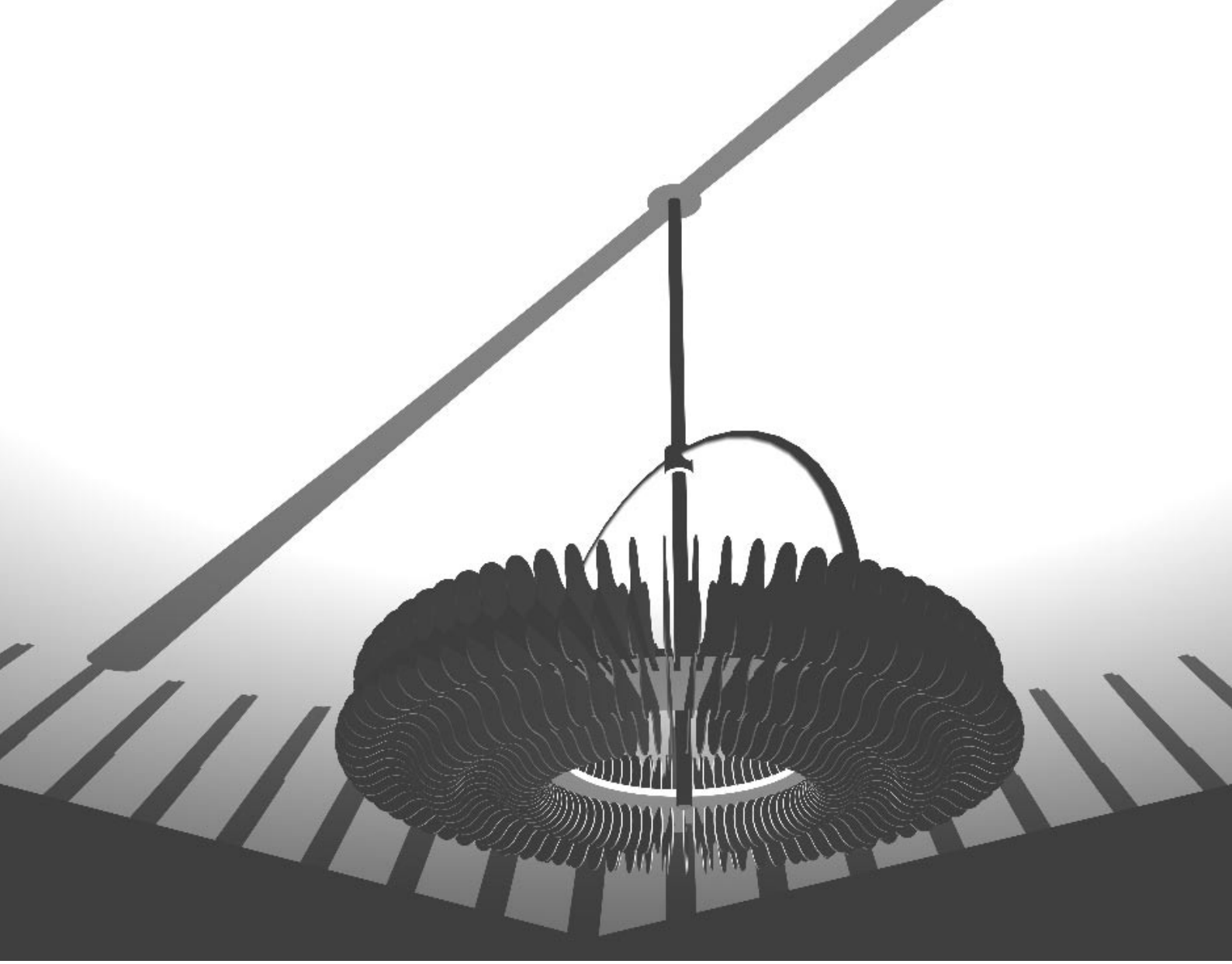
Design and semantics of form and movement



Design and semantics of form and movement

Loe Feijs, Steven Kyffin, Bob Young

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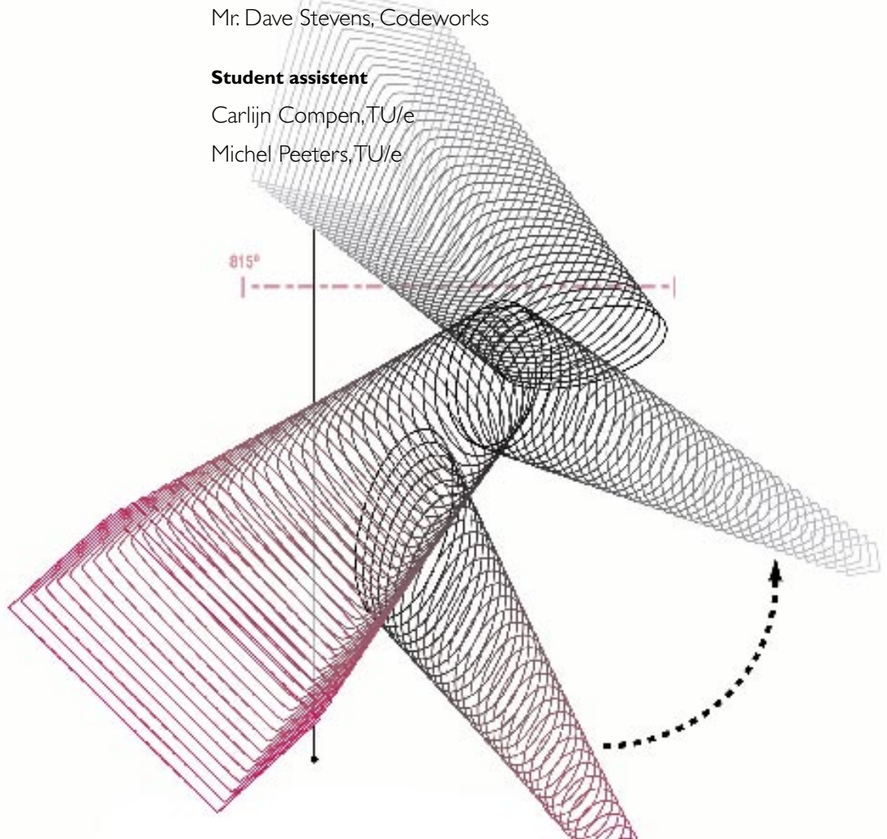

Foreword

These are the concept proceedings of the new DeSForM workshop, initiated by the new 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 of Philips Design, Codeworks, the Design Research Society, TU/e and Northumbria University.

DesForm is the first international conference seeking to present the current research into the nature, character and behavior of the emerging new typologies of co-designed, content rich, connected and intellegent objects with adaptive systems. This conference brings together researchers in the field of design and semantics of forms and movement to asses the outcomes of this research and begin to identify issues and territories for future investigation and exploration.

The important motive for this research is: Forms, either concrete or abstract, always carry meanings. It is the responsibility of designers to make good use of these meanings, for example, to make products beautiful, to stress the importance of certain values, or to improve a product's ease of use and to promote or negotiate enriched experiences between people (communities) and people, people and objects and in time between objects (systems of objects) and objects. Design uses its own languages for this purpose, just as poets, painters, journalists, sculptures, film makes and so on do. The topic of this conference is how to explore, study and exploit the combined usage of form, colour and behaviour as a design language. The conference will include presentations, debate and activities which look for new ways of exploring behaviour, not separately, but in relation to traditional and new forms.

The vision of ambient intelligence as put forward by Weiser and adopted by ISTAG and many companies and universities, forms the basis of considerable R&D efforts. The central theme is that powerful computation, communication and storage facilities are available, but are invisible. In Marzano's "La Casa Prossima Futura" the black boxes have disappeared and the living room contains objects and furniture, again. Then if the traditional terminals disappear, what are the mediators between people and this hidden intelligence? How do people control, and get feedback from, these resources in a way that is meaningful and even attractive at a human level.

The conference builds on the assumption that *objects* will play an important role as mediators. To take full advantage of the richness of human-object interaction and to use the potential of affective (emotional) interactions, there is a need for a new approach. Although many traditional products, even products which do have mechanically moving parts, follow a trend to converge with computing, this convergence comes in the form of electronic displays and buttons being added to traditional forms. As an alternative it is worthwhile to explore adding behavioral expression to the existing movement possibilities. There is a need for new types of processes and tools to support the creation of the envisaged new product types. Product behaviour will be enriched with physical movements. Several possibilities exist: either the product is moving anyhow, or the movements are added just for the sake of communication. In both cases, the designer has considerable freedom to shape the movements and the interactions.

Conversely, developments in computing are not only a source of new challenges, they also offer new options for addressing long-standing problems in product semantics. For example exploiting the insights gained in programming language semantics. New computerised tools may support the systematic exploration of semantics. Also, the developments in information storage and retrieval such as the Internet and the world-wide web offer new opportunities for collecting and unlocking design knowledge relevant to product semantics.

Prof. Steven Kyffin, Philips Design Eindhoven
Prof. Loe Feijs, Technische Universiteit Eindhoven
Dr. Bob Young, Northumbria University Newcastle
11 November 2005

DeSForM Programme, 11 November 2005

Welcome & Introduction
Professor Tony Dickson Deputy Vice-Chancellor, Northumbria University

Dr Robert Young, Associate Dean Research and Consultancy, School of Design, Northumbria University

Keynote 1
'The march of the soft machines - how ambient intelligence will be enhanced through extreme material science and vice versa',
Dr Raymond Oliver, Scientific Futures Institute, ONE North East, UK

Keynote 2
'Animating the Inanimate: Observations of Emotion and Usability as based on the relationship between the Object, Emotional Value and the User',
Dale Russell, Russell Studio, Cambridge

Keynote 3
'Industry Perspectives and Developments in Professional Design Practice'
Colin Burns, Freelance Service Designer, Former CEO, IDEO Europe

Parallel Session 1
Long Papers
Short Papers
Demonstrations

Parallel Session 2
Long Papers
Short Papers
Demonstrations

Plenary
Closing Remarks and Announcement of Philps DeSForM Student Award,
Professor Steven Kyffin, Global Director Design Research & Innovation, Philips BV.

Design and semantics of form and movement

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Robert Young, Daniel Pezzutti, Stuart Pill, Richard Sharp

The language of motion in industrial design

Abstract
This paper is the positional summary of the Centre for Design Research concerning its current thinking about the ontology of designing motion into system operated products. The paper follows after a programme of explorative research into the subject over one year. The objective of the research was to build a framework to structure the knowledge derived from a series of design project explorations and associated contextual reviews concerning the language of motion in product design. The purpose of the framework was to create a shared understanding based upon the learning gained from the projects and reviews. The starting premise of the research was that in order to create animated product we first need to understand what the characteristics and qualities of movement are. Through our explorations we have started to appreciate motion as a valid means of creating interaction between physical objects, and the information structure that they are a part of.

Key words
Explorative Design Research, Language, Product, Movement.

1. Introduction

Many products in contemporary society are part of information communications systems and incorporate display screens to enable users to interact with and control their mode of operation. A typical example is the mobile phone. These system operated products, Bull (2003) display their functional state within the information communications system they are part of by graphical communication via a display screen. They require a particular focus of attention for the user, i.e.: the screen, and their design has also re-focused the attention of the product development team to include interaction and interface design specialists and new-media designers alongside the more conventional role of the industrial designer Fujimoto (1990). Many traditional products, even products that do have mechanically moving parts, are also becoming more sophisticated, to the extent that there is no intuitive link between movement and function.

The introduction of interaction design methods into the product development process Preece et al. (2002) and the consideration of product semantics in order to bring a coherence to the determination of qualities within the human to product/system interface Demirbilek (2003) has assisted the evolution of system operated products but has not generated alternative modes of interface at a fundamental level. The focus of the interface is predominantly the display screen. Philips Design has hypothesised[1] that as an alternative, it may be worthwhile to explore adding behavioural expression through physical movement to the existing movement possibilities. The hypothesis is that introducing designed physical movements will enrich product behaviour. Several possibilities exist: either the product is moving already and the motion becomes more designed rather than a by-product of the function, or the movements are designed to communicate a specific piece of information. In both cases, the prospect is that the designer has considerable freedom in how to shape such movements and the associated interactions. However, in order to design movement into product we first need to understand what the characteristics and qualities of movement are.

To understand these characteristics and qualities, we have used the metaphor of language, acquiring an alphabet (familiarising oneself with the elements of designing with motion), forming words (joining the design elements together into cohesive, coherent and intelligible configurations) learning to apply the grammar (normative rules of developing sentences or devising how sequences of motion represent understandable states of information flow, and control operation), deciding upon the syntax, (understanding the most appropriate inflection to generate the desired effect, i.e.: understanding the poetry of movement, the qualities of movement behaviour which are distinctive, full of character and evocative). The language of existing 2D and 3D product design is relatively hackneyed but the phenomenon of this design process has not yet been fully described. The nearest examples are perhaps found in the proceedings from the Design and Emotion Society conferences[2] e.g.: Jeske et al. (2003). The questions posed by this research were ambitious, for instance:

- Can some of the functional states of system-operated products become animated within the simulated physical behaviour of the product as artefact?
- Could this form of user interaction with an animated product offer greater qualities of experience, create greater empathy with and feedback to the user?

The implication of these questions was that the research needed to explore designing within the 4th Dimension. How can we build a design language that will help products move poetically; to communicate meaning effectively to the user through motion? The point of origin of the questions was Philips Design Eindhoven. Their resolution was held as a strategic research aim for product futures. Philips selected three Universities to assist them in this research; the Technical University, Eindhoven, The Royal College of Art, London and the Centre for Design Research (CfDR) at Northumbria University, Newcastle. Philips Design approached the CfDR and a collaborative research project was set up to see what a 4D design language might consist of, what sort of language (methods tools and techniques) can be generated on a tentative basis, capable of being passed on as explicit knowledge and expertise to inform other design practitioners. The objective was to build a framework to posit this knowledge and expertise in order to make it accessible to other designers and design academics, to be able to develop and refine the knowledge base over time through addition to and refinement of its content. The CfDR team have worked to develop this framework over the period of a year carrying out various design projects to discover and develop our theories. The discussion of the findings from these projects is described below.

2. Understanding movement

Our early objectives were to investigate how motion could be used in a smoke alarm, a baby monitor and a Beach U.V strength meter to communicate various intensities of alert. The limiting factor that was agreed to make the scale of the research more manageable was to restrict the nature of interaction to one direction i.e.: the system operated product informs the user about its status but no two way user/product interaction was to be considered. We also spent a number of months developing our own digital content mediator, which we used to develop movements for ten communications such as receiving a message, sleep mode and making a suggestion. We need to understand the communicative value of movement, otherwise we could be sending out mixed messages rather then utilizing animated motion to enhance and not confuse the communication of information and behaviour. In order to start exploring movements that have real and established value, we started looking at other disciplines that have movement as an innate value to their process, such as choreography and dance, acting and puppetry.

