perceptions of them in terms of the function, compared to their tactility, sound, visual character and emotional cues. We noticed that one particular CD player looked like it was giving the CD gracefully rather than ejecting it. We noted through our observations that a 'gesture-like' movement suggested more character than a purely mechanical-like movement.

We associate some gestures with certain meanings. For example, an up and down movement at the top of a form could, if designed correctly, look as though it is nodding. We filmed ourselves product miming, where we performed a certain gesture associated with a certain product, such as using a computer mouse but without the mouse. From this we learned that we associate certain gestures with certain products. The gesture is perceived as intrinsic to its use. This realisation raised the question; could a motion, which contains a gesture, represent the Philips brand or can it only associate with a certain type of product?

3.2 Motion Mood Boards

A motion mood board [34] is a compilation of movies that can be strung together in much the same way as a mood board in traditional industrial design. In order to ascertain gestures and features that we, as the project team, believed were discernible to each of the Philips brand traits, a series of motion mood boards were compiled and tested with a sample of users to determine whether or not the viewpoints of the CfDR research team aligned with a greater number of people. It was found that the more obvious traits such as caring and playful were better communicated and the viewpoints of both the user sample and the CfDR research team aligned with these traits. This discovery led us to concentrate the traits down to three: Caring, Playful and Understanding, because they appeared to be the most promising for furthering the study, given that the project also needed to keep within a manageable scope of work.

Analysing the reasons for the selection of certain traits,

given by the sample of users, it was established that the context or scenario relating to a gesture are important to portray a desired message. For example, where a nod of the head had been used to represent an 'understanding' trait, one user commented that to them they thought it represented 'caring' as the person doing the nodding was an air hostess.

3.3 4D Sketching

4D sketching is a process of communicating thoughts using rapid model making techniques for quick testing and analysis. Within the context of our project, we have adopted methods of two-way interaction within 4D sketching at the same time as simulating movement and product behaviour. Figure 1 shows stills of some 4D sketches within our design process. The inclusion of two-way interaction requires that the sketch models are sturdier than might have been necessary for one-way interaction because tactility is required to communicate feedback to the user. This also adds to the difficulty of simulating movement, as timing is fundamental.



Fig. 1. Stills of 4D Sketches of the Beard Trimmer; the caring 'productivity' of the beard trimmer prevents an uncomfortable shaving experience

4 Inspiration

It was important for us to learn from the findings of previous CfDR research explorations into different tertiary disciplines such as puppetry, acting and choreography [35] as well as investigate complementary disciplines and sources of inspiration for ourselves.

4.1 Animation Methods

We developed a case study using animation methods that focus on how the story is created rather than the finished product. When a sketch or model is animated it can appear to have a personality. Animators get into the world of their characters, such as in a 'Bugs Life' [36], where they literally crouched amongst the plants to get a feel for the

environment. They tailor the environment to influence what you believe the characters are doing and feeling. For example: with 'Finding Nemo' [37], the sea was designed to suit the character. Of course this is something that we are unable to do as designers of interactive products because we can never present a product in a fixed scenario. Instead, we must attempt to anticipate the intended context(s).

The first scene in a movie sets the tone of the film [38] and the last leaves a lasting impression. To relate this to the work that we are doing, we used the notion that rather than the first and last scene, it should be the first and last interaction with the product that should be considered important.

Animators use exaggerated gestures to get their point across instantly. Therefore, we looked into gestures [39] and filmed ourselves gesturing to the video camera and then watched the footage to see what they meant to us. This showed the project team that gestures can be recognised universally as well as out of context. However, we became aware of the impact that facial expression communicates as well as the importance of the relative positions of gesture to body.

4.2 Ceremony as a Way to Enrich Interaction

We then decided to explore ways in which we might increase the empathy of users with the product/brand. We conjectured that if we could create a product that would behave in different ways according to the scenario, perhaps the user's relationship with the product would improve, hence their recollection of the experience of it. Our collaborators at Philips posed the challenge that a coffee maker used on a Monday morning in the kitchen when someone is in a hurry might need to be very different from one used on a Saturday night in the living room with friends [40][41]. To investigate this challenge, we put motion mood boards together of people setting a table and serving, which helped us to see the importance of detail and appropriateness to detail, dictated by the characteristics of the context. For example, it would be inappropriate to use a silver tray on which to serve a paper cup.

To study the importance of context to ceremony, we sent emails to everyone in the CfDR asking them about their daily routines and rituals, which showed how the smallest of tasks could mean very different things to different people. For some, the routine of taking a shower involved the process of laying out ones clothes, turning on the tap

and letting the water heat up, while for others; it was the way in which they used their shampoo and conditioner. This suggests the importance of allowing the user to tailor their own experience by providing innate capabilities that might be adopted in different ways as personal ceremonies and rituals. Slow theory [42] discusses that the user might continue to design or redesign new experiences and therefore encourage a more intense relationship between themselves and the product.

A ceremony might offer suggestions to the designer that would otherwise be over-looked; for example, in the way we lay a table, could metaphors from this ceremony be used to encourage the way we set up a product? 'Cutlery and crockery encourage you to use them in a ceremonious way' [43]; it is how we go about detailing this ceremony and its affordance to each scenario that will develop the experience.

4.3 Enhancing Interactions Using Associations

Using associations as a method of design can help to bridge the gap between new experiences and known experiences. With the project undertaken by our team to design an iron, the association of creating fire using two sticks was used as a method for designing the interaction of heating up (see figure 4). In the same way that the previous work in the CfDR relied on associations; so that 'if a person understands the form and it is not 'alien' then they tend to be able to move on and understand a motion' [44] an association might provide known interactions. Our study concluded that too many unknowns might inhibit the user's enjoyable experience of interaction with a product. A gesture might use associations in a way to convey a required meaning. This might be taken forward as a recognised gesture within Philips products when a product requires that it be heated up, however, there are many contextual factors that can affect understanding of the connotation of a gesture.

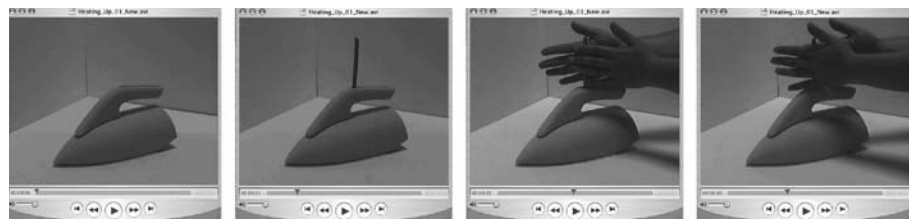


Fig. 2. Iron heating rod and use

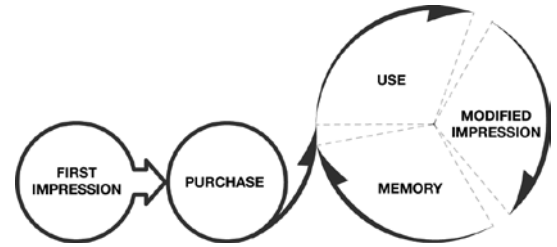


Fig. 3. Use – Modified Impression – Memory Cycle

5 Towards a Definition of Productivity

We realised that there were various elements we needed to investigate in order to move towards a definition of ‘productivity’, and the requirement to move beyond visual aesthetics. The research problem space or design solution space, which we are exploring, concerns most of what might be referred to as ‘non-functional requirements’. As with any product, there will be certain core functions and others that are peripheral. For example: a functional requirement might be that the iron needs to provide steam. The non-functional requirement might be how this steam is released by a button that is perhaps spherical, square or by some other interface.

We found it necessary to define the functional requirements clearly from the start in order to organise, prepare and focus our creative abilities on how each function might behave using our analysis of the non-functional. In this respect, the functional might be described as ‘what’ is being designed. Each design project is then made distinctive through the use of the non-functional requirements, or ‘how’ the design is implemented. We have looked at the ‘how’ and understood the ‘what’ as a given.

5.1 Beyond the Visual

Aesthetic, semantic and symbolic meanings in design are complex in their relation to the senses, the context and the consumer’s responses [45]. First impressions form a large part in the associated character that we give to ‘things’ and the impression is largely based on visual data. However, product personality is not just about visual perception. The entirety of the user’s experience of the product from first impressions to the point of the last interaction should be considered.

The concept of the evolution of user perception over time was described by Gavin Proctor of Philips as: First Impression - Purchase - Use – Modified Impression – Memory, and then: Use – Modified Impression – Memory, etc. The interrelationship between Use – Modified Impression & Memory is important here; if we can enhance this cycle and provide an object with behavioural capabilities that the user gets to know, then ‘productivity’ might be instigated (see figure 2). The requirement to support sustainable business for an interactive product manufacturer is that the modifying impression becomes catalytic to a virtuous cycle not a regressive one in terms of user experience.

Through our research we have formed a ‘productivity’ diagram, a process model of work in progress that evolves as we continue to learn more about the problem space (see figure 3). This has used a generic concept of Philip’s products. It flows top to bottom and begins when ‘First impressions’ are formed, based on an assumed character of how the product will behave. Further assumptions are made after first contact (interaction e.g.: first touch) with the object. Judgements are formed over time as the user gets to know how the product will respond to their interaction and behaviour. If this process is followed faithfully it is expected that it will enhance the user’s experience and the perceived ‘productivity’ of the object.

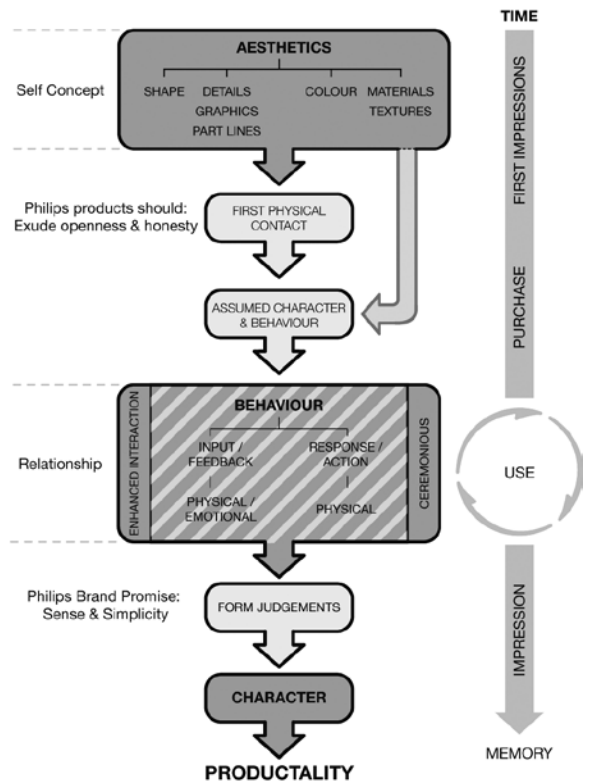


Fig. 4. ‘Productivity’ Diagram

6 Developing New Tools and Techniques

A main target of our research has not only been to understand and investigate ‘productivity’ behaviour and interaction with a product but also to devise a method that could be used by other designers to assist them in

a similar process. This is important in order to establish the replicability and therefore the reliability of our research. The process of development of worksheets and diagrams, which is described here, have been used to plan, design, record, evaluate and reflect upon the action research process of our explorative design practice. These methods therefore help to bridge the gap between theory and practice in the design process. Two action research cycles or concept projects have been completed to date: an iron and a beard trimmer. Each project informs the next with findings and deductions, which enables the progression of the investigation. This explorative design research has been based on a reflective practice methodology, which means that the development of the design projects have been the vehicle for simultaneous development and refinement of the 'productivity' design methods model and its diagrammatic representation. Reflecting and portraying these findings in order to determine what is of value and worthy of taking forward is part of the challenge of the project. We anticipate that as we learn more from our research, the nature of the new tools and techniques we are deriving will be changed or refined.

6.1 Initial Design Process

Initially we planned to directly apply the Philips brand traits or 'Productivity Attributes' to each designed feature (see figure 5). For example, with the iron when we tried to design a way of filling the water, we might have designed it in a caring, understanding or playful way and the most effective concept would then be taken forward. However, we soon realised that this method of designing, which we referred to as 'designing by numbers' constrained our creative abilities because it was too linear and would therefore not appeal to design practitioners.

6.2 Evolution of the Behaviour and Interaction Diagram

We realised that it is important to be aware of the limits of the products' behaviour, in order to ascertain the level of response that an object is giving within these limits at any one time. For example, it is rare that we use a car to its extremes, for example driving as fast as it can go. However, if we impel that car to its maximum limit, we are made fully aware of its capabilities and therefore able to gauge the level at which we are pushing the car at any one time. A similar theory developed by the previous CfDR team was known as 'freedoms of movement'. This theory was used to provide 'an understanding of what range of movements an object is capable of performing' [46]. We started out with the idea of applying levels of response to each functional requirement. For example, with the iron, there were different levels of 'thirst' to indicate the amount of water in the tank. By looking at both the input and output, we could start to see a pattern developing between user interaction and product response. Figures 6 and 7 show the evolution of the diagrams over the two project stages to date. Figure 6 (versions 1 and 2) of the diagram were adopted and developed with the iron then further developed to figure 7 (version 3) with the beard trimmer. The main divergence into the latest diagram (figure 7, version 3) is the incorporation of physical and emotional interaction as well as feedback, and development of the thinking behind how other related products, for example the ironing board to the iron or the charging dock to the beard trimmer, have been incorporated.