2.1 Multi disciplines

Our approach to the research was to build upon our knowledge base using existing disciplines as starting points. Hence by investigating theories within the field of choreography the knowledge would contribute to understanding the language of motion we were trying to create. Choreography is an established form for communication using movement. Within choreography, we specifically looked at Laban theory (Newlove 1993) - a method of notating movement. We found though that

[1] Kyffin S., Senior Global Director, Philips Design, Hypothesis stated in a presentation to the School of Design, Centre for Design Research 2004

[2] Design and Emotion Society, see: www.designandemotion.org/

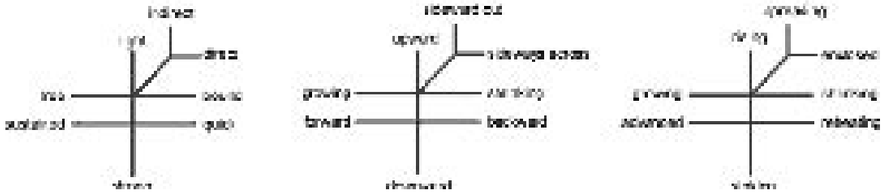

Figure 1

Laban notation related too heavily to the human form whereas we need a motion language that can be applied to differing forms. Laban notation is also very laborious and would never be employed in a design process due to the fact that in design we don't work with just one form. The most useful information gained was in the way that Laban explained movement in terms of a make up of qualities. E.g.: direct and indirect movement, short or sustained, towards or away. (see figure 1 above):
"Any movement always involves a certain amount of tension and a quality of weight; it takes time and travels in or occupies a certain amount of space. Thus the changes in the flow of tension can be either free or bound; the quality of weight can become either light or strong: the quality of time can become either sustained or quick and the quality of special focus or attention, either indirect or direct." Dell (1979). This thinking has also been developed further by Camurri et al. (1999). Recent internet discussion led by Curran, in April 2005 shows the continuing struggle of Laban Motif Notation practitioners to identify and map similarities and differences in practice across the choreography communities. The questions below are recurrent and have a generic value for all involved in the codification and review of forms of movement, that is, how to; evolve, develop and refine movement notation based theory (Laban), symbols and concepts including:

1. Should there be a uniform standard that goes across all aspects of the Laban work?
2. Should certain applications (e.g. dance, pedagogy, choreography, movement research, therapy) be more influential than others?
3. Should there be a priority toward using symbols and concepts already in the systems vs. developing a new symbology?
4. Should the system contain ways of expressing both generic and specific concepts? Is there a universal way this can be done?
5. Should context affect meaning and how?
6. Should prior publications and discussion be referenced?
7. Should the capacity of current technology (e.g. LabanWriter or Calaban) be taken into account?
8. Would it be useful to have a procedure that is recognized and has authority for establishing uniform standards across all aspects of the Laban work?

When alive, the human body is always in a more or less 'energised' state. Therefore, it is not really accurate to think of the polarities of motion as extreme 'tension' and 'relaxation' as a dead flop. The rhythmic changes in breathing, the constant responding of the body to both inner and outer stimuli, provide a constant stream of urges to move. Thus, when we describe movement, we must look at it from the beginning as the natural state of the living human body. This is particularly important in understanding the 'opposite' or extremes in quality in the flow factor, Dell (1979).

An important discovery informing the research was the paper 'Understanding Movement', which discusses motion in relation to screen based animation and which develops a language of motion from screen animation from Laban theory Vaughan (1997).

We also decided to look into the disciplines of acting and puppetry. From these we became aware that to develop an understanding of motion one must experience motion and understand the qualities that make up a movement sequence. We were not able to gain any deep insight into these disciplines as we found that the people often learned through doing and understanding came from critique at rehearsals and personal reflection about how they felt about their performance. The knowledge base was experiential, not explicit and therefore not easily accessible and we had to talk to a number of different performance artists in order to begin to comprehend the significance of the literature on the notation of movement. The significance of the need to experience motion concurs with the intention of our research to present the details of the explorative research undertaken in our motion in products project by workshops, demonstrations and interactive sessions, in addition to the content of this paper in the DeSForm conference.

2.2 Qualities of movement

A number of studies were conducted that enabled us to break up the characteristics of movement into various variables that make up the quality of a movement. We further developed the work of 'Understanding Movement'; Vaughan (1997) and derived appropriate variables (grammar) for motion in product notation to be: path (the line that an object movement follows), volume (the use of space by the object including scale change and kinesphere (the limits of an individual's reach into space without changing place or usage), direction (the direction in which the object moves; up, down, towards and away), velocity (the speed, acceleration and tempo of the object). (see Figure 2 below):

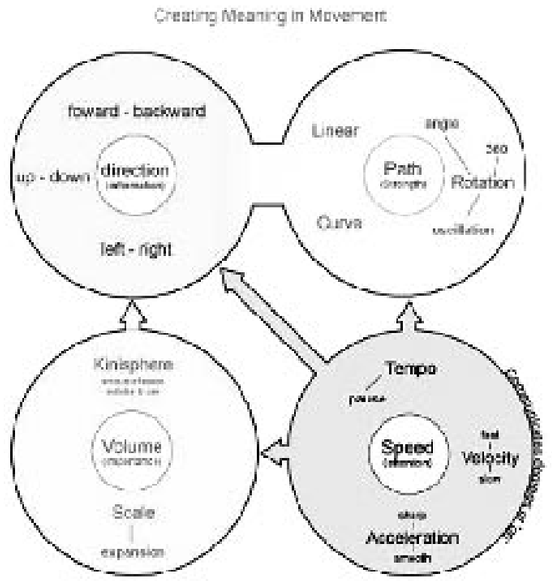

Figure 2. Adaptation of the control variables in 'Understanding Movement' by Vaughan (1997) to movement within system operated product.

2.3 Posture and gesture

We also drew from a review of literature concerning the subject of choreography and through discussion with choreographers, the way that movement is categorised into postures and gestures. Although at first it appeared that posture and gesture seems only relevant to a human body form, there is a latent value to be learned with respect to animated product. In this sense, posture can be seen to relate to the whole form changing and a gesture can be seen to relate to a specific part of a form changing.

2.4 Movement as a Sequence

Motion happens in a sequence having no beginning or end. By understanding qualities of motion we are effectively examining slices of sequences of motion. In choreography, dancers take a static image (for example of a footballer taking a shot) and then try to get into that position and back out from it in a motion. This is a technique that can be used when developing ideas for animated products because what happened before a movement occurs is just as important to the appreciation and comprehension of its meaning and significance as what the movement is going to do next. If one matches the expectation for peoples' prediction of a movement sequence you can engender contentment and reassurance but by confronting the expectation of what people predict will happen, our studies have found that it is possible to influence the perceived alert level in an animated product and produce an alert response in the user.

2.5. Affordances in movement

J.J. Gibson (1977) introduced us to the idea of 'affordances'. This concept propounds the idea that which is inherent to the properties of an object or material is essential information about that object or material. Gibson's thinking implies that the 'values' and 'meanings' of things in the environment can be directly perceived. A butterfly's movement may afford chasing, where as a spider's may afford avoidance. We are able to recognise the creature by just the movement alone and from the pattern of movement we are able to interpret the 'meaning' or quintessence of the creature. This concept is vital in helping to theorise the need to go beyond the level of understanding the mechanics of motion and its potential for codification and notation, in order to appreciate the concept of qualities of motion that signify the characteristic of evocative movement. This concept is the most esoteric to have to come to terms with in the study of introducing 'meaningful' motion into products.

2.6. Degrees of on

During the process of developing ideas about 'affordances' in objects we developed the idea of 'degrees of on'. Essentially 'degrees of on' is the amount of intensity in a designed movement. Everyone has personal preferences about what is fast or slow. In terms of music what is loud for one person may not be for another. For example in an alarm 'degrees of on' relates to how much attention the object demands, whether it is a subtle movement for an alert or an expressive movement for an alarm. Essentially 'degrees of on' is a theoretical concept that can be used to visualise a product coming from the background to the foreground.

2.7. Freedoms of movement

To have meaningful movement in a product there must first be an understanding of what range of movements the object is capable of performing. This is important because different forms will have different abilities, both potential (perceived) and actual (physically possible). We called the physical ability for movement the 'freedom of movement'. An object can have up to three Cartesian axes of freedom, which apply to its characteristic posture and its gesture, where these are appropriate.

After understanding what 'freedoms of movement' an object has you can then define what the 'degrees of freedom' are going to be. This is a term that one of our working group sessions derived to describe how far a motion could go, for example a 'freedom of movement' might be only capable of working through 180 degrees.

2.8. Anthropomorphic/zoomorphic and abstract movement

Arnheim (2004) observed that the more complex the behaviour, the more that human qualities were associated with the movement. We found in our work that people had more empathy with more complicated or sophisticated movements and creating abstract simple movements were perceived to have little meaning in terms of their denotative capability (physical movement to depict functional status) but especially their connotative ability or affordance (perception of a coherent product identity exemplified through its range of movement sequences).

At first we aimed to develop abstract movements. However, we found that people look for anthropomorphism or zoomorphism in objects and in Lakoff and Johnson's (1999) work; 'Philosophy in the Flesh' that movement is related to our experience of the physical world from our own anthropomorphic bodies.

2.9. Organic – random – mechanical movement

Exploration showed that it is possible to create three types of movement from organic, random or mechanical movement using an understanding of 'degrees of on'. A simple organic movement (typically slow speed with smooth acceleration and a non direct path and a small use of space and regular, relaxed motion) conveys a low' degree of on' or a mild alert whereas a mechanical movement (fast speed, abrupt acceleration, direct path, large use of space, tense movement) is more attention grabbing. We discovered that Vaughan (1997) had also used these terms to describe motion in animation. Further, we found a third which was random. Random is the most attention grabbing, as a person is not able to predict what the motion is going to be.

2.10. Form and motion

Initially we planned to test pure motion in our explorative studies. That is movement devoid of form. We realised very early on that this is impossible because the two are indivisible in the perception of the user/respondent. This then raises the question as to whether a person is being influenced more by the motion or by the form.
Is the level of influence constant or does it change with respect to the characteristics of the movement range and types. We found that in experiments where movement was tested using a range of simple geometric forms with simulated movement and a range of respondents from different backgrounds that slow speed motions produce a perception that the form is more important, based on the focus of attention obvious in the responses of the respondents. Whereas, when fast movements occur the respondent's responses showed that they had concentrated on the nature of the movement because their focus of attention was in descriptions of the effects of the movement. We concluded from these experiments that when people react with products where movement occurs at low speeds, they notice formal qualities more, whereas at fast speeds the message/information is determined more from the movement instead of the form. We also found that the background to a moving product then becomes important as participants in our experiments used the background as static reference points for the context of the movements. The context in which products reside is therefore also important and it would appear that this importance increases as the rate of movement increases, however our studies did not allow us to determine if there is any proportional relationship inherent between these variables.

We discovered that it is possible to utilise details of form to accentuate movements and infer possibilities of or potential for movement. Also, when people understand what the maximum parameters of a movement are, they can more accurately understand the meaning to be inferred from a movement. This can be used within design to create the opposite effect, that is, if a form moves in an unexpected way it produces the effect of surprise, thereby increasing the level of attention of the user with the product.

2.11. Associations that people make

Another workshop was conducted and the results demonstrated that the tendency of people is to make associations as part of their 'sense making' response to the world around them. If a person understands the form and it is not 'alien' then they tend to be able to move on and understand a motion. People tend to make associations with forms based on their experience of the world, their mood and their personal preferences.

3. Conclusions

At the moment we are at a very early stage in understanding what the language of motion in animated product could be.

As a result of our research we know movement has much to offer as an additional channel for communicating content in product function and status in an idiosyncratic way. In order to design with motion it has been necessary to carry out a study of a broad range of disciplines to be able to understand the phenomenon and its capacity for effective replication to suit the context of interactive system operated products.

We began our research with an inappropriate presumption that we could use motion to simulate emotional behaviour in objects. However we quickly realised 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.

As a result of workshops to review our research and determine the reaction of people to the research process and its content, we concluded that the conventional industrial designer needs time to adapt to the whole concept of designing movement into products. The process is significantly different to their previous experience, particularly with respect to the mentality of approach needed to contend with the complexity of designing in four dimensions and the necessity for collaborative concurrent design team working. Our experimental project showed that you have to enable people to warm to new concepts. In creating a new typology of object of this kind using new methods and processes, there are generally two paths one can follow. You either have to be careful not to step too far away from peoples current understanding of product so as not to lose their interest, or you need to be prepared to work hard and act on intuition to create exciting new product that is more suited to the 'early adopters' of technology.

Throughout the project we have had to consider the opportunity and potential of real world applications for designing movement into products. The current state of technological development of systems of motive power and control does not allow us to create the qualities of movement we require to be credible as empathic translators of human behavioural characteristics. Nevertheless, by engaging in explorative projects designed using movement as an important design element, we can influence where and how these technologies should develop. The prediction, following discussions with the North East of England Centre of Excellence for Nano and Micro technologies[3] is that these technologies could represent the way forward to meet the challenge and this could lead to a new generation of sophisticated system operated motive products.

The I-motive mediator was the last of the explorative projects in our research over the last year. For this project we attempted to develop form and movement conjointly using a series of choreographed qualities of movement and a range of functional requirements and contextual intentions that we wanted to communicate. This was difficult because we were attempting to express many things in one object by only using movement. In practice there are always going to be trade-offs and compromises when designing movement into the product development process due to the limits of the affordance of form.

Movement can be extremely powerful in gaining our attention and communicating various types of information to us. We have to be aware that there are a series of conditions to designing effectively with movement. In the first instance the user must understand the form of the product to ensure that the context of movement is correctly associated. The movement must be complex to be convincing. If the movement is not well choreographed then its communicative intent will be lost or misunderstood.

[3] CENAMPS is an international Centre of Excellence for Nanotechnology, Micro and Photonic Systems: www.cenamps.com/

3.1. What we don't know
We have struggled throughout to develop a framework with enough detail to be applied to products of varying form. We also need to develop methods and techniques for recording the qualities of movement in 2D form as a notation to assist the design and specification of movement in products.

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Robert Young, Daniel Pezzutti, Stuart Pill, Richard Sharp

The development of tools to assist the design of motion in system operated products

Robert Young
Daniel Pezzutti
Stuart Pill
Richard Sharp
Northumbria University,
Squires Building,
Sandyford Road,
Newcastle upon Tyne,
UK

robert.young
@northumbria.ac.uk

daniel.pezzutti
@unn.ac.uk

stuart.pill
@northumbria.ac.uk

mrrichardsharp
@hotmail.com

Abstract
The traditional industrial design process can be described as a complex choreography in three dimensions of the visual elements: form, colour, texture and light. These are designed in order to present the user/consumer with culturally embedded, pleasing and easy to use products. This traditional industrial design process has evolved over a period of approximately one-hundred and fifty years in service of the development of physical products. However, we are now in an age where many products are the point of contact between people and systems of information communication. In this era of human-system operated product interaction, additional dimensions of interaction are possible. The system operated product development process has only just begun to attend to the challenges that this new era poses, specifically; how to design products that operate and interact using the fourth dimension of time. Philips Design Group believes that to create richer interaction with consumer products, the channel of motion within the fourth dimension can be further explored and better used. The challenge of this hypothesis has been explored by three Universities in conjunction with Philips, using three different research approaches. Northumbria University, Centre for Design Research has concentrated on the development of the 'language of motion'; the process of developing system operated products that are culturally embedded, that enrich and enhance the experience of the user. The aim of this paper is to present a series of tools that have been developed to support this process, that will aid the designer in exploring and 'designing' in motion.

Keywords
Product design, movement, exploration, tools & techniques

1. Introduction

We live in a multi-sensorial world, where every human interaction is a complex display of meaning. One of the most subtle yet powerful forms of expression is displayed in the form of body language and facial expression. [1] Through developments in on-screen technologies and in the field of multimedia design, product users have become accustomed to an interaction that is rich, colourful, intuitive, involves movement, yet exists within two dimensions.

Consumer products are traditionally still objects, only moving to fulfil a functional need (in the case of a washing machine, the drum rotates to wash the clothes, and spins to dry them) and sometimes moving as a consequence of this functional movement (the washing machine shakes when on the spin cycle). In order to present the user with a physical alternative to on screen interaction, it is proposed that the expressive channel of movement can be used to great effect in taking rich interactions out of the screen and into the three and four dimensional world.

[1] 4D dynamics: an international interdisciplinary conference on design and research methodologies for dynamic form.
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It has been our role over the last year to start to develop these interactions, exploring how products could move, and what type of information they could express through movement, (in a separate paper entitled 'the language of movement' an exploration of some of the findings of this research will be presented). In this paper, the tools with which we have started to explore and develop movement in product design will be presented and shown in relation to the traditional industrial design process.

2. Background

The traditional industrial design process operates predominantly by utilising the design elements of form, colour, texture and light. These elements are key to the designer's engagement with the product development process since its inception as a professional competence in the mid 19th Century at the time of the Great exhibition of 1851[2]. The emergence of digital working practices[3] and the opportunity for the industrial designer to play an important role in the development of interactive, system operated products[4] in the late 1980s and early 90s led to the increasing use of multi-media design software to design and represent the interactive nature of these products, utilising the added dimension of time.[5] This development has led to a situation where many interactive products incorporate display screens to relay content and control function. The design of these products has similarly evolved to incorporate the process of producing and directing on-screen content, which has an affinity with the process of film and media production[6].