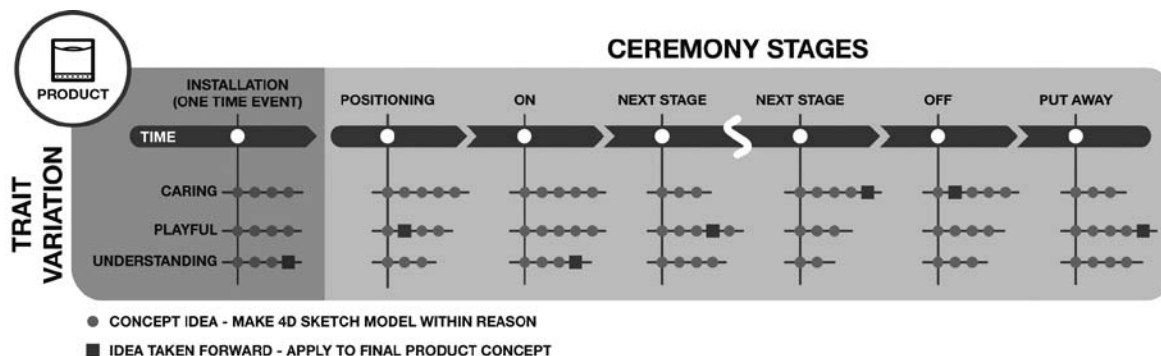


Fig. 5. First design tool to adopt the Philips brand personality as part of the design process

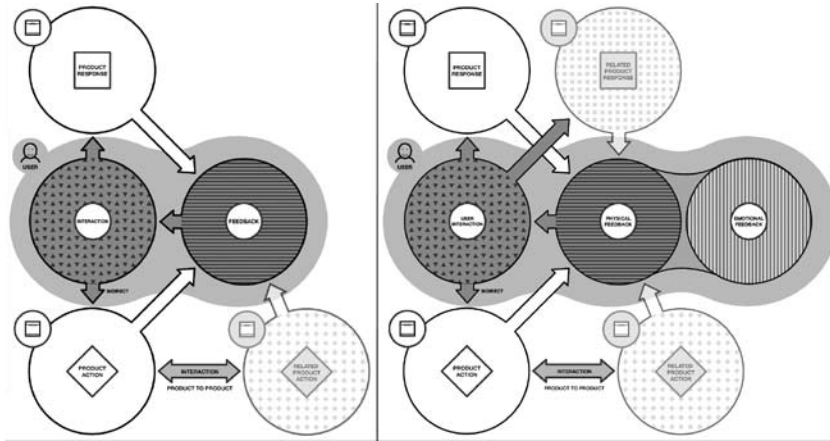


Fig. 6. Left: Behaviour & Interaction Diagram Version 1
Right: Behaviour & Interaction Diagram Version 2

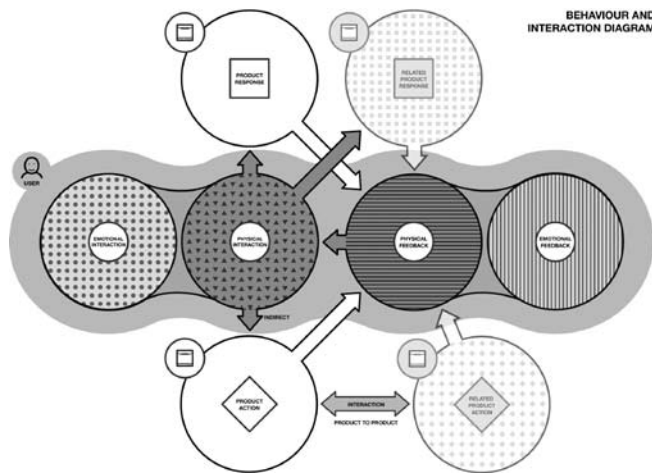


Fig. 7. Behaviour & Interaction Diagram Version 3

6.3 Explaining the Behaviour & Interaction Diagram (Figure 7, Version 3)

Within the behaviour and interaction diagram there are various definitions that need to be detailed. The four inner circles represent the user input and the user feedback. Each of these is split into emotional and physical. These will be explained using the example of switching a product on or off:

User Interaction: The physical interaction is the literal 'pushing of the button'; the emotional interaction might be 'the manner in which that button is pushed'. This is because our belief is that the emotional state manifests itself in a physical manner. For example the emotional state of feeling angry might be manifested in a hard push of the button.

User Feedback: The physical feedback from the product to the user will be that the device is on or off and if applicable on or off in a certain manner. So to use the same example, the product is on in an angry way.

The emotional feedback is a reflection on the physical feedback. If the user recognises that the product is on in a certain way (physical feedback) this will prompt a certain emotion. So in this instance, the user might be prompted to try to relax as they recognise that they have treated the product in an angry manner.

The products are represented in the circles surrounding the user. The faded circles with diamond and square inners indicate the 'related product' that might interact with the main product under enquiry. To look at the main product, a breakdown is re-quired to define product response and product action:

- **Product Response** - The product might react to a direct user interaction. The response to being switched on would be that the product is on, which if done in a certain manner, will be indicated through this response.
- **Product Action:** The result of either an indirect interaction or the need to present a message providing an immediate physical feedback to the user. A product action might be the indication of a battery running low, which may then start the interaction with the user.

6.4 Timeline of use

The timeline of use outlines all of the procedures associated with the product in mind and could be described as a specification of the functional requirements. Deciphering the process through which a product is used is of utmost importance. A thorough investigation into every ascertainable interaction with the product is carried out. With the iron: the iron, ironing board and garment to be ironed were all included in the timeline in order not to overlook any of the important stages of use (see figure 8).

KNOW YOUR PRODUCTS' TIMELINE - GARMENT CARE

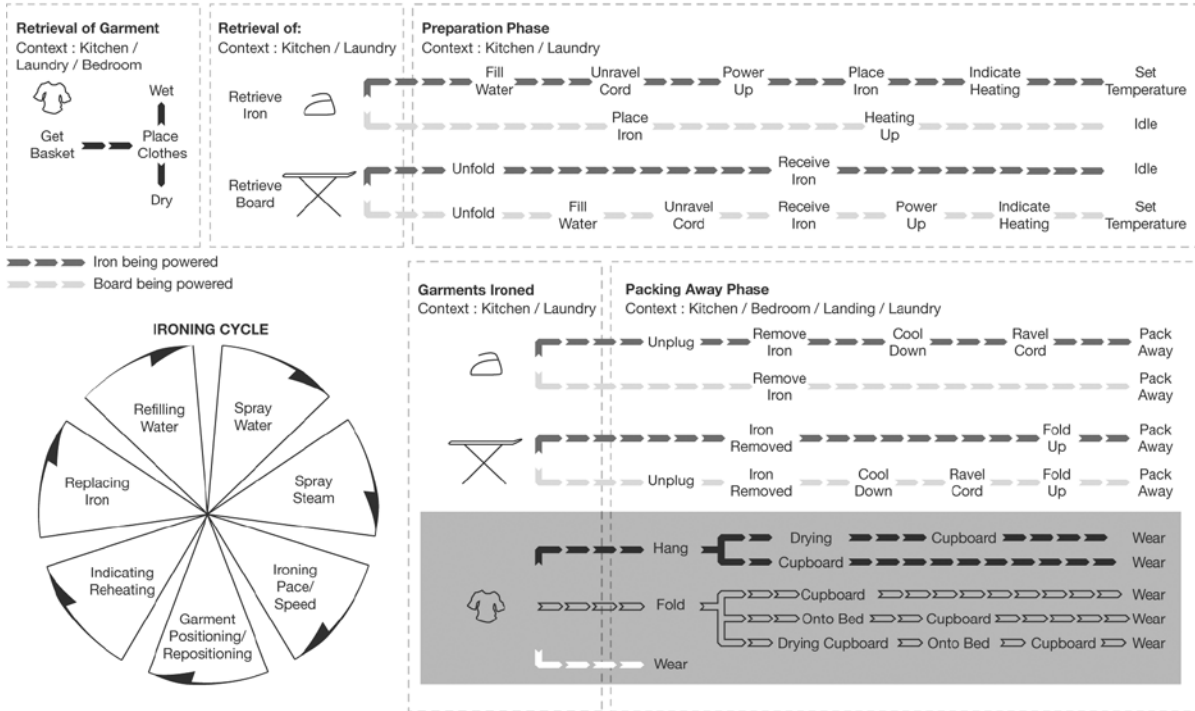


Fig. 8. Timeline of use for the iron

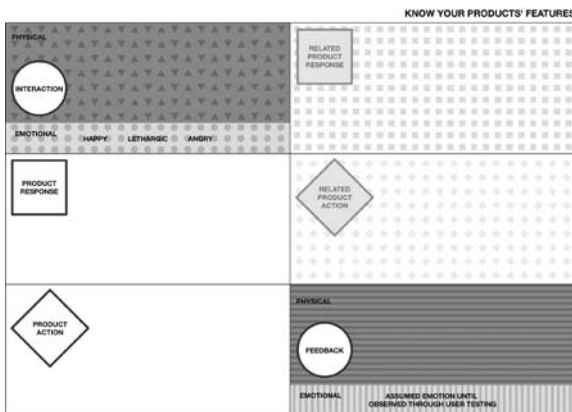


Fig. 9. Know your Products' Features

6.5 Various Worksheets

Traditional product design might entail devising a list of features or functional re-quirements at the outset of the design brief. To begin the process of assimilating standard industrial design practice with this new method, we devised a worksheet for separating response, action, interaction and feedback (see figure 9).

Figure 10, left, shows a tool we have developed to encourage the use of designing levels of behaviour (see figure 12 for an illustration of these levels) within a product feature during this concept development stage. We have also devised a standard sketch sheet (see figure 10, right) where the designer can self-analyse and guide their concept in relation to context/scenario, limits, ceremony, behaviour, and interaction, ease of use and personality traits.

6.6 Example of Use of the Behaviour and Interaction Diagram

Each behavioural feature can be applied as a spoke to the main behaviour and interaction diagram to show how everything links together. Figure 11, the design of the beard trimmer represented on the diagram, shows how the levels of behaviour or number of interactions might vary depending on the design of each feature. The number of spokes reveals the complexity of interaction that has been developed.

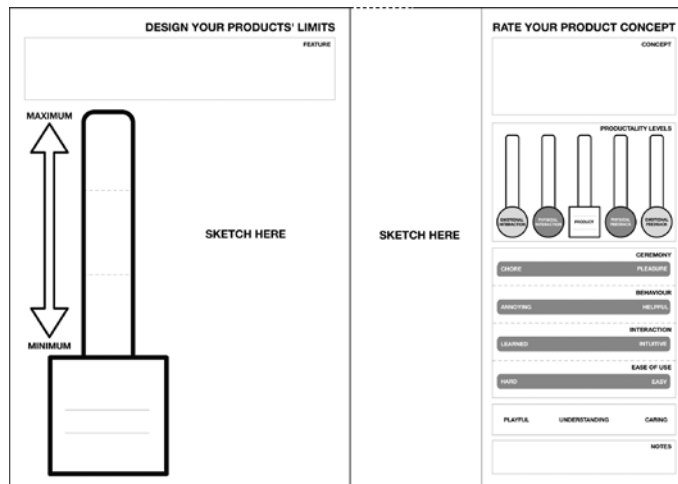


Fig. 10. Left: Design your Products' Limits Right: Rate your Product Concept

7 Findings

The methods described in Section 6 have been used to try and bring some clarity and coherence to what is a vast and complex subject, while still allowing the designer the flexibility to be creative. The dilemma on the one hand is that being precise can restrict creative energy, while on the other, a lack of constraint restricts decision making, as illustrated in Section 6.1.

7.1 Findings from the Iron & Beard Trimmer

Through the iron project, we refined our methods and found that there were certain elements to reflect upon for application to the method used for the beard trimmer project. We found three levels of behaviour to be the optimum for recognising a transition between levels. For example, the amount of water was indicated by three various levels of product action, a slow movement of the mouth opening, indicated that the tank was slightly empty (image 1, figure 12), a random movement of the mouth opening indicated; running very low of water (image 2, figure 12) and finally, movement of both the upper and lower 'lips' indicated; that the water tank was completely empty (image 3, figure 12). The use of random movement as well as different types of movement meant that the behaviour was more evident. Simply changing the speed was not enough to animate the product. The physical appearance was also important to provide associations (zoomorphic or anthropomorphic) with the water fill being positioned correctly and made to look like the 'mouth' of the iron.

We concluded that the start and finish of the interaction should link together. How the user last used the product should be reflected in the product response on next use. Enabling a reward to be given for good use at the consequent use. However the behavioural response should be helpful, not annoying. A balance is required, that allows the user to benefit from a more pleasurable experience. For example, with the beard trimmer, a more pleasurable way of charging could only be used if the trimmer had been treated well on the previous use. The method of using levels to design behaviour into products has the potential to create interactions that might, in certain contexts, be deemed annoying. It is important to be aware of this, as well as try to evaluate the advantages versus disadvantages. A product's performance should not decline below a tolerable average of acceptance.