Thus, many products in contemporary society are part of information communications systems and incorporate display screens to enable users to interact with and control their mode of operation. They display their functional state within the information communications system they are part of by graphical communication via their screens. These types of product require a different focus of attention for the user, i.e.: the screen, and their design has also re-focused the attention of the design team to include interaction and interface design specialists and new-media designers. This situation raises the question; will the future characteristics of products be predominantly determined by the user's interaction with the digital or virtual domain represented via a display screen, or can some of these functional states become animated within the simulated physical behaviour of the product as artefact? Could this form of user interaction with an animated product offer greater qualities of experience, create greater empathy with and feedback to the user? It is these questions that have been posed by Philips Design as a key area for research in their strategic research plan for product futures. Philips has selected three Universities to assist them in this research; the Technical University, Eindhoven, The Royal College of Art, London and Northumbria University, Newcastle.

Northumbria's Centre for Design Research (CfDR) in the School of Design has addressed these questions from the perspective of the industrial design practitioner. It has considered the questions in terms of the 'language of design'! If industrial designers have evolved a notional language of form' as a result of their engagement in traditional product development in order to manipulate the design elements of form, colour, texture and light, what elements (vocabulary) would be needed to comprise a 'language of motion' for animated system operated products? Also, what rules of grammar and syntax would be needed to manipulate (write or speak) with the vocabulary. The 'language of motion' is the title of another paper written by the research team at the CfDR about the topic. However, this paper deals with the rules of grammar and syntax or the tools and techniques that have been developed to enable the industrial designer to operate as an interaction designer of motive products.

The images used as examples throughout this paper are examples drawn from our explorative project work over the course of the last year. These projects were the key components of the action research process described below.

3. Methodology

The methodology that has been devised and adopted by the research team in the CfDR is in keeping with an explorative, reflective design practice approach to address the research question. The undercurrent research method has been action research[7] and reflective practice based on a philosophy of empiricism and phenomenological enquiry. [8]

The action research approach has involved three cycles of planning, action, reflection and evaluation in order to bring rigour to the process of knowledge generation through explorative design practice. The design explorations were based on carefully selected design briefs that identified 'real world' user needs and products. In this way the work has kept a clear line of sight with the practical concerns of the product development process and the industrial designer's role within it. The three cycles of action research comprised research explorations as described in the following table, which culminate in a peer-review process to assess the utility of the methods and tools developed during the preceding cycles of research (see Table 1. above).

[2] Heskett, J., Industrial Design, Thames and Hudson, 1980

[3] Baker, R. Designing the Future, Thames and Hudson, 1993.

[4] Bull K., Industrial Design Within System Operated Product Development, PhD Thesis, The University of Central England, 2003.

[5] Laurel, B., Computers as Theatre, Addison-Wesley Publishing Company, 1993, Chapter One, Nature of the Beast, Theatre as an Interface Metaphor, page 18.

[6] Misera, T., Visualising the Future – Industrial Designer, the Craftsmen of New-media. In: European Academy of Design, Design Cultures Conference, Sheffield, 1999.

[7] McNiff J., Action Research Principles and Practices, McMillan, London. 1988

[8] de Jong T.M. van der Voordt T.J.M. (eds.)Ways to Study and Research. Urban, Architectural and Technical Design, Delft University Press, 2002.

	1
Plan	- Explore motion as a channel of expression in product design. - Develop the tools that are to be used while designing in motion. - Develop a language of movement, to be applied to various products.
Action	- Designing and user testing of three products (U.V monitor, smoke alarm, baby monitor) - Development of the rules of movement, developed within the design process. - Exploration and development of the tools for designing in motion. - Review and draw conclusions from work previously undertaken by UNN into motion.
Reflection	- The three products were developed to a presentation model standard, and the outcomes stimulated debate and discussion into the future of motion in product design. - The outcomes could have been tighter and more interesting if we were influenced by a wider range of sources than user testing and our own intuition.
Evaluation	- Although outcomes from the first generation of work were deemed successful Philips believed that we would further our learning more if we looked at other established disciplines that use movement to communicate meaning.
	2
Plan	- Explore tertiary disciplines that use motion intrinsically. The disciplines identified for exploration were puppetry, choreography, and acting.
Action	- Conduct Interviews with - Steve Roberts, Acting; Alison McGowan, Puppetry; Liz Pavey, Choreography. - Inspiration gathering from Animation, Existing moving products and research into movement in multimedia disciplines.
Reflection	- By looking at other disciplines, we discovered new concepts that could be applied to our motion design process - Laban Theory and notation from Choreography, experiencing motion from acting, and animating convincing emotions from puppetry.
Evaluation	- The learning that we had acquired through looking across different disciplines gave the team a more thorough understanding of communicating meaning through movement. - This new learning needed working back into the design process and areas for specific relevance identified.
	3
Plan	- A new brief was set by Philips to test the learning and understanding gained from the previous two phases of the research. The brief was to create a digital content mediator for the domestic environment that used motion as it's main channel of communication.
Action	- By approaching design of the product as if it were still product, we were able to identify the key points at which the new tools we were developing could be implemented. - We also edited the tools in order to understand which were useful and which ones were not. - Consequently greater skills in creating 4D sketches, animations and hard modeling were developed.
Reflection	- It was interesting to examine how designing in motion fitted in with the traditional industrial design process. - most of the methods we had developed were used previously and were employed somewhere within the process. A greater understaning of designing in motion was reached through applying our techniques and reviewing their effectiveness.
Evaluation	- during a two week workshop with Philips in Eindhoven we were given the opportunity to present our research to a diverse cross section of Philips design team. I-cat was scrutinised and our intuitive process questioned, which highlighted points that had become second nature to us.

Table 1. Three Cycles of Action Research of the Explorative Design Process

4. Developing new tools and techniques

Industrial design practice has evolved a comprehensive range of tools and techniques to manipulate form, colour, texture and light, for example 2D sketching, CAD modelling and 3D soft and hard modelling. Similarly, designing movement into product will also need to evolve effective tools and techniques. If a product moves deliberately, these movements will need designing and considering. Therefore the approach of the research team at the CfDR to the development of suitable tools and techniques has been to explore and refine through design practice enquiry over the three cycles of hypothetical design projects described in the chart above.

A chronological description of how each new tool can be used is presented here, referencing key texts and observations of events within our working process.

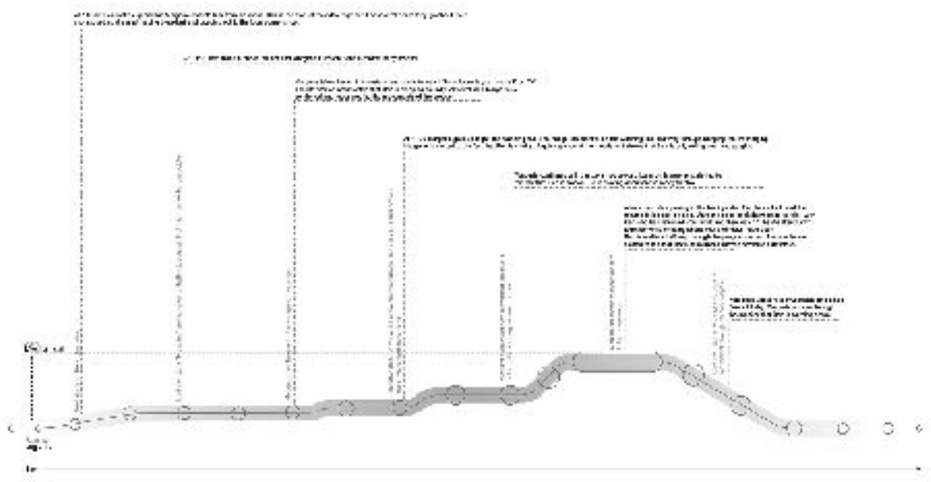

Figure 1. A visual, displaying a scenario in relationship to both the user and product interactions

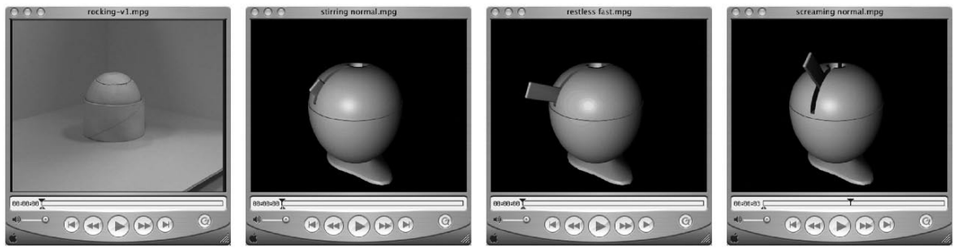

Figure 2. Baby Alarm Monitor

4.1. Designing in motion
The work of the CfDR research team has resulted in a collection of the most effective tools for designing in motion, derived from over a year of explorative research into the context of and through practising motion design.

The tools will be presented under four subheadings, these are: The Adapted Industrial Design Process, Software, Experiencing Motion and 4D Sketching Within the Designing Movement in Product Process. It is not intended that the tools and techniques that are presented here are to be used in a strict chronological sequence but rather as a palette to reference at any stage of developing a product.

4.1.1. The Adapted Industrial design process
This section presents the basic tools with which motion in product design can be explored:

4.1.1.1. Scenario writing
Scenario writing is used in three stages. The first explores a user, from their perspective, how they live their day to day lives, how the product might fit in and aid in their rituals, this can be written in story format or presented as a cartoon. The second stage of scenario writing explores how a product might fit into the daily routines and rituals, looking at the scenario from the product's rather than the user's point of view. The third stage of scenario writing looks at how the user and the product interact, and identifies what types of movement might start to facilitate this. This is then used as a starting point from which to begin brainstorming. (see Figure 1. above):

This schematic is indicative only. The original was created at A3 size and is meant to act as a planner to assist the monitor, review and control of projects.

For example in a baby alarm, the alarm needs to communicate an alert therefore the baby monitor may wave or become larger and taller. (see Figure 2 above):

Figure 2 shows images for the development of a baby alarm. The first image on the left hand side is a 4D sketch where the ball rocks from side to side in its socket. The following two images are snap shots of the CAD animation whereby the 'hand' rocks at various heights to show different alert levels. Finally in the fourth image along the whole top half of the model rotates to show the highest intensity of alert.

4.1.1.2. Brainstorming
Once a series of movements have been identified using the process described above, three issues can be used as a framework round which to start brainstorming. Using the baby alarm example given above, the movement of waving can be examined and brainstormed in relation to
The context – this section of the brainstorm is used to identify other contexts with which the movement might be used for example: getting attention, waving hello, looking for someone.
Qualities of movement - The qualities of the movement are discussed and examined in relation to the context brainstorm. Qualities such as speed, rhythm, and scale can be discussed in a brainstorm.
Form – At this point it is important to consider how the movements might fit into a form, and what sort of formal properties will be needed in order to create the intended movement. Using the example of a baby alarm getting attention, some sort of arm will be needed in order to wave.

4.1.1.3. 2D sketching
The sketching process when designing in motion does not necessarily have to come at the start of the process. We often found it was important to discuss the movement in abstraction, before discussing and interrogating formal properties.

Quick 2D visualisation of form still has a place in starting to discuss how the product might look, and how it might actually move. This discussion is important in starting to explore new product typologies, and in not letting the qualities of movement develop too much, leaving important formal qualities behind.

4.1.2. Software
When designing in motion, we have found that we have needed to explore and identify different programmes and digital tools that can be used within the design process. It is important to design in 4D (time and movement) from an early stage in the process, as movement is a sequence and not static, therefore traditional techniques such as brainstorming and sketching have been modified and are presented as a set of 4D tools below.

4.1.2.1. Creating a motion scrapbook
A motion scrapbook can be created at any point of the project in order to create a collection of movies that can be used as inspiration, reference and to stimulate discussion. Through the website www.gettyimages.com, a collection of QuickTime movies can be compiled, similar to the way a pile of clippings from a magazine can be made at the start of the traditional design process.

Again, using the baby alarm as an example, a collection of waving people, or people trying to get attention may have been gathered. The designer will then need to view these clips. One way is to look at each one separately through the quick-time viewer, the second way is to compile the clips in an Applemac programme called I-movie. I-movie allows very quick and easy editing of clips, as well as the ability to string them together in a sequence. The stringing together and viewing of related clips allows the designer to get a feel for the types of movement they would like a product to perform. (see Figure 3. below):

4.1.2.2. Sketching in motion (motion sketching)
Again using I-movie, the designer is able to take a clip and manipulate it. By speeding up, slowing down, reversing and stringing together clips, the designer is able to examine

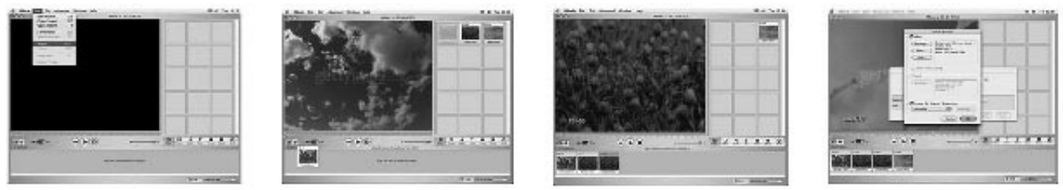

Figure 3. Snap shots of the CfDR Team creating a motion mood-board using Apple's Imovie.

Figure 4. Snap shots of the CFDR Team creating a motion sketch using Apples Imovie.

Figure 5. Snap shots of the CFDR Team creating the animation of our " using Apple's Imovie.

specific qualities of movement using existing clips. For instance an opening flower can be used to examine speeds and rhythms. From this abstract source the designer can identify qualities of motion that may be appropriate to the product.
(see Figure 4. above).

4.1.2.3. CAD (computer aided design) tools

Using the movement inspiration of the motion scrapbook and motion sketching, a crude CAD model can be designed, with initial ideas about the form included. This tool allows the formal development to 'catch up' with the movement development, and allows the designer to experiment with different movement speeds in order to begin to communicate the correct meaning. To do this We used short quick-time exported files from CAD and then edited a longer movie together. (see Figure 5. above):

4.1.3. Experiencing motion

From a process of looking at tertiary disciplines such as puppetry, acting and choreography, we have learned that actually experiencing movement through ones own body is an integral part of starting to understand how movement and meaning relate, therefore, running parallel to the development of physical tools, we have also developed some methods to aid the designer to experience motion.

4.1.3.1 Examining existing protocols for notating movement (Choreography)

By looking at protocols such as Laban theory [9], symbolism and representation of movement can be vital inspiration in looking at the breakdown of movement into key parts.

As a result of studying systems of notation for movement such as Laban, our researchers quickly realised the special emphasis that is necessary in terms of the approach of the Industrial Designer to comprehending and manipulating qualities of movement in product contexts. The analogy is the difference seen in the Industrial Designer's approach to configuring the form of a physical product to help it to embed culturally in its context, compared to the approach of a Mechanical Engineer who might only see the form as a structural component. (see Figure 6. below):

Figure 6. A choreography performance at the Baltic.

[9] Newlove J., Laban for Actors and Dancers: Putting Laban's Movement Theory into Practice : A Step-By-Step Guide, 1993

4.1.3.2. Animating actual objects (puppetry)

Through looking at the discipline of puppetry, and interviewing puppeteers, skills related to animating inanimate objects have been learned. From these discussions, vital comments such as 'do you really have to use a stick to control a model, when using hands with black gloves on can be more flexible and effective' have been used to develop our 4D sketching process. Projecting emotions onto an object and using breathing as a way to time movements are other important points learned from the puppeteer. (see Figure 7. below):

Figure 7. A lesson in puppetry by Alison McGowan.

4.1.3.3 Imagining oneself as a certain motion (Acting)

Interviewing and discussing motion with actors has taught us about the importance of imagining and being aware of various parts of ones body during everyday life and interactions. For instance, during the project, we have become aware of how our bodies are positioned during actions such as being surprised, interested or concerned. Being aware of subtleties in body position creates a greater understanding of detail when these movements are translated into products.

4.1.4. 4D Sketching within our process

4D sketching represents a valuable link between traditional skills found in conventional design practice and how they can be utilised for motion design. Working with materials is for designers an integral part of the design process and facilitates idea generation and development.

Forms and prototypes already exist as a recognised medium and deliverable in design and therefore represent an accepted and useful medium to illustrate ideas.

However 4D sketching is limited in the way that it only facilitates a very rudimentary construction of models. This is fine for the study of formal qualities but it falls short for portraying motion. The problem stems from the crude control that is currently possible for the models, which means that they are just not sophisticated enough to be manipulated in a way that allows any value to be derived.

Model making is also extremely time consuming and expensive as an exercise.
The images below show the development of our smoke alarm, including the quality progression with rough first 4D sketches building up to better quality three dimensional models capable of being animated by puppetry acting. (see Figure 8. below):

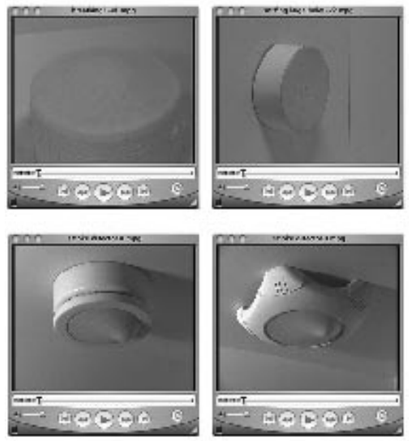

Figure 8. Progression of model making sophistication

4.2. Applications for Industrial Design

The aim of this work has been to develop an improved understanding of motion, to be able to create animated products with more considered movements so as to enhance communication rather than hamper it.

In creating an informal palette of tools that facilitates the designer to explore and learn from the many issues that relate to the challenge of designing moving objects, we can begin to develop a language of motion for the world of product.

The following description is a review of all the tools and techniques that have been derived from the research process described above. These have been categorised under headings which represent key phases in the designing with movement product development process.

4.2.1. Essential tools and when they are most useful in the design process of system operated products

4.2.1.1 Changing approach
To learn a new attitude of approach for an imotive project and to give confidence in working with a new design process.

A motion scrapbook (mood-board) enables a person to collect footage from image banks and DVD's to create a quick-time file for general inspiration. Studying video is a good way of understanding motion qualities and sequences.

Motion sketching enables the person to manipulate a single movie clip to experiment with the various qualities that make up movement. It is a useful tool to get into the mindset of thinking in motion.

By using techniques employed by actors a person can act out a motion using their own bodies. This is important also to see the link between form and motion. If you act out how a rhinoceros would act sad you have to consider the frame of a rhinoceros. You can act out abstractly by looking inside yourself to see how you would move if you were sad. A good technique to try is to act out and experience the difference between excitement and anger (remember only using motion and no facial expressions).

4.2.1.2. Inspiration
These tools are used within the team in order to inspire and change the designers approach to the industrial design process, from a static approach to an approach that stimulates discussion and development of motion.

Brainstorming can be used throughout but is useful at the beginning of a project to get all ideas out and allow people to move on.

Motion mood-boards are a collection of movie clips which enable a designer to debate a movement in its natural state, as a sequence of movements.

Acting and experiencing motion using your own body can also be undertaken as a tool for inspiration in a group exercise.

4.2.1.3. Making decisions
Scenario writing is a good tool to use to decide what needs to be communicated and in what sequence.

Soft model making allows the designers to manipulate a model in 3D to explore how it could move.

Creating CAD animations of forms is a quick way of using form and motion. CAD is best for simulating smooth accurate motion.

Experiencing motion can be used as a decision-making tool, where a person can act out what needs to be communicated in order to understand the movement.

4.2.1.4. Development tools
The following tools were used during the project described above, to develop both form and motion simultaneously. The benefit of this application is that it results in a balanced product. This collection of tools helps to work the concept up from raw ideas within the design team to making the models public and open for discussion outside the design team.

Traditional sketching can help when thinking of ideas.

Filming 4D sketch models can be used to see how a designed form operates and the motion model will work.

Again, CAD animation is a quick way of using form and simulating smooth accurate motion.

4.2.1.5. Communicating to team mates
It is important when working in a team to be able to function on the same level, especially when adding in the fourth dimension of motion to traditional product design. To communicate a movement precisely and accurately is important. There can be a lot of compromise because some movements are only possible with certain forms.

Scenario writing is also a way of keeping everyone in a team on level ground so that they know what the order and sequences of the movements should be and just as important, why they are in that order.

4D sketching and soft model making – interrogating in 3D. CAD animation – fine-tuning motion qualities.

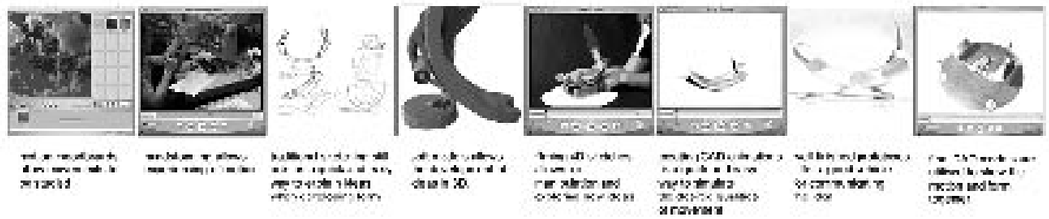

Figure 9. Application of tools and techniques in the context of the project.

Motion mood-boards allow discussion, debate of ideas and also manipulation of movement qualities for discussion.

4.2.1.6. Evaluating ideas
Again CAD animation is a quick way of using form and motion.

One can revisit an initial scenario for evaluative purposes using motion mood-boards and the techniques for experiencing motion.

5. Summary
The greatest benefit to the research team from the tools and techniques introduced and explained in this paper for designing with movement was in experiencing their effect on the project work and on our working habits. All of the tools and techniques described here were put to use in our i-motive project called 'Icat'.

This paper hopes to illustrate how inadequate conventional techniques and processes are for dealing with motion in design. Methods that have been developed and explained in this paper create an essential part of a new palette of tools to tackle motion in design. During a workshop in Eindhoven with Philips staff and representatives from the other collaborating research Universities; the RCA and TU/e, the sophistication of movements that the CfDR Team had been able to produce in their 'icat' product concept were regarded by those present and involved in the review to be a direct result of the application of the new tools to the design brief. It was interesting to note the high level of interest of the other designers in the workshop as to how we had tackled the medium of movement in design. For example, these new processes and tools were something that designers at Philips were keen to try out for themselves. The workshop enabled the nature of the motion design process and the tools to be experienced rather than simply observed. This meant that the designers present could start to appreciate the complexity of designing specific motions. Through this dissection of movements we were able to illustrate the different needs for these tools to allow the designer to work with movement. The reaction of the workshop members to the motion design process and tools indicated that the CfDR Team had been successful in its objective of creating tools that were effective and of utility to practicing product/interaction designers of system operated products.
It is highly recommended by the CfDR research team that this paper is also considered in relation to the experience of being talked through the tools workshops that are proposed for delivery at DeSForM. In this way the reader will be able to get a more adequate understanding of the description of the research findings.

Icat Project Example
The figure depicted below shows the application of the tools and techniques in the context of the Icat project. (see Figure 9. above).

Glossary of common terms used
4D sketches - term defined by Loe Feijs[10] in relation to rapid model making for quick testing and analysis
context - the circumstances or events that form the environment with which something exists or takes place
degrees of freedom - the range of motion that a specific form will allow

[10] Kyffin S & Feijs L. ibid

emotions - short term feelings
e-motive - considers the effects of motion on peoples' emotions
freedoms of movement - defined by the number of axis that a form utilises in motion
Future Philips - our term for describing ourselves: Bob Young, Stuart Pill, Dan Pezzutti and Richard Sharp
language of movement - general 'alphabet' of terms used to categorise movements
mediators - products that act as an interpreter for changing a raw input into motions
moods - long term feelings
motion moodboard - a collection of motion clips that allows for analysis of motion
poetry of movement - producing elegant sophisticated movements that blend together
priming - creates a more in tune way of thinking for a person who is 'cold' to the e-motive project, having the effect of increasing the persons comprehension of the task
Qualities of movement - make up of a motion, including speed, volume, direction and path
sentences of movement - constructing phrases using the 'alphabet' that has been established
super beacons - term described by Steve Kyffin to illustrate the idea of creating a singular product that can communicate multiple emotions
u.v monitor - large scale, group communicative product for sun safety
smoke detector - experimental control product that directly compares to Team-work
baby monitor - small personal household appliance for child safety
Team Philips - consisting of five under graduates who provided the e-motive projects foundation

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Robert Young
Daniel Pezzutti
Stuart Pill
Richard Sharp
Northumbria University,
Squires Building,
Sandyford Road,
Newcastle upon Tyne, UK

robert.young
@northumbria.ac.uk

daniel.pezzutti
@unn.ac.uk

stuart.pill
@northumbria.ac.uk

mrrichardsharp
@hotmail.com

Sietske Klooster, Kees (C.J.) Overbeeke

Designing products as an integral part of Choreography of Interaction: the product's form as an integral part of movement

Abstract
Recent developments in design research concentrate on two themes (1) the unity of form, function and interaction and (2) the semantics of movement. The Design Movement approach incorporates unity of form, function and interaction through movement. Design Movement introduces the design of products as an integral part of Choreography of Interaction, and thus as an integral part of (the design of) movement. This approach therefore puts forward a distinctive view on the relation of product form and movement in interaction design and, consequently, a view on semantics. In this paper we introduce this challenging view. In order to do so, we explain the framework of Choreography of Interaction, its motivation, and the way the 'interaction choreographer' uses it to create interaction. The framework is based on the idea that movement (1) is the embodiment of interaction and (2) comprises the trinity of Physical Involvement, Dynamic Quality and Expressed Meaning in interaction. The framework incorporates the way Design Movement approaches the relation of product form, movement and semantics for interaction design.

We realize that theoretically describing this approach is a nearly impossible venture. In fact, only through movement, through practicing it, the idea can actually be grasped. Therefore, we commence with examples of projects to illustrate our endeavour.

Keywords
product design, form, interaction, movement, choreography, physicality, dynamics, meaning, semantics, integral.

1. Introduction

During her graduation project 'Ontwerpen Beweegt' ('Design Moves') [1], the first author explored the way movement relates to design. This project was the starting point of ongoing research and development of the Design Movement approach.
Design Movement is conceived as a cross-pollination of interaction orientated product design with dance improvisation and choreography. Design Movement understands movement as the embodiment of interaction and hence it perceives design as 'Choreography of Interaction'. Herewith it introduces the design of products as an integral and motivating part of Choreography of Interaction and movement as pivotal for design. [2].
Both the design process and the design outcome are approached through Choreography of Interaction; creating and creation are interlaced. Choreography of Interaction is based on a framework, which incorporates the trinity of Physical Involvement, Expressed Meaning and Dynamic Quality.
Design Movement is an explorative approach, which develops through practical experience and experiment and is embedded in design research. It is not typical design research nor purely design practice; it involves both.

Design Movement researches and develops primarily through bringing it into practice, reflecting on it and processing insights. Design Movement seeks interaction with and confirmation from research as it challenges parallel and related topics.

Product design research recently re-focused on (1) the unity of form, function and interaction [3] and (2) the semantics of movement [4; 5]. We think that Design Movement offers a unique contribution to this re-focussing.
Since this approach addresses product design as 'just' an integral part of Choreography of interaction, it demonstrates to have a characteristic view on the relation of product form and movement in interaction design and, consequently, on semantics. In this paper we put this view before you reader, as input for discussion about the role of movement in interaction design.

As we introduce a distinctive view and inherent jargon and know the complexity of reading into a new perspective, we like to give and partly repeat some definitions before proceeding, in order to enhance the readability of our paper:
- 'Design Movement' is the name of the design approach we introduce.
- With 'Design Approach' we mean a way of understanding and thus addressing design, which here concerns both the design process and the design outcome that are seen as a unity.
- The term 'Choreography of Interaction' indicates the way Design Movement approaches design.
- If the 'Product' is mentioned, we mean the conventional understanding of this word, the concrete object. This product is designed as part of the actual design outcome, the Choreography of Interaction.
- When we talk about the Choreography of Interaction 'Framework', we address three interconnected pivotal points to understand and create Choreography of Interaction.
- This trinity consists of 'Physical Involvement', 'Dynamic Quality' and 'Expressed Meaning' of Choreography of Interaction, which we define later on in this paper.

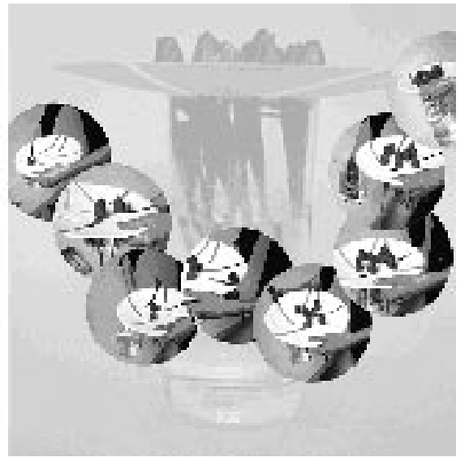
Having provided the reader with this introducing, we will first present a set of examples as we feel that theoretical, abstract understanding and insight are best supported by practical experience. These examples illustrate the ideas that are put forward in the following parts. In the third part we introduce Choreography of Interaction as something to be created. Here the Choreography of Interaction framework is introduced, which entangles product form and semantics and their integration in movement. We explain the way Choreography of Interaction operates as a creative and creating process in part 4. Here it becomes clear how the framework is established during the Choreography process and thus how movement, which incorporates product form and semantics, embodies interaction. We bring this paper to a conclusion by putting forward the next steps we are about to take with this approach and the opportunities we see, and hope to unlock with laying out our ideas.

2. To illustrate

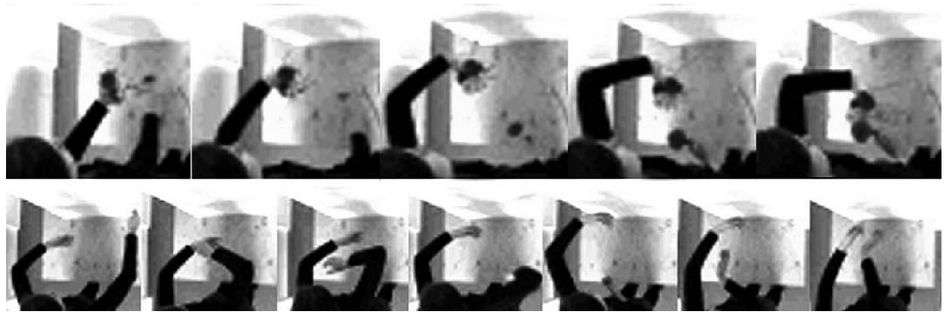
As we ourselves experienced the need for examples from practice to understand theory and develop new insights, our paper starts with this illustrative part. We intend to waken the reader's imagination and empathy and thus support insight in the more abstract parts of this paper. This second part depicts three cases. Each case starts with an introduction to the created Choreography of Interaction and a subsequent part that explains the process that preceded it. This matches the structure of the following parts in this paper, where part 3 focuses on Choreography of Interaction as a design outcome and part 4 on the Choreography as a process.

2.1 Commit: Choreography of Flower Arranging

A light fluent rhythmically intertwining whirl of curving traces from outside inwards:
With greedy admiration she looks down on top of the beautiful corollas, which she brings in one after another, composing a plane full of them. Elegantly lifting, she feels the weight hover in her one hand. From almost nothing the weight increases, while the other hand brings in more of these colourful flowers. Left and right arm turning and curving around each other, steering the circle and grooves of 'Commit' to choose where to enter the flowers. With a rhythm of one flower after another, irregular, depending on the pace of choosing position and composition.
The flowers open upwards where she looks down.
The stalks' weight hangs passively downwards while she holds them carefully with the tips of her fingers, steadily, just under the flowers corolla, aware of their fragility.
Slowly, she slides them into the curved grooves, with a slight deceleration just before the sharp rim of 'Commit'.
Gradually the Commit-dish is filled with corollas and the stalks dangle lightly underneath. With a final slow gesture she brings the composed result downwards and hands it over to rest and bloom in the glass vase.