8 Conclusion

We began our research with an inappropriate presumption; that human personality could be defined and summarised to help us apply human qualities to 'productivity' designs. We soon realised that it was not possible to define or apply human qualities to products because inanimate objects cannot have a personality but they can reflect a particular personality characteristic back to the user. To help us consider these qualities in product design terms, new methods tools and techniques have to be created and implemented. We have undertaken this task with the introduction of a new descriptive term; 'productivity' as opposed to product personality (see section 2.3).



Fig. 12. Three levels of behaviour from the water fill of the iron

to interaction con-texts, using movement as a main channel of communication between users and products to complement the aesthetics of other sensorial channels. We know from previous research sponsored by Philips involving the CfDR that movement is extremely powerful in gaining attention and communicating various types of information to the user through one-way interaction. We anticipated that the two-way interaction process is far more complex and our experience suggests that it is not just twice as complex rather more exponential. As a result of the research conducted so far it has been established that understanding how to design with behaviour has much to offer in enhancing relationships between users and products. In order to achieve the goal of designing 'productivity' a broad range of topics has been studied and our research has opened up many possible avenues of exploration, which often demanded an eclectic response on our part. In a relatively open field of enquiry such as this, where much is to be done [49], our decisions concerning the direction of the project have been made on the basis of opportunism, resource availability and the pragmatics of promoting the role of the design practitioner. We therefore see the benefit of our work to date as an exploration, which will hopefully create a bridge-head for further study.

9 Further Research

At the moment we are using our understanding of interaction and behaviour based on our explorative action research, including the evolving methods, tools and techniques for designing with behaviour. The next project cycle will attempt to develop form and dual personality conjointly using two user personas as inspiration in the design of a DVD HD Recorder. The intention is to gain further insight into the elements of behaviour that

enhance the experience and user product relationships while at the same time, seeing if one form can provide two behavioural identities suitable to two different personas. This raises various questions: Can the perceived behaviour of a product vary in the same form and therefore can different products take on the same behavioural identity in different forms? Can this reinforce company brand traits? Can there be such a thing as product impersonation and if so; will this give rise to new concerns about product behavioural affectation, fidelity and integrity, in the way traditional industrial design debates on truth to materials raged a generation ago [50]. Whilst it is not expected that all of these questions can be addressed in the timeframe remaining for this research, a fourth and final project cycle will be carried out feeding the in-sights gained to date into a more context related design.

We also intend to accumulate user interpretations of the product outcomes in response to the above project cycles. These should help us to gain further insight into how the emotional feedback that we trigger will be described for the benefit of other designers wishing to apply our methods. We propose to ascertain how or whether the manner in which a product is used can be reflected in the responding actions (behaviour/productivity) of the product and therefore inform the user of their own behaviour, whilst betokening a memorable experience of the product manufacturers brand identity.

Glossary of common terms used within this paper

4D Sketching – ‘term defined by Loe Feijs in relation to rapid model making for quick testing and analysis’ [51]

Action Research – Investigation cycles where each project informs the next with findings and deductions, which enables the progression of the investigation, [52]

Anthropomorphic – Assigning human qualities of motion, characteristics or behaviour to in-animate objects

Appropriate Detail – Within the context of ceremony, where a level of detail is correctly applied depending on circumstance and scenario

Associations – Looking to existing interactions and symbols for inspiration and application where appropriate

Behavioural Feature – A feature that has been assigned levels of behaviour

Brand Personality – Human personality traits aligned to the essence of a brand

Ceremonious Behaviour – Forming greater interaction through encouraging repetition and habitual behaviour with a product

Context – ‘the circumstances or events that form the environment with which something exists or takes place’ [53]

Dual Personality – Displaying two behavioural identities within one product form

Emotional Feedback – The user emotions in response to the physical feedback given by the object

Emotional Interaction – The manner in which the user interacts with a product

Emotional State – The emotional disposition of the user at any one time

Experience – The memorable aspect surrounding a certain scenario

Freedoms of Movement – ‘defined by the number of axis that a form utilises in motion’ [56]

Functional Requirements – The specific functions that a product requires as part of its make up

Gesture-like – Using anthropomorphic/zoomorphic movements as a movement within the product or as a way of interacting with the product

Human Personality – Constant character that is formed over time

Innateness – Inbuilt components of behaviour

Known Interactions – Similar to associations where the user can recognise aspects of an interaction from previous experience with the same type of interaction but a different object

Mechanical-like – No associations with human or animal characteristics or movements

Motion Moodboard – ‘a collection of motion clips that allows for analysis of motion’ [57]

Non-Functional Requirements – The aspects of a function that are unnecessary and afford individuality

Physical Feedback – The actual information displayed to the user by the product action or response

Productivity – The conjoined term of product and personality encompassing all the factors in a product that trigger the perception of character and behaviour on the part of the user.

Productivity Attribute – Product language term in place of personality trait

Product Behaviour – How the product responds and acts to display information as well as interact with the user

Product Limits – The maximum and minimum boundaries (amplitude) that describe the levels for each behavioural feature

Product Miming – Performing gesture associated with certain products that are recognisable without the product in use

Product Personality – The area under investigation, at present defined as the physical product itself attributed with human personality characteristics

Product User Relationships – The manner in which a user interacts and forms bonds with a product

Scenario – Where time, context and user are all specified

Self-Concept – How a person sees his or herself

Semantic – Product language and meaning

Sketch Model – Process of rapid model making to resolve a concept

Symbolic – The manner of or means of expressing symbols

Zoomorphic – Assigning animal qualities of motion, characteristics or behaviour to inanimate objects

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Interactive tiles



Toys

The Interactive Tiles haven been developed as toys for children between the age of 3 and 4. At this age children transform from an individual to a more social person.

The goal of the tiles is to support the social interaction between these children. During this project I searched for a way to combine the more traditional way of playing with technology. I searched for a subtle integration, rather than making the technology scream its attendance.

The upper side of the tile is made out of Plexiglas. It can light up in different colors. The color or the light is linked to the pressure upon the tile.

Freedom

An important aspect when designing for this user group was freedom. This, combined with the energy, creativity and the child's natural urge to discover, was the starting point for the project. As designer you only have to give the child something to discover, something that can be discovered and isn't bound to a big set of rules.

The interactive tiles are a good step into this direction.

Moreover, positive aspects of playing can be found back in the interaction with the tiles. Let me shortly elaborate on some:

Social Interaction

Since children from this age are still very individual, it won't be a good idea to force them to play with others.

The basic goal is to let them have fun, play. With the interactive tiles, it is possible to play alone, but playing together has a clear added value. The children see that they can do more when playing together.