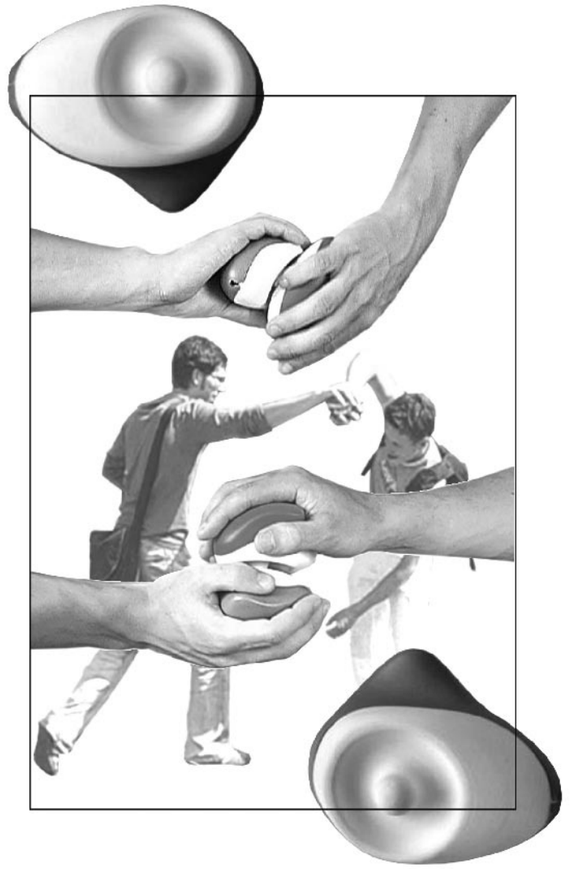
This is a Choreography of Interaction and thus product design by Sietske Klooster, the first author of this paper. This case was part of her graduation project in 2002.
Having named her Choreography of Interaction project with 'Flower Arranging', this designer, or interaction choreographer, first explored who and what are to be involved in her Choreography. As flower arranging has to do with the greedy admiration of the flower arranger (the user) towards flowers, the exploration started with these two involved parties: By empathising with the user and thus moving into interaction, the choreographer searched for the way she wished the user and the flowers to be involved in arranging a bouquet. While doing so, she felt the importance of the bending circular connection between fingers, arms, shoulders, neck, head, eyes, line of sight, flower corollas, steels and back to the fingers again. She discovered this connection to be breathing-like and fluently deforming while looking down admiringly from different angles. While holding the fragile stalk of the flower carefully, she discovered the importance of the centre of gravity of the flower's weight. If she held the stalk relatively far under the corolla, this would result in an uncontrolled wiggle of the flower and necessarily forceful pinch with her fingers to prevent this to happen. Holding the stalk just under the corolla resulted in an elegant, stable balance and caring lift. At the same time she felt the greed to bring more and more of these beautiful flowers into her personal space, which she bordered by her arms. Having a shortage of hands she was urged to squeeze more and more stalks in her hand. Disliking this rough interplay with these fragile flowers, the choreographer impulsively slid the flowers between her fingers, enabling to hold more of them and protectively lift them in the palm of her hand. This impulsive discovery also resulted in an interesting relation between the corolla and the hand; they both opened upwards to the users admiring eyes. The stalk at the same time was free to passively hang under the lifting hand, in which the user could feel the weight grow while entering more and more flowers.
The choreographer also realised her discovery resulted in a duet of arms: She saw a whirling correlation between both arms. The one arm embraced the space to bring the flowers into. The spaces between the fingers of this arm imposed directions for the other arm to bring the flowers from outside in. Both arms thus appeared to turn in relation to and towards each other, with an irregular, fluent rhythm of one flower after another, to find the entrance to the right composition. While doing this all, the functional-emotional role-play between user and flowers became evident. The admiring elegance of arranging flowers expressed a greedy kind of care. The fragile flowers were carefully forced for their beauty. The watching, collecting, turning, bending of the user, related to the passive, fragile, beautiful up-looking flowers. While this flowing rhythm of turning arms with one flower after another evolved, the choreographer again met a limitation. She was still not able to hold the amount of flowers that would answer her admiring greed. The choreographer wished to fill the embraced space and expand it into a plane of flowers, opening up towards their admirer. She felt the need of an expansion of her hand into a grand collection plane. She wanted to enhance the turning of both arms around each other, confirming the embraced space while searching and positioning the composition. She wished to support the contradiction of care and greed in admiration.
While movingly investigating her wishes for abilities, the choreographer started to focus on associations that would lead her to the final step of her creation. She focused on characteristics of a product: A product to be involved as a third 'dancer' and with characteristics that would enhance and elicit her created way of flower arranging.



‘Commit’ enhances and confronts with the contradiction of commitment for care and committing the sin of greed. It has a circular shape and curved grooves that fit the turning of the arms and sliding inwards the flowers with a fluent, irregular rhythm, one after another. The bent plane fits the corolla’s upwards direction towards the user looking down on it. The grooves support the holding of the corollas and hanging stalks and herewith the lifting of the arm. ‘Commit’ is of lightweight material, which supports the feeling of growing flower-weight and elegant lift. The sharp rim of ‘Commit’ demands extra care when entering the steel in the grooves; it makes the user experience that greed is to be balanced with care, while forcing the flowers lightly to be owned and admired. The supportive imperative form of ‘Commit’ takes the role to elicit the user and involve the flowers to ‘Commit to Flower Arranging’: Thus she defined the final name of her Choreography of Interaction and of the product that developed as an integral part.

2.2 How are you? Dancing: Choreography of a coincident Meeting Duet of two friends

Impulsively connected, exploring contact, bouncing and turning to extend into dichotomy:
Stopped by impulse he curiously senses distance. He pinches the rubber backside skin of ‘Join’, which shape merges with his right hand. By doing so he gives a pulse that circles outwards in all directions, like a ripple on a water surface when a stone is thrown in. He pauses silently and waits to feel the moment the pressure comes back, vibrating in the inside of ‘Join’. When this happens he pulses again, while he hesitantly chooses a street that imposes a direction. He turns right. He receives the answering pulse a bit quicker then before while he heads towards the next street corner. Being sure now he increasing his pace. The pulses speed up gradually, until he reaches the next corner. Here he meets a choice of direction again.
Through ongoing pulse exchange with his friend, they attempt to reach each other: They both are equipped with their ‘Join’s’ sense of distance, but handicapped because they cannot feel direction. Direction towards each other can be found by experience and experiment, by changing place, relocating and sensing change of distance through ongoing pulse exchange.
On the next corner he guesses and enters a new street, to the left; now the duration between sending and receiving increases. Wrong direction. Resolutely he turns and chooses the other street. The tension of curiosity and excitement increases, as the speed of pulses do. He suspects to be able and see his friend now and starts looking around, hoping his eyes will show him the way now.
‘It is you!’ he shouts, when seeing his friend. With shared feeling of surprise they bridge the last piece of distance directly. The distance decreases as they approach, until they can touch and share a personal space between them. Mirroring each other they right handily link their ‘Joins’ to a joint. An affirmative connecting sound can be heard when the hard material of their ‘Joins’ front parts make contact. Their joint hands transfer into a touching and turning plane, supported by the mirror-fit of their ‘Joins’ knob-trail-shape. Their point of contact extends to their full bodies and challenges them to explore their dichotomy movement. Throughout this meeting game, they bodily investigate the way they relate. They interactively explore their equivalence and differentiated roles through their ‘Join’ body extension.



This Choreography of Interaction was created by the second year students Jan Hoefnagels, Charles Mignot, Bram Steevens, Bram van der Vlist and Mathijs Wullems, in the ‘How are you? Dancing’-project in 2004.

This Choreography of Interaction was created by the second year students Jan Hoefnagels, Charles Mignot, Bram Steevens, Bram van der Vlist and Mathijs Wullems, in the ‘How are you? Dancing’-project in 2004.
The creation of their Choreography started with an exploration of a coincident meeting of two friends, as it exists at present. While moving into this meeting interaction, the students experienced the involvement of the infrastructure. This involved party influenced the way the two friends were coincidently led towards each other, until their lines of sight could cross. When this moment of spotting occurred, there appeared to be a short stop-motion; the starting point of an excited tension of opening towards and approaching each other. The students discovered a more or less mirroring approach that evolved to a physical greeting contact, like shaking hands or embracement. The deviation in this symmetry gave expression to their relation, which could be both seen and felt.
Through moved exploration of the existing coincident meeting duet, the students got aware of and provided with a scope of possible variables for their meeting Choreography. Their experience also provided them with the discovery of a vision for new Choreography. They found their design motivation in the recognition of the fact that the latest communication technologies diminish opportunities of coincidence and physical contact. The students therefore decided to enhance the possibility of a coincident physical meeting duet. Supported by their exploration, experience and motivation, the students elaborated their idea. They created a play that involved the moment of recognition, the building up tension of approaching and the linking together to explore the expression of friendship.
Inspired by their discovery of the role of infrastructure, which leads to and opens views to see a friend coincidently, they involved this infrastructure as an important player in their new Choreography. In the original coincident meeting, the two friends met when the infrastructure allowed them to see each other. In the new choreography they wanted to introduce sensing a friend without seeing him yet, they wished to sense over a wider range and thus elicit a curious search through the infrastructure to find out who this friend is. Based on their discovery of the tendency to mirror in the initial coincident duet, the students created the idea of action-reaction cooperation between the friends to meet each other. Because distance and direction appeared to be a

key aspect in meeting, the rhythm of cooperation aimed at finding direction and decreasing distance. This way the students created a search of finding direction and decreasing distance, until the friends could spot each other.
Subsequently the Choreography was elaborated from the moment of spotting, towards a way of making physical contact that allows the expression of friendship quality. The students worked on different moved explorations to find the appropriate way of explorative physical contact. They discovered a symmetrical link with the palms of the hands that touch as two planes. These planes formed a touching and turning joint between the friends and allowed a play of leading and following (Although the students did not know they reinvented it, this kind of duet is well known as an exercise in improvisational dance. This exercise makes dancers explore the way they movingly relate into a duet. The role of leading and following can interchange, or it reveals a typical leader and follower). The student's intention was to support and elicit the expression of the kind of friendship: playful or gentle or provocative, etc.
Having designed the involvement of the 'existing dancers', the students completed their Choreography with the embodiment of a concept that elicits and motivates the created meeting play.

It takes two 'Joins' to elicit the game of approach of two friends.
At a distance they are in contact through a wireless connection. Both 'Joins' embody a transmitter and receiver that reach over a distance between 100 and 1000 meters. The backside of 'Join' fits and affords the pinching hand with flexible rubber hand-palm-shaped material.
An incorporated bend sensor catches the pinch as input, which is translated into the sending of a signal. The output of the received signal involves a vibration motor that can be felt through the rubber backside of 'Join' and in the palm of the hand. The time duration between sending from the one 'Join' to receiving in the other, depends on the distance between both of them (and thus on the distance between the two friends): The shorter the time to receive a signal back, the nearer the other friend is. To support this time-distance relation, both 'Joins' involve a Receive Signal Strength Indicator, which information is translated into relative change of distance and thus in the time duration to give the vibration output. This in- and output design loops rhythmically with the action and reaction of the hands and simultaneous relocating of both friends. It rhythmically connects both friends and it relates to the street pattern that imposes choices of direction to reach each other.
At the moment the coulisses of the infrastructure open the way for visual contact, the 'Joins' are designed to motivate joining hand palm contact. 'Join' is designed as half a joint, which fits with the partner 'Join' to be a complete joint. Both halves are of exactly the same shape with a knob in the middle and a circular trail around it. The knob of the one 'Join' fits the trail of the other and visa versa. This equality fits the symmetry of body and dynamics of both friends and elicits to link into a plane of touch and turn. The touch and turn connection extends to the different bodily joints of both friends, thus turning and bending them to become a moving unity. Both 'Joins' join the hands equally, but with the freedom to explore differentiation in the dynamic quality of turning around each other. As a body extension, 'Join' motivates both friends to extend into a joint body and to explore their relation interactively.

2.3 For(m)movement: Choreography of closing and opening dichotomy

A crossing of closing and opening, making space by excluding space, breathing between personal and general space:
As if she makes her bag inhale, she lifts her left arm widely upwards, led by the diagonal line of the bag. Her curved arm stretches an opening to the inside of the bag, while concurrently excluding the world around her: Her arm hence makes an opening and defending gesture at the same time. She enters the space of her personal belongings with her right arm diagonally downwards and with her head bending over to allow a view inwards; again corresponding with the bag's diagonal shape. This results in a cross direction of both arms and her line of sight. In reverse order she makes the bag exhale and entangles the big piece of cloth through her intertwining arms. She emphasises the locking, when directing her glance up again, towards the world around her: Closing in means opening outwards again. All happens close to and around the centre of her body; centred around her belly, as this feels as the most natural place to keep, hold and protect.

This Choreography of Interaction is a creation of Marieke van Liempd, who participated in the assignment 'For(m)movement', as part of the educational program at the Faculty of Industrial Design, in 2005.
Her Choreography started with a moved exploration of the relation between personal belongings, the user and other people in public space. By moving into the situation, Marieke discovered the interesting dichotomy of opening and closing. She explored (1) the excluding an outside world, when opening and entering the way to her personal belongings and (2) the closing in of personal belongings while opening attention to other people and the outside world. As part of this amalgamation she discovered and created the involvement of crossing arms and the focus of the eyes: (1) To open towards her personal belongings she involved the expanding of her left arm. Hence she bordered a personal space in front of her body and excluded the outside world at the same time. Concurrently her other arm crossed under the expanded left arm to enter the created opening. While doing so she bent down to view into the space that was created in front of her body. This way the world around her was shut out not only by her left arm, but also by her bending upper body and by the right arm and eye focus that were directed into this bordered personal space.
(2) This personal centre of the Choreography was also emphasised in the reverse way, again through crossing arms and eye focus. For closing in personal belongings, the lifted and bordering left arm descended to a body crossing embracement around the waist, and under the right arm. This gesture gave affirmation of protection and related the storage of personal belongings to the equally vulnerable belly. At the same time this gesture related to the outside world; because the arm descended from the screening position, it offered space to straighten the upper body and focus outwards again.
Having created this dynamic physical involvement of the user, the personal belongings and the people in the surrounding public space, Marieke generated ideas for product characteristics that elicit this involvement. She built simple models and validated these models by moving them into her Choreography of Interaction. Through these moving and making iterations she created the last needed element to motivate her interaction design; her final product as an integral part of her Choreography of Interaction:

The grand cloth of the bag guides and emphasises the expanding and descending arm, in relation to the belongings and the world around. The pouch of her bag embodies the centre of her Choreography, which focuses the involvement of the user, the personal belongings and the surrounding public. The skewed shape and lines of the bag relate to the diagonally crossing arms and to the line of sight into the bag and outwards to the world around her. Marieke designed a bag, which mediates and motivates the dichotomy of opening and closing, moving between personal belongings and the surrounding world.

3. Choreography of Interaction as a creation

In this part we introduce the way Design Movement sees the design outcome as Choreography of Interaction and we explain the framework on which this Choreography is based. After this explanation the framework is put into the light of the research themes that investigate unity of form, function and interaction and the semantics of movement: We lay out the fabric of product form, semantics, movement and interaction according to Design Movement. We do realise we ask quite a lot of concentration from the reader in this part. Although knowing this, we hope you want to bear with us here, as this part withholds the focus of our paper.

3.1 Framework of Choreography of Interaction

Design Movement views the design of a product as 'just' an integral part of Choreography of Interaction. This means that Choreography of Interaction is viewed as the design outcome and the product as the motivating part that is interwoven in it. This idea suggests that Choreography of Interaction contains and integrates more than the product alone:

Choreography of Interaction and thus movement embodies the trinity of Physical Involvement, Dynamic Quality and Expressed Meaning. These three pivots, strictly speaking, cannot be separated; they are entangled and overlap. We differentiate this trinity for the sake of design perspective and argumentation. The choice for differentiation determines the manifestation of our vision. It brings a certain way of looking at 'reality' and consequently a certain character of creative possibilities. Having said this, we now move on to elaborate on this trinity, which forms the framework of Choreography of Interaction:

As conventional design is seen as design of something physical, we will start with the pivot of Physical Involvement.

This pivot affects who and what are involved in interaction. This includes the user, as the protagonist party. It also involves other people, objects and the location; that is, everything and everyone relevant for the user's concern to move into interaction. Consequently this involves the designed product. It exists as one element of all involved parties and as the one that motivates all other elements to become involved.

Physical Involvement also comprehends physical characteristics; the physical characteristics of user, product and other parties involved. These characteristics include e.g. shape, dimensions, material, weight, texture, construction and mechanics; bones, joints, muscles, skin, eyes, other senses, etc. Physical characteristics offer possibilities and constraints to interact. The particularity of the designed product is that its physical characteristics are designed to appeal to the desired physical involvement of other concerned parties and to their needed physical characteristics.

The relations between the physical characteristics of all involved lead to certain dynamic possibilities and constraints. Here the pivot of Physical Involvement entangles with the neighbouring pivot.

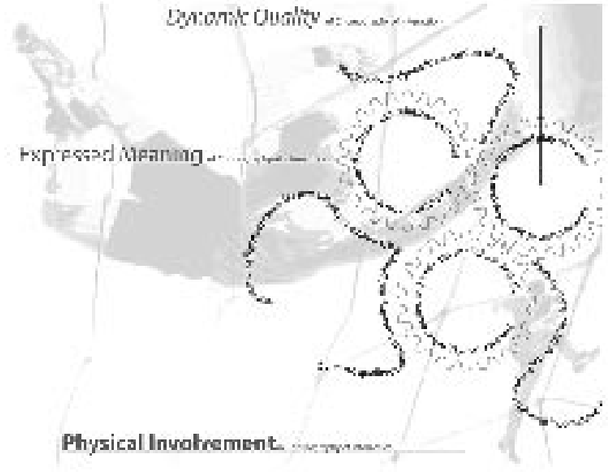
This next pivot involves Dynamic Quality. Dynamic Quality is novel in design and is closely related to knowledge from the field of dance. Because we see it as the crucial pivot that fits physique to meaning, we will go into this matter a bit later. We first proceed with the pivot of Expressed Meaning:

When all parties are physically involved to form one interactive unity, this happens for a reason, with a given motivation and each party having a given role. The pivot of Expressed Meaning therefore concentrates on the meaning of interaction and the different roles that all involved parties have as part of this. It focuses on the meaning of and roles in interaction, which are expressed in movement.

Here the functional meaning of the (inter)action is recognised, differentiated in the different roles of each element, to reach this functionality. Not only functionality comes forward as the meaning of interaction. Function is movingly expressed in close relation with other nuances of meaning, like social, emotional, cultural, and historical, roles and reasons to interact.

When looking at the roles, the role of the user (as the protagonist) is always seen as central. The role of the product is to elicit and motivate the Choreography and thus to appeal to the user's concern to move into interaction and take along all other relevant parties.

Expression of Meaning develops through the physical possibilities and constraints of all concerned parties, and their involvement into a unity. In other words: Meaning is expressed through a certain kind of Physical Involvement, which is dynamic and qualitative. This leads once again to the before mentioned neighbouring pivot; the key pivot Dynamic Quality.



Physically expressed meaningful involvement in interaction is essentially dynamic; it has a Dynamic Quality. Dynamic Quality concerns:

- *The way* relevant parties are involved with their physical characteristics, enabling each other to fit into an interactive unity.
- *The way* the meaning of interaction comes to expression, including the roles that all elements play as part of this.
- Dynamic relations; it concerns the Dynamic Quality of all involved parties together and relative to each other.

Although this pivot involves a novel range of design aspects and details, we decided to only give you an over all idea of what this pivot involves, for the sake of the chosen focus in this paper:

Dynamic Quality consists of three interconnected dynamic dimensions, which are derived from knowledge in the field of dance, i.e., the Rudolph von Laban movement analysis [6]. The first author of this paper still develops this derivative version to be specifically relevant for Choreography of Interaction. The three dimensions of Dynamic Quality are (1) Spatiality, (2) course of Time and (3) play of Forces. Spatiality involves aspects like directions, paths and planes, personal-general space, big-small, etc. Course of Time concerns e.g. fast-slow, accelerating-decelerating, rhythmic-melodic, regular-irregular. Play of Forces is about aspects like passive-active use of weight, tension-release-relaxation, control-uncontrolled, free and bound flow, etc. The composition of these dimensions colour the quality of dynamic interplay of user, product and other involved parties and can result in Qualitative Dynamic actions like floating (which is a combination of curved paths (spatial), sustained (time) and lightweight (force)) pressing, flicking, wringing, dabbing, slashing, gliding and punching.

These Dynamic Quality characteristics closely relate to physical characteristics; physical characteristics enable Dynamic Quality characteristics. On the other hand Dynamic Quality characteristics express the characteristics of the meaning of interaction. Hence Dynamic Quality connects meaning and physicality, Expressed Meaning and Physical Involvement.

Now we have come full circle and shown the interconnection and integration of the three framework pivots. This interconnection and integration is essential for the creative and creating process of Choreography of Interaction, which we will explain further in the next part of this paper. Before doing so, we first highlight the framework's concern with product form, semantics, movement and interaction.

3.2 The fabric of product form, semantics, movement and interaction.

When clarifying the framework, we implicitly came across the link between Design Movement and the research themes that investigate unity of form, function and interaction and the semantics of movement. We will now make this link explicit.

Our basic contention is that movement embodies interaction and consists of Physical Involvement, Dynamic Quality and Expressed Meaning.

- This means that Design Movement understands movement as interaction.
- Another consequence of this idea is that Design Movement does not perceive interaction as BETWEEN product and user in a context. Choreography of Interaction is the total system of user, product and other involved elements IN interaction, as integral part of interaction.
- Subsequently movement is not perceived as something that is 'produced' by a body or object. Movement INVOLVES physicality, the body or object IS movement; physicality is 'motivated'. This also means that Design Movement understands the product form as movement, as motivated.

- Movement is neither perceived in relation to one object or person. An object or body is movement TOGETHER with the other involved parties. This is also the case when one of the parties is statically involved. Being static contributes to the Dynamic Quality of the interaction as a whole.
- This contention also holds that movement is more than dynamics alone, as is often thought. Movement incorporates the trinity of Physical Involvement, Dynamic Quality and Expressed Meaning, of which Dynamic Quality is the key pivot.
- According to Design Movement, the product form is part of movement and comes under Physical Involvement. Product form contains physical characteristics that elicit and offer possibilities for meaningful dynamic involvement with other parties. These characteristics include, among other things, shape, dimensions, material, weight, texture, construction and mechanics.
- Semantics is what is being expressed, the expressed meaning. The meaning emanates from the dynamically involved physique or dynamic possibilities and constraints that are suggested by this physique. This physique does not only concern the product form, it concerns all involved parties and their unity.
- Here the position of function comes forward. The physical unity of all involved parties is a dynamic system, which expresses the meaning of this unification. These semantics regard, amongst other things, the functional meaning of the interactive unity and the role that each involved has while taking part in it. This functional aspect of meaning merges with other nuances of meaning, like social, emotional en cultural expression and roles.

This part of our paper and these points specifically, illustrate how Choreography of Interaction unites a diversity of design topics and how the framework supports insight in this fabric. In the following part we will give an idea of how this fabric is woven: The Choreography of Interaction process.

4. Choreography of interaction as a way of creating

In this part we explain how the framework is filled in as a design process, establishing Choreography of Interaction. We subsequently show how the research topics product-form, semantics, movement and interaction are interwoven and come into existence in the Design Movement process.

4.1 Framework for Choreography of Interaction

Design Movement creates movement through movement: Choreography of Interaction is explored and created in (inter)action, through the moving body of the designer. Consequently the designer becomes an interaction choreographer. This choreographer puts himself in the place of the protagonist, the user. Being this way involved in his creation, interaction is put in motion and wakens bodily awareness of the various framework issues comprehensively. Moved exploration at the same time activates creativity. The use of the moving body as an embodying tool empowers the interaction choreographer to discover and create unexpected, because unexplored, interactive possibilities and combinations. By doing so, he brings his Choreography of Interaction into being, including the trinity of pivots and thus the design of the product as an integral part. This way Design Movement comprehends the design process and the interaction design outcome as a unity; creating and the creation are interlaced.

By being involved in his to-be-created interaction, the interaction choreographer establishes the trinity framework. The product evolves integrally as sediment, resulting from Choreography of other framework aspects. In other words: The product is finally designed as the not-yet-existing 'dancer', with its physique and related role, needed to afford the created Choreography of Interaction. This means the choreographing process starts without a clue of, or focus on a product. It starts with a first idea of the action, the interaction that is about to be created. The starting point therefore is the naming of a provisional functional meaning for interaction.
The composing of the framework proceeds by moving into interaction to explore and determine who and what are relevant to be involved. Here it concerns already existing 'dancers': user(s), other people, objects, location, etc. Because the choreographer is movingly involved, he is able to experience and experiment the trinity of Physical Involvement, Dynamic Quality and Expressed Meaning. He can explore and discover the possible roles when in- or excluding certain parties. He subsequently can feel the dynamic possibilities that therefore arise. He can experience what this adds and changes to the meaning of the interaction; e.g. social and emotional nuances and the way the function can be interpreted and named. This way he can make a first overall investigation through the framework and the first estimation and decision of who and what are to be involved.

The composing evolves towards decisions of how the choreographer wishes the chosen 'dancers' to be involved with each other. He elaborates and refines the coherence of Physical Involvement, Dynamic Quality and Expressed Meaning. He now explores and chooses relevant physical characteristics and the way to involve them for a certain dynamic fit. He investigates the related composition of dynamic dimensions, the nuances of the dynamic quality and, as a reason for this all, the refinement of the meaning and roles. By detailing the embodiment of interaction, he actively fine-tunes the expression of meaning; the functionality, the social, emotional, cultural, etc. roles and relations. Here he elaborates the Choreography into clear decisions about what he wants to elicit and motivate. What makes this part notable is that the choreographer explicitly designs the involvement of all participants, including their relevant physical characteristics. This idea compares to the view on the computer's interface that determines the physicality of the user who needs one eye and a hand with 24 fingers to fit with the computer. [7]. The design of the computer implicitly involves a design of the involvement of its user. In Design Movement the involvement of the user is choreographed explicitly. However (!): This immediately raises the question whether the involvement of the user, the protagonist of interaction, should be manipulated and controlled. The answer is no: The intention of this explicit attention is to concentrate on ELICITING a user to interact. It is the intention to propose the user a motive for expression and experience and to enable new possibilities. Weighing the range between demanding and eliciting, between steering action and offering freedom for expression, comes forward as an important and sensitive part of design.

Until now the process was specifically focused on designing involvement of people and things that already exist. These involved parties however are not motivated and connected by anything yet and therefore the Choreography of Interaction cannot exist yet. Another physical element is needed to elicit the Choreography. This missing link is the to-be-designed product. The product is to be created to offer the needed physical characteristics that fit and motivate the wanted physical involvement of the other parties. The product's physical characteristics are needed to elicit the desired dynamic quality that meaningfully relates all participants to become an interactive unity.

By putting the designed involvement of existing 'dancers' in motion again, the choreographer explores and designs the physical characteristics and related role of the product. By moving he 'thinks' with his full body and wakens associative thinking towards possible product characteristics. His associative thinking is stimulated because he literally senses the missing link, the to-be-designed product. By making many (simple) models and exploring their fit in his Choreography, he iteratively elaborates the product and thus the Choreography of Interaction into a final outcome.
Throughout this process the choreographer directs the 'who and what', 'the way' and the 'why' of the Choreography of Interaction. Herewith the initially chosen active name of the Choreography can gradually change and be nuanced.

During this process it is crucial for the choreographer to develop and detail coherence in the framework through movement. It would be impossible to device the unity of aspects of the framework through imagination and observation only. By being physically involved, the diversity AND unity of the framework can be experienced, hence grasped and created to become a coherent Choreography of Interaction. Physical involvement of the choreographer literally moves him through the framework and thus supports direct and interconnected contact with the Choreography he is creating. Consequently the choreographer's experience directs and motivates the creation of a meaningful Choreography of Interaction.

4.2 Weaving product form, semantics, movement and interaction.

Having introduced the way Choreography of Interaction is created, we will put forward when, where and how the before mentioned recent research topics are interlaced in this process.

Our basic contention here is that interaction and thus the fabric of Physical Involvement, Dynamic Quality and Expressed Meaning, is embodied through movement.
- As movement is the embodiment of interaction, it is a natural consequence that the designer embodies *interaction* through *movement*. Movement here literally is meant to move into interaction as a way of designing, in full contact with what is created and throughout the design process. This way the designer can sense, interconnect and motivate the way he fills in all aspects

in the framework and thus establish the Choreography of Interaction.

- The process is entirely focused on *movement* (and thus on interaction), with the *product form* as an integral part of this. The product form evolves as a trace in the creation of Choreography of Interaction, when all other aspects of the framework have been designed. The choreographer literally and physically can feel the missing link, and thus is able to form the physical product. This form is an establishment of physical characteristics. These integrate in the Choreography to relate to and motivate the Physical Involvement of the other parties. This way it contributes to and elicits the designed movement; the Choreography of Interaction.
- In relation to this the choreographer senses the meaning and role of the product that is needed to engage the user and other parties to become involved meaningfully. By moved and modelling explorations he can feel and thus steer the development of the product form towards the proper body language and related character: The products appropriate *semantics* to afford the Choreography of Interaction.
- Involved with this semantic understanding, the choreographer steers the role of the product as part of the *functional* meaning of the Choreography: The development of an active name for the Choreography, relates to the function of the Choreography. Throughout the process this function is refined with other meaningful aspects like social, emotional and cultural expression and roles. The embodiment of the product form completes this refinement.

These points highlight the way unity of form, function and interaction and the semantics of movement arise and become united while creating Choreography of Interaction. This completes our introduction to Design Movement in relation to the mentioned design research topics. In conclusion we like to show the opportunities we see for future developments, both for Design Movement and for design research and practice in general.

5. In conclusion

In our paper we introduced the Design Movement approach in the light of two recent themes in design research, namely (1) the unity of form, function and interaction and (2) the semantics of movement.
In our experience this is a challenging and appropriate way to approach design, also while this was not done so explicitly before. We believe Design Movement offers opportunities to bring novel nuances and diversification in design: A shift of focus from the design of products to the design of movement leads to a lively and deep-rooted motivation for design. It brings forth products that are explicitly designed to interlace with the world they exist in and for. It leads the way to new kinds of products or refreshing perspectives on existing products. At least that is how we see it and we hope to have challenged design research and practice to evaluate these ideas.
The other way round we feel challenged by recent developments in new technologies. What possibilities do sensors, actuators, software, smart materials, etc. offer, when integrated in the creation of Choreography of Interaction? We are eager to explore and create self-active behaviour of products as an integral and motivating part of Choreography of Interaction.
We also will further explore the borderland we started to share with the dance profession. Design Movement incorporates knowledge and experience from the field of dance, i.e., choreography, improvisation and movement analysis. We therefore work in close relation with this other professional world and imagine this can be intensified into a joint and novel professional field.
We are not the only ones that recognise the value of knowledge from the field of dance for design research and practice. Research at the Mads Clausen Institute for Product Innovation in Denmark, for example, involves the work of Rudolph von Laban to support their idea of Interaction Quality and their observation and analysis of the user's movement [8]. Olin College of Engineering, Boston USA, also discovered the value of the moving body of the designer. Here students are asked to design mechanical principles through moved exploration [9]. The works of MCI and Olin show many confirming similarities with Design Movement, but also very interesting differences to explore and exchange ideas about. This confirms our belief and interest in close co-operation with other approaches in design research and practice and with the dance profession.

We sincerely hope this paper motivates and challenges further discussion, development and co-operation with respect to the role of movement in design. We hope to have triggered many ideas to explore and questions to answer in interplay with each other. EPPUR SI MUOVE.

Sietske Klooster
Industrial Design,
Eindhoven University
of Technology
&
designmovement
Berberisstraat 16
1032 EL Amsterdam,
the Netherlands
Tel: +316 14681018

sietske@designmovement.nl

Kees (C.J.) Overbeeke
Industrial Design,
Eindhoven University
of Technology
&
Carnegie Mellon
University Design
Margaret Morrison.
110 Pittsburgh PA
15213 USA
Tel: +1 412 2687642

kees@andrew.cmu.edu

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Mark Baskinger

Responsible aesthetics: visual noise and product language

There is a radical and detrimental trend in product design, which is responsible for the breakdown of product communication and the rise of visual "noise." The freedom designers have to create any form imaginable, coupled with exploitative methods of attracting users, has affected product language, semantics and commu-nication through a rejection of utilitarian principles and a focus on visual stimu-lation. The relationship of product language and semantics to visual perception establishes whether an object effectively communicates its purpose, function and relevance. When a product fails to communicate, chasms develop between what the user sees and what the user understands and between user intent and action. This failure of product language, called visual "noise," can add complexity to environments, activities, and the visual palette of our lives.