Motor Skills

While the children play with the tiles, they are physically very active. The stamp, jump on the tiles, move and throw

the tiles and walk and run over them. During these activities, the child's motor skills are trained (e.g. when jumping from one tile to another or balancing on a tower).

Build & Use

The tiles are robust and have about 30 cm square. Children can quickly build simple things and use them immediately (like a path or floor to walk over, or a tower to stand on). Because they can build things, use it, and break it down again, they can enjoy themselves for a long time with it...

Embedded

The tile is built in such a way that it can respond flexibly. Every tile has its own microcontroller. This microcontroller can easily be programmed to respond differently. This way, different types of behavior can be given to the tiles. During this project I haven't experimented with the behavior.

Demo

The demo will exist out of a set of working tiles (that can be tried out by people) and a video of the tiles being used by children. The video shows clearly how the tiles can be used by the children, and how the children respond to the concept.

Conclusion

As you can see in the video, the children play on a variety of ways with the tiles. They play for a long time, together, and are physically very active. These are promising observations, but they can't be supported yet, when looking at the long term use.

Invitation to Discover: Introducing New Functionality through Physical Exploration

Abstract

In our contemporary lifestyles and with the introduction of new technologies, how can we discover the functionality of complex objects? We enjoy self-explanatory systems, which we learn through exploration. Familiar objects and materials in tangible design may encourage the exploratory discovery of new functionalities. Design should consider the initial interactions and behaviors which enhance understanding and define the relationship between the user and the object.

Keywords

Tangible interface, technology, self-explanatory, affordance familiarity

1 Introduction

In the discipline of Interaction Design one has to consider not only the introduction of new objects, but also the introduction of new technologies and the communication of new uses into our familiar environment. Nowadays, with the introduction of new devices and systems, users face even greater complexity.

Design should clearly present new functions, and also take into consideration the user's discovery process, i.e. the design is not only of a static object but also of behaviors and of the interactions between users and objects. Tangible design¹ invites users to explore unfamiliar functions through familiar materials. Interaction design aims to define new interactions⁴ – how can we phrase new models with shapes and forms?

2 Discovering new functions through physical exploration

As users we gain confidence and pleasure when we discover and master a new device. We enjoy exploring it by examining and trying it, not by reading a manual.

An encounter with a new technology or appliance does not have to be aggravating; it can be an enjoyable and playful learning process. As Donald Norman argues², a well-designed object is a self-explanatory one. It provides the user not only a sense of control but also creates a trustful relationship. When the user explores the 'new territory' and receives feedback, the result is satisfaction and confidence, and therefore, a deeper understanding and better use of the product and its logic system.

A new concept can be represented in diverse ways and expressed in different designs. However, when facing a new object, we seek familiarity and always use our existing cultural baggage in the process of discovering the new functionality and logic. A non-structured lexicon exists in our culture; it is not a fixed dictionary that we can use for translations. This knowledge is organic, dynamic and developed over time. As such, it is obviously different from one culture to another and is projected to objects that we see for the first time: we try to put them in already existing category. This is the space where ontology and culture resist the design of narrative propositions. In this respect, how can we design for more interpretative appropriation⁵?

The encounter with tangible design invites the user to experience and develop skills through interaction; Naturally, we are more familiar with physical objects and qualities of materials, then with software behaviors and abstract systems³. Tangible design has the familiar physical qualities, which invite the user to explore directly the unfamiliar function. Design should shape the object, but also consider the exploratory interactions of discovering it. Therefore, the mission of design is to expose through tangible design the logic of the innovative functions, but also to design the process of discovering through physical interaction.

3 Design explorations

In this chapter I present three design approaches. Each unfolds a different way to transfer an idea of interaction into a physical object. All of them share the goal of communicating the functionality to users and all invite a certain behavior – an interaction that engages the understanding of the objects and its use. These approaches are neither formal nor contradictory – they can therefore be combined in one single design.

3.1 Form follows function: materialize a concept and follow its new physical logic

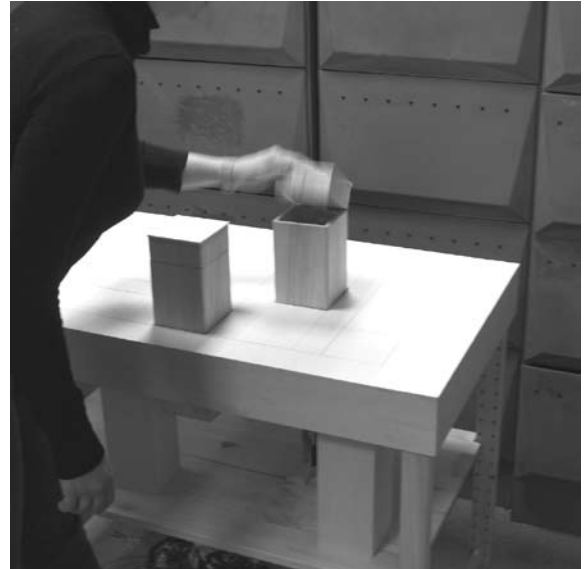
One way to express a concept in physical form is to define its rationale then use basic shapes or compositions, which express the same meaning. This way, the design is in fact a 3D conceptual model, translating an idea into material, mostly using abstract shapes. In this approach the function defines the design.

The Message Table: An answering machine

‘The Message Table’ (designed with Shawn Bonkowski): For each message received, a box rises out of the table – depending on how long the message is the box rises accordingly. To listen, open a box and to delete it push it back into the surface. This proposal suggests separating the answering machine from the phone and merging it into furniture.

It provides not only a visual display but also a physical one that invites a direct interaction. The design focuses on the everyday use, and aims for a clear, simple understanding of the basic functions: receiving, listening and deleting messages. This is a translation of the rationale of the answering machine into a physical object. An answering machine collects messages and keeps them for the user to hear, delete or keep. Using boxes as containers, the design translation follows the conceptual equivalence; the box is not a metaphor but the archetype physical form of a container.

Is this box really the absolute logical translation for the concept? Obviously, there are an infinite number of different ways to design a box. In this case all that was needed was a simple box that can appear on the table, invite the user to open it and disappear back into the surface when pushed to delete its contents. A cylindrical box would still have been a container and could function identically in that table, but we were able to fit more boxes in the proper way as squares. The focus of this design is to simply present these functions through the change of the furniture landscape.



3.2 Form follows interaction: Reshape a new ‘organ’ for a familiar object according to the interaction

When using an object one also develops special behaviors, body gestures, and playful habits as part of the interaction with it. These express the relationship one forms with that object. The design process can refer to this vocabulary of gestures in order to suggest a unique tangible interface that emphasizes the qualities of that specific object. In this approach the design is generated by behavior, gestures and the way users interact with the object.