This paper explores the relationship of visual "noise" and perception, defines visual "noise" in the context of product design, describes methods for minimizing its effects and clarifies how the designer must become the key agent in controlling the spread and acceptance of visual "noise."

Introduction

Each object is designed to visually communicate its attributes, functions, abilities, characteristics, and relevance to the user in some way. Through visual language these characteristics take the form of messages which create a visual dialogue between the object and the user. People use vision more than hearing or smell for important tasks in daily life because our natural visual system is highly developed (Baxter, 1995). Natural visual abilities of humans is referred to as "visual intelligence," the innate ability to construct and deconstruct images according to principles of visual perception (Hoff-man, 1998). With visual experiences serving as a map to interpreting things, visual abilities make people perceptually attuned to be able to receive, interpret, and act upon the messages sent by each visual form (Hoffman, 1998).

The rules of visual perception enable information to be extracted from any scenario (Baxter, 1995); this system of visual intelligence is based on surveying, detecting, and identifying the characteristics of forms. Generally, the system studies first the simple, then the complex, searching for logic to construct and deconstruct images (Hoffman, 1998). When viewing an image, familiar and simple properties are perceived first to provide some context for further evaluation. Eyes scan for simple, obvious elements which can be easily identified; the brain is programmed to decipher complex elements and visual patterns. These images are then constructed into a something meaningful by the viewer. When a product form fails to communicate, a chasm develops between what the user sees and what he/she understands. This discrepancy, called visual "noise," can have a deterimental effect on product interaction.

Perception, Interpretation and Form Language

Human visual intelligence has evolved from the innate life-sustaining abilities to identify things that are dangerous, distinguish edible from poisonous, and to recognize facial features and expressions (Baxter, 1995). As an extension, perception of product forms creates visual intelligence through the ability to detect regular patterns according to particular rules which include: (1) rule of proximity – objects or features that are in close proximity will tend to be seen as a pattern; (2) rule of similarity – objects or features which are similar in shape or form will tend to be seen as a pattern; and (3) rule of continuance – patterns are perceived due to continuity, trajectory, or vector of their component parts (Baxter, 1995). When viewing a product form, the image of the object is first seen through a global assessment where the entire form is absorbed at one glance and definitive conclusions are made. This system has the most to do with defining beauty and inferring meanings from forms, rather than anything fundamentally characteristic about the form itself (Baxter, 1995).

Pattern recognition and visual perception enable individuals to create a "primal sketch" that in general terms sets the playing field for an experience. In the case of an ambiguous product form or incomplete information, a person is immediately able to construct a hypothesis based on prior knowledge and project it onto the visual form being viewed. Familiar features and information provide the user with known reference points which can help it from being seen as ambiguous, overly complex, or unattractive. Unfamiliar features demand more attention if the unfamiliarity is to be overcome through visual exploration and understanding (Baxter, 1995). Primal sketches shape the way forms and images are created. Also known as canonic representations, they embody generic views of an object, image, form, person, emotion, or idea and are expressed by mental images activated when a theme or subject is mentioned. Canonic views are important for understanding base-line qualities in product forms, interpreting the personal qualities of a user's perception of form, and shaping more communicative experiences.

Managing information + complexity

A key challenge for designers is in realizing that there is a saturation point where too much visual information or complexity creates a negative effect in product interaction. This threshold generally var-ies depending on user experience, age, and facility with technology and is directly linked to the holistic understanding of designing product experiences. While we generally need some degree of complexity to provide visual interest and hold our attention, an excessive amount of visual information in a product form can have far reaching impli-cations on its surrounding environ-ment, usability, and the mood of its user/audience.

Figure 1: Complexity of visual and physical arrangement of components makes this stereo nearly impossible to decipher.

Visual "noise" and humanism

An audit of contemporary products reveals that many products are somewhat inhumane, meaning, that by their very nature, they create a perceptual barrier or chasm between their product form and the user's expectations. These products can be considered "imbalanced" as their overall form language or particular configuration obscures any meaningful structures for human interaction. In part, humanism in product design acknowledges the cognitive abilities of the user and incorporates expressive visual language to give a form special meaning and relevance. Developing a scaffolding of humanistic principles into a designed artifact can create the "bridge" which connects the user and the object through perceptual interpretation. This specific linkage to an individual or group (participants who maintain similar values and abilities) can enable more effective and meaningful product experiences. The two calculators in Figure 2 have two very different interfaces.

The Radio Shack calculator on the left has a complex and tight arrangement of similar keys with little or no distinction. In contrast, the Texas Instruments calculator on the right shows a more organized arrangement and hierarchy of keys by size, shape and color as reinforcement. While each product has the same capability and functionality, the interpretation is completely different and therefore the product experience dissimilar (Baskinger, 2001). Both calculators employ color and key shape and scale to distinguish between functions; however, the Texas Instruments calculator oversimplifies the keypad to have only two distinct shapes and uses color (blue and yellow) to link the elliptical buttons with the secondary functions notated on and above the keys. In this case, using color as communication makes for a more simple and friendly appearance. The Radio Shack calculator looks to be more complex, less intuitive and takes longer to decipher.

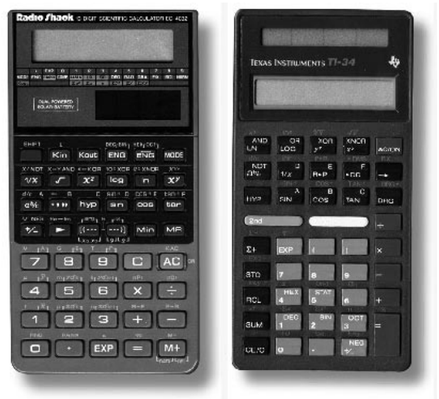

Figure 2: Each calculator has the same functionality, but their form language creates different product experiences.

Some examples of visal "noise" in product design

The nature of "aggressive" forms

Many of the latest design trends are intended to evoke emotions by trivial, superficial means. The main issue here is stimuli; new, strong, loud, exciting, and subsequently "aggressive" signals whose primary aim is to be noticed. These forms visually "speak" to consumers to establish dominance in the marketplace and as a result may visually "assault" any environment they are brought into. The main purpose of "aggressive" products is to "speak" as loudly and/or as boldly as they can to visually establish their presence. The object's "voice" enables users to perceive emotional meanings and language from object forms. Design objects with loud "voices" represent destructive and "aggressive" tendencies that are gaining momentum in culture. As Dieter Rams, a man considered perhaps the world's most renown authority on form simplification, stated, "[Simple] objects do not fit into a world of such vandalism, aggression, and cynicism. In this kind of world, there is no room for design or culture of any type" (Rams, 1989).

The character of "exploitive" forms

The visual styling of objects in effect stores messages which reflect and shape the identity of their owners. There are two forms of styling; "functional and rational," which supports the nature of the product and its role; and "arbitrary" styling which is manipulated to achieve forced or artificial obsolescence. In an attempt to create strong identities for both products and users, much of contemporary design has been reduced to a series of imitation and arbitrary usage of styling cues of innovative or successful products. This practice can generate visual "noise" because the arbitrary and misplaced styles of these forms neither support nor reflect the nature of the product itself; instead they create a superficial veil of value and timeliness.

An example of an "exploitive" design style is apparent in the numerous products that borrowed their styling from the Apple iMac; originally developed to express new views on technology and computer usage. The transparent, streamlined form was a new approach and innovative style designed to change the relationship of users and their computer; it also created a strong identity by which Apple products could distinguish themselves from the market. This style-based identity became fashionable in the technology market because it spoke clearly that the previous models of computers were archaic and out-dated. Ralph Caplan wrote, "Technical obsolescence is reinforced by styled obsolescence, which makes products look old by regularly issuing products that look newer. To buy the new model is to be perceived as new oneself." (Caplan, 1982) Identity buying has made design a commodity in contemporary society. While extending the iMac form language to companion componentry and other technological devices seemed natural, the jump from the tech industries into home appliances, tools, and toys made little sense. In this case, the iMac language was stolen and misapplied to a variety products which inturn made made the iMac less special and less important.

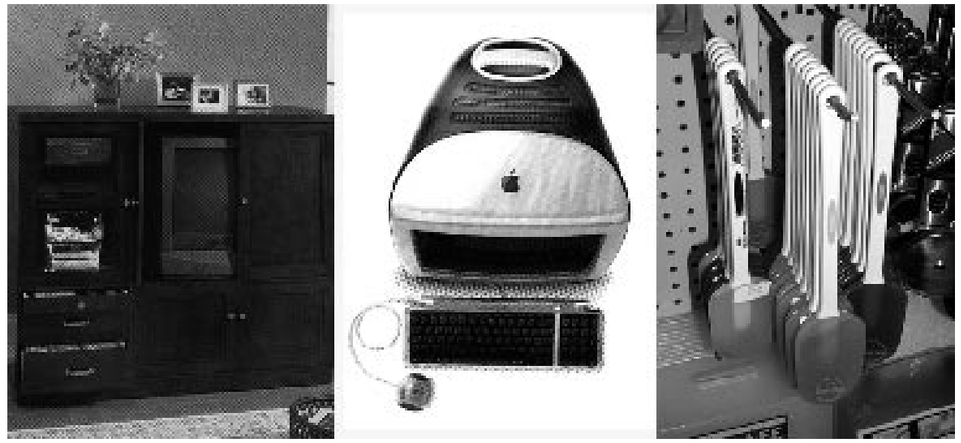

Figure 3: "Aggressive" forms like this silverized stereo can have loud visual "voices" that call for attention and can add complexity to the visual texture of an environment. Product forms that "exploit" the iMac style can have weird and inappropriate formal relationships, like these translucent plastic kitchen wares. Images from potterybarn.com, apple.com, and photo by Mark Baskinger.

Understanding and resolving imbalanced forms

Imbalanced forms represent a dysfunction in the relationship of the appearance and configuration of an object and the way it is perceived by the user during interaction. It is here, in the space between user intention and action that product form language is a critical component in user interaction. Dietmar Winkler, noted educator and graphic designer, wrote, "Science suggests that in chaos, the structure which relates an entity to an organism is not obvious. The observer is either too close or too far, too aloof or detached, or even too lazy, to see new structures. Such a new structure may be a multi-dimensional model that can not be understood unless the traditional language and perception is expanded (Winkler, 1999)." Following are two paradigmatic methods for creating taxonomies of product forms: from the design-centric/creative standpoint and from the user-centric/participant's viewpoint. Evaluating how these product archetypes communicate with their users provides a schema for solving existing inefficiencies in product experiences.

A design-centric paradigmatic approach

Product forms that are created through a literal and logical arrangement of parts can be grouped into a category of "form follows function." In this paradigm, it is easy to decipher how form relates to its environment, structural system, and its purpose (Wake, 2000). Although these forms may have a degree of styling or subjective embellishment, the emphasis of their semantic language reveals direct methods for communicating to the user, as in a counter-top Kitchen Aid mixer. Often these basic configurations can yield a beautiful aesthetic of their own. By respecting their function, these forms reflect the duty and relevance of the product to its intended user and environment and can be viewed predominantly as utilitarian.

A second paradigm where "function follows form" shifts the emphasis of product language toward the expression of individuality and focuses on the user's identity. Often the user must decipher the function of the object after interpreting the meaning of its form. Products that are created in this manner can be described as expressive, emotional, visually interesting, potentially visually chaotic to environments and perhaps compromising user behavior. Dieter Rams stated, "The complicated, unnecessary forms are nothing more than designer's escapades that function as self-expression instead of expressing the product's functions (Rams, 1989)." Peter Dormer wrote, "The 1980's generation of graduate product designers has grown up in the post-modern aesthetic, taking part in but not initiating the rebellion against the modernist belief in classical, ideal form (Dormer, 1990)." As demonstrated by the portable electronics industry, and illustrated in Figure 4, these formal qualities often surface when products are differentiated by purely cosmetic characteristics, not functional abilities.

When form is "independent of function," a great discrepancy between product language and user expectations can occur. In this third paradigm, the physical appearance of the form can create such a strong message that function becomes irrelevant or the visual language is nearly arbitrary. The objects in Figure 5 are actually a camera, phone, and radio that play upon humor as the defining characteristic over utility. Rather than drawing cues from functional requirements, these objects use form to elicit an extreme emotional response (Wake, 2000). Mental models, canonic views and prior knowledge generally provide little support for understanding these forms in relation to their function; the very nature of

Figure 4: JVC Kaboom box photo by Mark Baskinger; Jeep radio from www.businessweek.com photo by Mark Baskinger

Figure 5: Camera image from DiNoto, 1984; telephone from www.disneystore.com; radio photo by Mark Baskinger

these forms may be to surprise the user and challenge their preconceptions. In fact, preconceived notions may only serve to interfere with the user's ability to understand completely the relevance of these forms. This practice of form development reflects a drastic and sometimes final attempt to diversify product lines, and to add nominal differentiation at the end of a product's life cycle. These imbalanced forms can affect the user's ability to interpret, understand, appreciate, and interact with a product. They can also frustrate and confuse, and like any agitation, can increase muscle tension and can cause restlessness (Coates, 1978). Furthermore, these forms generally do not align with mental models, prior experience, or canonic views. Therefore, what the object looks like and how its function is perceived do not coincide. Thus, there is little, if any respect for an individual's perceptual abilities or visual interpretation.

During a product's life cycle, its form will evolve into many configurations to satisfy different markets and respond to the characteristics of the user. Early adopters of technology will have an easier time understanding the evolution of form as they rely on prior experience as a mental model. Late adopters may automatically feel alienated without this prior experience. The general trend for products is to eventually culminate with arbitrary shapes designed to sustain outdated features or technology. To achieve psychological attractiveness and sustain the life of a product, design makes use of aesthetics such that the shape of an object achieves a semiotic (elements of language or other systems of communication that comprise of semantics, syntactics, and pragmatics) quality relative to the user. In many cases, this approach to aesthetics has a consequence of perversion and mutation (Morales, 1984).

A user-centric paradigmatic approach

Identifying and classifying the primary intention of product forms creates a new set of paradigms to include "economical configuration, expressive language, emotional significance, and surprise impact." Looking at products from the user's perspective is less about the proportional balance between pure aesthetics and pure functionality and more about appropriately classifying products relative to the visceral reaction one has prior to and during interaction.

The paradigm of "economical configuration" includes products that effectively achieve a level of refinement above a purely technical or mechanical object. These forms generally represent a conservative translation of the object's functionality. Most often this is referred to as the "black box" scenario where the most logical configuration to the manufacturer and the user is a container-type housing. These forms tend to be visually benign and emphasize the functionality of the object (Baskinger 2001).

The "expressive language" paradigm provides a dynamic scenario that illustrates the functionality of the object through the form language. Logic and creativity are utilized to separate, combine, isolate, and merge elements to create a highly communicative form. This paradigm reveals the most effective means to balance the presentation of an object and how it is to be interpreted for use (Baskinger 2001).

The paradigm of "emotional significance" includes products that generate an emotional response, portray a personality, or create an identity. These forms relate specifically to users based on age, prior experience, knowledge, and preference. Emotional objects tend to be fashionable and reflect the values of contemporary society with primary emphasis on superficial aesthetics over functionality (Baskinger 2001).

The fourth paradigm of "surprise impact" includes object forms that have little or no relevance to the user, their environment, their lifestyle, or the specific functionality of the product, and thereby surprise users as their functionality is revealed. These products generally create intense and sometimes random messages about their forms with no regard to their function (Baskinger 2001). Surprise is derived from the combination of the user's inability to perceive the functional aspects of ambiguous forms and the happenstance of circumstances that reveal them. Winkler stated, "Ambiguity, the dissolution of clarity, is extremely agitating, and although sometimes enjoyable, mostly frustrating. Generally, the more ambiguous the form (not physical size) the greater the number of stabile units and clusters of messages have to be tracked, requiring greater concentration and attention. Ambiguity is constantly shifting energy and its temporal complexity does not allude organization" (Winkler, 1999).