Undercover: A sound blanket

'Undercover' (designed with Alejandro Zamudio). Sound blanket contains a system of wireless speakers, which provides an all-over physical sound experience. The volume is controlled by pulling the 'ears' of the blanket – the right one increases the volume and the left one lowers it. Here, a new function (sound) was merged into a cosy blanket and therefore required the development of a new 'organ' to the familiar blanket. We followed the natural cuddling behavior when interacting with a blanket to design the suitable tangible interface. The upper corners turned into fabric handles (each in a size of a hand) inviting the interaction of pulling them.

This interaction embraces the blanket's sense of comfort and the pleasure of getting into a warm comfortable position. The funny looking handles on the corners created a new reference for the blanket. They were added as a touch-point for new function, but created a unique animated identity for the blanket (they were named 'ears' by users, not according to their function, but because of their shape and location in relation to the blanket).

3.3 Form suggests interaction: 'Packing' new functionality in a familiar icon

In this approach the design is inspired by a parallel model, which holds similar qualities of interaction. Borrowing a familiar shape (a cultural icon), can inform the user regarding the function of the object and hint to the opportunities of its experience.

Narciscope: A reflective biofeedback device

'Narciscope' is a hand-held mirror that visually reflects the user's state of being. Responding to biofeedback from the hand, the image sharpens or blurs depending on how relaxed or tense the user is. In order to receive a clear focused image, the user must hold the device by its handle. When reaching a relaxed state, the image sharpens. Selecting the design of a classic mirror for a device that reflects one's personal state is not only a rational metaphor; it utilises the familiar shape to inform the user of the required handling. It uses an existing mental representation as the basic 'formula of use', suggesting the interaction. Using such a mirror suggests self-attention, an act done alone, probably in a private space. The hand-held mirror defines the way users hold it, the space in which this interaction might take place, and even the ambiance of this action.

4 Perspectives

These three approaches have been tried out with different user groups during workshops and exhibitions in England (at the Victoria and Albert museum) and in Italy (in Salone del Mobile). Similar frameworks have been validated by other practitioners in the field such as Ishii I with the concept of tangible interfaces and Dourish 6 with the notion of embodied interaction. However, the results presented here are not final. We envision further iterations and evaluations to understand how people actually interpret what they « physically » perceived.



As we gain confidence from deeper understanding of new functions, design must take into consideration the process of discovery. With this idea in mind, the design proposes the users' interactions as well as that of the functioning objects.

In the process of recognising new systems we turn to the familiar. Tangible devices have a familiar quality that invites the user to physically explore them. This exploratory approach may engage people to develop their own explanations or narratives for the functionality and gain further confidence handling it.

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Mr. Pong !

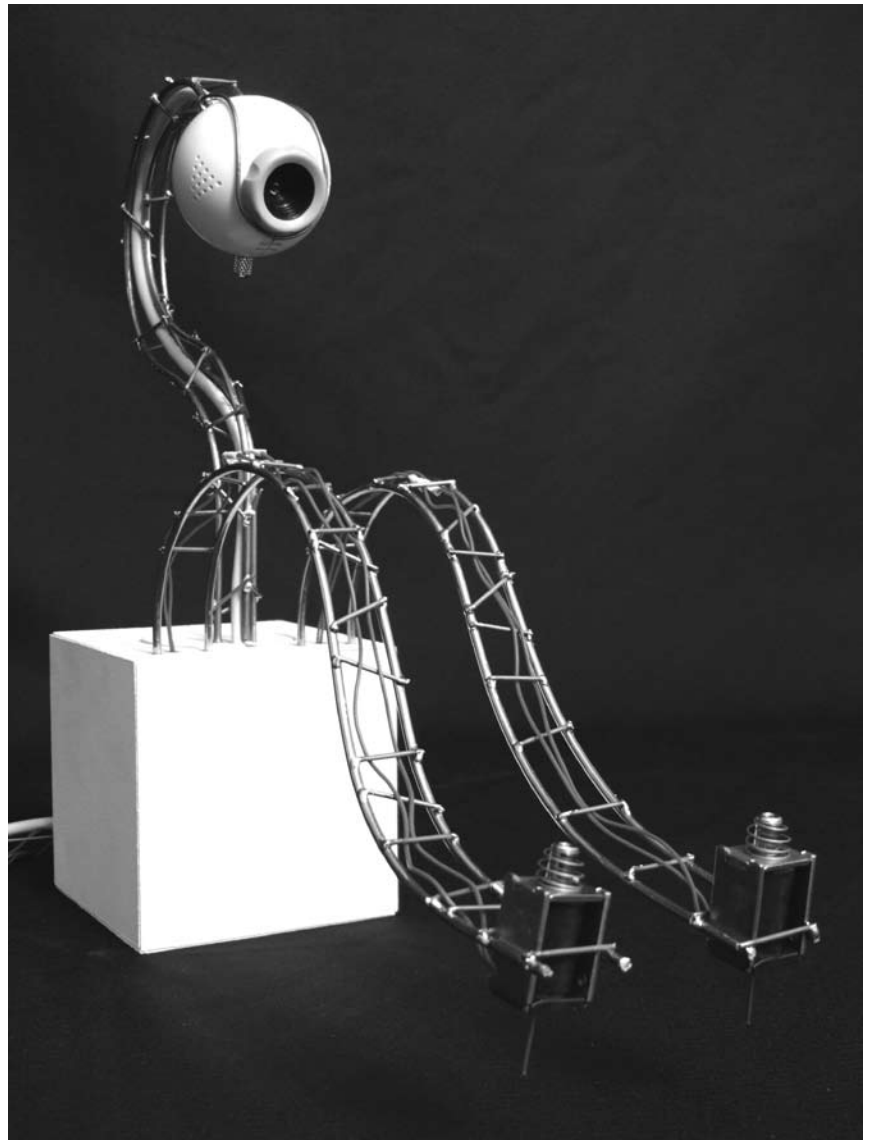
A simple game that you can play against your computer gets a whole different meaning when embodying the computer player

The computer is incarnated by giving it sensors and actuators, and human and computer are allowed to meet on the same playing ground.

Mr. Pong uses simple image recognition, to keep guessing the direction of the ball when the ball is heading towards his paddle. For each guess he then computes the end position of the ball when following that angle. He then averages these end-positions and moves his paddle to the average so obtained.

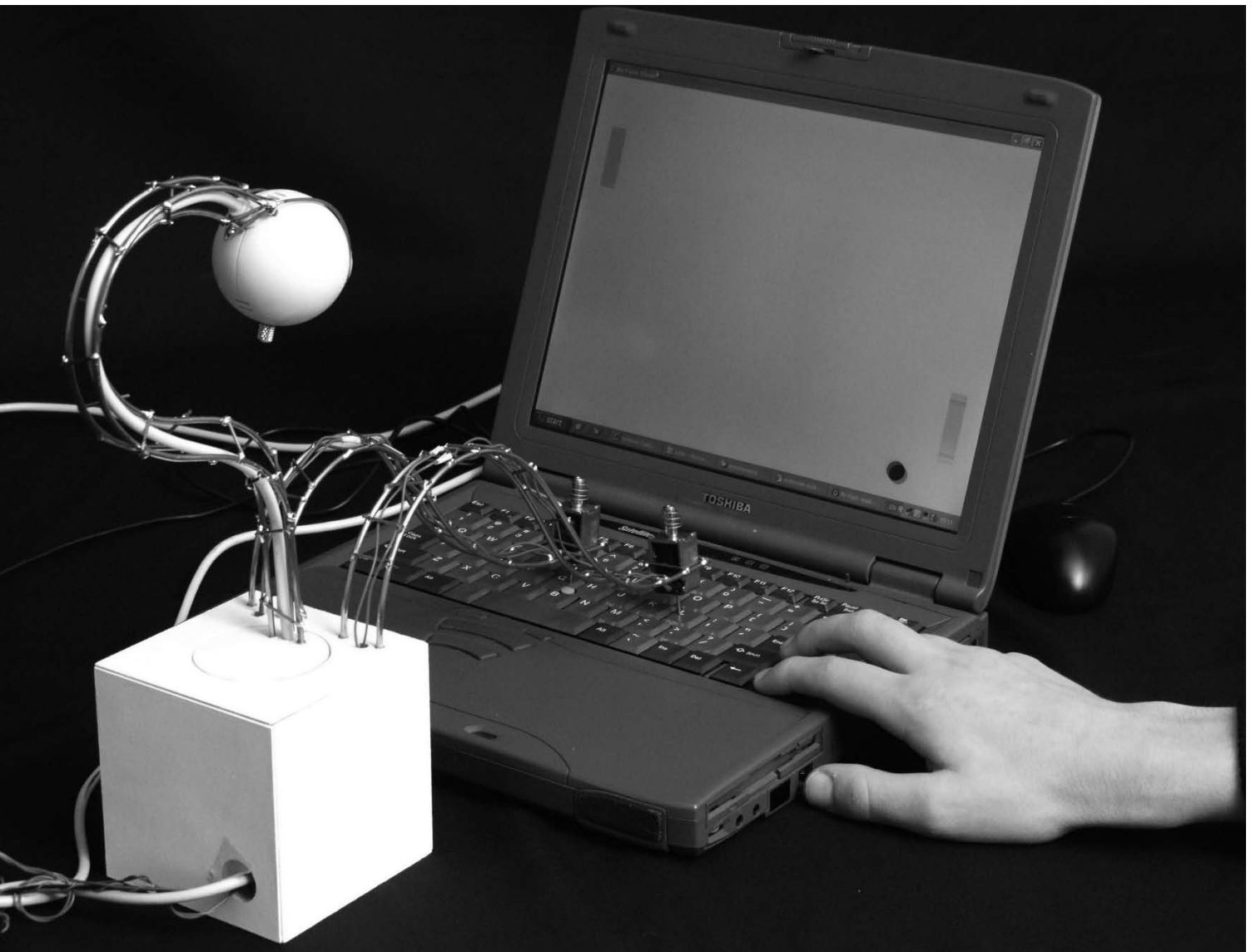
When you see him typing away, it is hard not to hope that the poor chap will be able to catch the ball. For it is hard not to notice that incarnation has made life a lot more difficult for Mr. Pong. Once out here in the physical world with us, his simplicity and lack of context awareness is exposed, and one feels his helplessness.

But what if he were not so helpless? What would we feel when Mr. Pong would get better and better at this game and would eventually start to outperform us?



Certainly, we can always assert our dominance, by blocking the view of his camera. Clearly embodiment adds a realistic touch to gaming.

How do you feel about Mr. Pong?



4D Design briefing

Abstract

The aim of this demo is to illustrate an innovative approach to generating a design brief using 4D Design techniques. We suggest that '4D Design Briefing' could be a useful tool as inclusion of the 4th dimension – 'time and motion' provides a design team with a richer content which potentially opens new spaces for the product/service development team members to explore.

Introduction

In addition to the 3 dimensions of length, width and height, the 4-Dimensional Design (4D Design), takes into account additional dimension(s) – 'time and motion'. This approach incorporates 'time-based-activities' which redirects designers' focus from exploring the product only to how this product could be used by its users. Thus, 4D Design allows designers to explore interactions which take place between users and products. Inclusion of the 'time and motion' dimension provides designers with an opportunity to approach the problem they are exploring from a broader problem definition.

Young et al. (2005) proposed that 4D Sketching technique which incorporates time-based activities which allow designers to experiment with interactions between a user and a product at early stage of a design process. Thus, facilitating 'idea generation and development' (2005, p. 19).

4D Design Briefing

This demonstration showcases the use of 4D Design techniques to generate a Design Brief which was produced as a part of a collaborative research project between Northumbria University and Unilever on the topic of 'Ritual of Washing Clothes'. The project explored the idea of generating a visual narrative (4D Design Brief)

which could be used as a reference point by the design team to generate product/service ideas. The 4D Design Brief has incorporated multimedia files such as video clip grabs, stills, and sound bites. These were edited to illustrate these broad categories: 'Past Concepts of Clean (West)', 'Effects of Clean?', 'Relation to Dirt', 'Cleaning in the Developing World', 'Cleanliness and Family', 'Contradiction of Clean' and 'Future Potentials'.

Conclusion

This project raises a number of interesting issues that need to be further investigated. For example, in what ways a design brief is closing and/or opening potential spaces for design exploration and ultimately affecting the design outcomes; or, in what ways does knowledge and techniques already developed and used in other disciplines such as cultural studies and social research, inform design in this important area of research.

Acknowledgements

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Concepts of Clean (West)



Effects of Clean?



Relation to Dirt



Developing World



Cleanliness and Family



Contradictions



Potential Futures

Daniel Pezutti, Stuart Pill, Gavin Proctor, Angus Dick

Philips Design, The Netherlands

Smart skin media hub



smart skin media hub

The Smart Skin Media Centre can display gaming effects, and when listening to music it shows an animation related to that particular track.

On, approaching the Smart Skin Media Centre, the display reveals more detailed track and artist information.

Tracks can be altered and the volume changed without touching, using gestural controls.



DeSForM PHILIPS

Design & Semantics of Form & Movement

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