The evolution of music player systems demonstrates various paradigms and illustrates how product forms can become imbalanced. Home music systems have slowly changed over the course of a hundred years since 1900, from a mainly logical/functional design to surprising and highly emotional forms. Although each progressive trend of radical styling was complemented by a following reprieve with an emphasis on functionality, the end of the century (1998+) showed there was an extreme focus on emotional forms. The imbalance of these forms was reflected by their over-styled, emotion-aimed appearance that was created to attract the user, but was functionally difficult to decipher and compromised the effectiveness of the product experience. Portable music devices and wearables have followed this trend with far shorter evolutionary paths into this state. Small or micro media players demonstrate the quickest jump from a logical, balanced form to emotional styling which can be both

Figure 6: Images from www.jvc.com, www.kitchenaid.com, www.toysrus.com; Starck juicer photo by Mark Baskinger

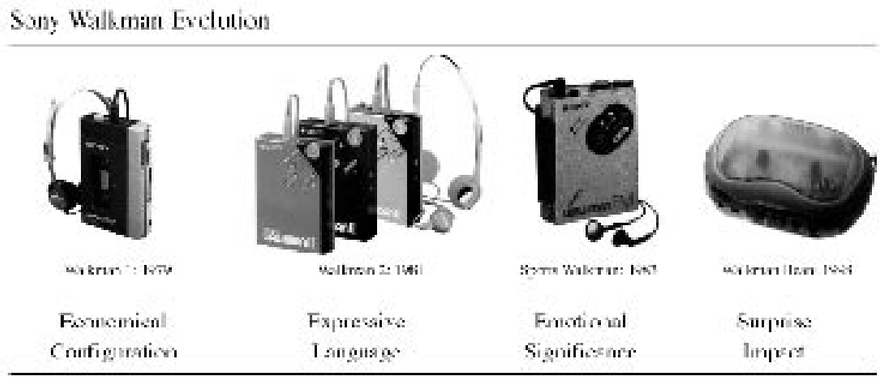

Figure 7: Images from Kunkel, 1999 and www.pocketcalculatorshow.com

arbitrary and confusing. The design of mp3 players that utilize the most current technology were originally based purely on superficial cosmetic differentiation. The arbitrary nature of these forms speaks nothing of their function or of their abilities. The iPod was the first of such devices that clearly incorporated a form language that communicated its various functional attributes - the simplistic form and monochromatic palette accentuated the differing geometries of functional components and set the new standard for physical interaction and navigation through these digital files.

Sony has long been an industry trend-setter but generally characterized as a conservative company. Evaluating their products along paradigms shows that in recent years there is an increase in forms that are emotional and surprising. See Figure 7. The reason for the increase may be economically based to add variety among product lines or to extend the lifespan of defunct technology. However, it demonstrates that all products have the ability to become imbalanced. In fact, Sony offsets this trend by maintaining a few products that are still seen as logical or expressive. This attempt may represent an ideology and company philosophy or may add to Sony's dominance of the market by a scripted appeal to late adopters of new technology (Baskinger, 2001).

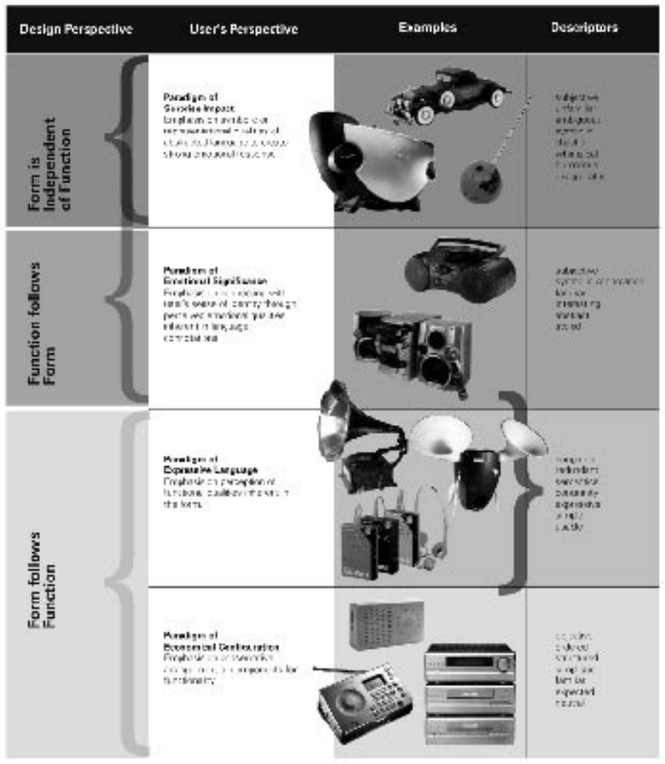

Figure 8: The visual language of expressive products more effectively communicates their duty and functionality. Emotional and surprising objects tend to require more cognitive work to decipher as the user must attentively perceive meanings and symbols from their visual configuration. Image adapted from "Visual Noise in Product Design" by Mark Baskinger, 2001.

This trend toward imbalanced forms forecasts the need for change; to rebalance product aesthetics according to principles of perception to create meaningful and appropriate product experiences. Currently, the profession of industrial design is economically, socially, and ideologically poised to address these issues in compelling ways to create meaningful product experiences.

Using cognitive models clarify form

The most important aspect of any design is how it is understood in the minds of its audience. Everyone forms a cognitive model for nearly everything they encounter to serve as a basis for navigation, evaluation, and participation of subsequent experiences. These cognitive models can be constructed textually, visually, aurally, temporally, geographically, etc. The principles of meaningful cognitive models address the methods of the audience to find meaning, what they are able to remember, and create alternate ways of moving through the experience. Hence, these principles, based upon clarity of information, navigation and participation, are direct contraries and potential remedies to the epidemic of visual "noise."

Metaphors

Metaphors and metaphorical reference can help form cognitive models, orient people to understand an experience more completely, and make an experience memorable. While generally advantageous, metaphors can be equally disastrous if not applied appropriately. In short, metaphors apply references to known experiences as clues to new ones – like the virtual desktop on Mac and Windows operating systems that help people to create, to use, to store, to arrange, to delete, and to work with files. The success of this metaphor relies on the fact that it is reminiscent of and not totally consistent with the real desktop experience. In the real world we rarely place folders inside of folders, nor can we create immediate identical copies of folders and instantly have documents live in two places at once. Instead this digital metaphor represents a simplified, abstracted, and idealized version

of the analog experience. Thus, too close adherence to the theme can either limit the functions of the system or can create confusion when the two do not work together identically. A relevant example is the womb-like appearance of a front-loading washer, shown in Figure 9, where the form speaks clearly about nesting, safety, assurance, and completeness.

Symbolism and Abstraction

Symbolism can be used as a way of collapsing information into a smaller form and turning it into a mnemonic device. What makes symbols powerful is their ability to transmit meaning under difficult circumstances, especially across linguistic barriers. However, just because something is a symbol does not guarantee effective communication. Symbols, icons and logos rely on shared context and can be misinterpreted or misapplied due to cultural constructs. Without a more complete understanding of cultural modifiers, constructs and climate, these symbols can not only fail to transmit what is intended, but can communicate false or defamatory information. Symbolism excels when it is paired with other forms of communication, including diagrams, labels, and text that provide a broader field or context. This not only allows symbols to be more easily recognized and remembered, but is especially important for simplifying complex or critical information. Expecting a symbol, icon or mark to communicate completely on its own when depicting new information places heavy emphasis and responsibility on the abstracted character to provide an effective informational experience.

Abstract concepts are inherently more open to judgement, experience, and interpretation and are thereby more difficult to communicate. Conceptual information relies heavily on personal contexts and can pull difficult or unconnected meanings into an experience that make it richer and more complex. Creating broader connections can generate more emotional, personal, and surprising experiences that leave us more satisfied than representational experiences that replicate literally.

Emphasizing humanism in product design

Currently, there seems to be a greater acceptance of forms structured with inappropriate language and visual "noise." In fact, it appears that consumers now expect and value a certain amount of complexity, "aggressiveness," and over-styling in their products. One might conclude that globally, there is a desensitizing of visual perception resulting from the prevalence of visual "noise" which requires much stronger messages and dynamic forms to communicate. The cyclical nature of perceptual desensitizing of product users and the response of product creators to use visual "noise" to amplify product commmunication may have serious and lasting effects on how we live our lives. "Aggressive," exploitive, and imbalanced forms represent only the visual indicators of visual "noise." Further study may conclude that it reaches far beyond the scope of perception. Over time, the ramifications of visual "noise" may become apparent and wide spread. Design now stands at the proverbial crossroads and can save itself from visual "noise" by evaluating its significance and social impact – focusing on creating balanced, socially useful objects which are relevant to users, respectful to environments/contexts, in sync with visual perception, and supportive of one's innate need of expression.

Figure 9: Images from www.parenting.com (Photo: Getty Images) and www.whirlpool.com

Arthur Pulos, noted educator and author, wrote, "Industrial designer's natural and educated sensitivity to form makes it possible to select proper shapes and proportions for the elements of a product and to establish a harmonious relationship between them" (Pulos, 1978). This harmony is achieved when a product can be evaluated on four levels of logic: (1) the logic of use value; (2) the logic of exchange or equivalence value; (3) the logic of symbolic meaning; (4) the logic of difference or consumer value (Morales, 1984). Furthermore, this idea of harmony embodies the principles of humanism, where common human needs are emphasized and rational ways of solving human problems are sought.

Communicative form language most resides in the "expressive language" paradigm where form is a physical and visual record of functionality. Fundamentally, this paradigm is the most humanistic, as functionality is resolved through the form and placed at the center of the user's attention. Interaction with such forms is often highly structured as physical and visual cues are organized by proximity with emphasis on critical components.

An example of using the "expressive language" paradigm to manage visual "noise" and create meaningful product experiences is shown in Figure 10. The goals for the prescription medicine bottle were to simplify the visual language of the existing bottle and to synthesize the communciation of the bottle shape and graphic components. This rectangular shaped vessel with an angled cap provides separate and clear information panels that display the necessary and vital information for proper storage and use of the medication. The additional panel space allows for larger print and more user-specific information. In addition, the angular geometry of the vessel and cap provide easier access to those with arthritis and similar debilitations and provide clear visual cues when the cap is not properly locked. For those who take multiple daily medications, the angled cap and interpretive labeling system provide for easy indexing and cataloging.
This concept for a kitchen fire extinguisher is another example of "humanizing" a utilitarian product to improve the product experience and minimize visual "noise." In this case, expressive visual language becomes evident once the housing unit opens in an emergency situation. Because most of its life is spent waiting for a crisis, the housing unit was created to simplify or quiet the form in the context of the kitchen environment. See Figure 11. Through a reduction of elements, colors and superfluous graphic communciation, the traditional overly-mechanical fire extinguisher is transformed into a device that home owners will more likely install in accessible and visible locations.

The Designer as Catalyst

Carefully designing visual language, rather than styling, shifts thinking to the creation of optimal product experiences through the crafting of design language and product form. This implies a change of thinking from designing objects to designing how objects are understood and used by a particular group. Moreover, the product appearance is the conduit through which product interaction often begins. Recognizing that in contemporary society there is an unhealthy tendency towards the chaotic, product designers can promote humanism, a healthy relationship with objects and use form language to bridge the perceptual gap between user intention and action. In the complex, multidisciplianry process of product development, the designer is the key agent in enhancing human experiences with products by managing visual "noise" and promoting appropriate and meaningful visual language.

Figure 10: The redesign of this prescription medicine bottle uses simplification, hierarchy, and clarity of information to create a better product experience that encourages safe practice and potentially minimizes accidental poisoning. Designed by Mark Baskinger, 2000.

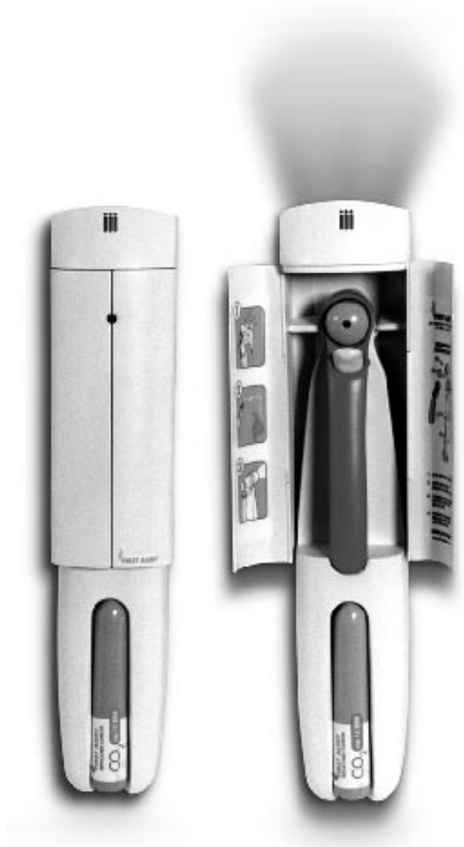

Figure 11: This concept was designed to minimize the fire extinguisher's presence in the kitchen environment since fire extinguishers spend almost 100% of their lives waiting to be used in a crisis. Designed by Mark Baskinger, 2001.

Mark Baskinger
Assistant Professor,
School of Design
Carnegie Mellon
University Pittsburgh,
Pennsylvania USA

baskinger@cmu.edu

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Wellington Gomes de Medeiros, Philippa Ashton

Issues in formulating research methods to access the meaningful responses of men to product shapes

Abstract
This paper describes an iterative process of formulating a specific empirical method of investigation which aims to access the meaningful interaction of male users with product shapes. The two pilot tests applied demonstrated that combining methods such as video-ethnography, open-ended questionnaire and unstructured interview is a useful strategy to access male affective responses to product shape. Firstly, the paper briefly outlines connections between product signs, meanings, gender and behaviour. Then, it explores the issues and benefits of combining methods to access affective interaction. Finally, it describes the two pilot tests and argues that the empirical construction of design studies methods based on several methodologies is a powerful tool to access the emotional dimension of affective interaction.

1. Introduction

As a design-based study, this paper aims to contribute to the debate on emotion and design by describing the issues involved in the process of devising a method to investigate the affective responses of men to product shapes. It builds on theories in three main disciplines which have Psychology and Semiotics as their roots; Marketing (in particular consumer behaviour), Material Culture and Design, the latter of which connects and applies the former two. Psychology and Semiotics provide insight to understand the emotional and cognitive behaviour of users and their relationship with the signs and meanings incorporated in the products. For their part, Material Culture and Marketing provide relevant information regarding social relations and preferences.

The paper starts by briefly stressing some of the main issues that should be taken into account in this investigation of emotion and design related to interaction with products. Social Psychology underlines the changing societal role of men in social context and the social construction of gender. Many studies point to a crisis in male identity, and this is provoking profound changes in male consumer behaviour. Industries are aware of this 'new man', and have applied aggressive marketing strategies to target him. In order to understand how men really relate to products it is important to apply a semiotic approach. Indeed, designers themselves are using this approach to improve the communication between men and products. Therefore, Ethnography, Cultural Studies and others fields of study located under the capacious umbrella of Material Culture provide important information on artefacts and social relations, and represent a vital wellspring for the formulation of methods in design studies.

The next section of the paper discusses some crucial issues regarding methods and design, focusing on accessing emotional responses to product shapes. Considering that affective interaction is strongly related to socially constructed behaviour, this study argues that methods from Ethnography and Social Studies brings together fundamental concepts and is therefore crucial for devising tools to access interaction in design and emotion. The published studies on emotional interaction and the first results from the videoed male-product interactions on which this paper is based point to the necessity of methods anchored in established fields such as the above. At the end of this section methodological directions for study are presented based on the assumption that there is a gap in the design field regarding a specific investigation of the cognitive and affective responses of males to product shapes.

The paper concludes by describing the process of constructing a specific method for this study. The first of two pilot tests that were carried out is described. An account is then given of the refining of the methodology in the light of the results of the first pilot. This is followed by a description of the second pilot and its results. The outlines for the final version of the test process are then established, applying the further insights gained during this second iteration.

2. Overviews of Gender, Consumption and Design

The changing societal role of men is generating, among other things, a phenomenon in the global market: the contemporary male consumer. According to some researchers the stoic male-related behaviour, which sought functionality and usability in products [1: 113], has been modified to a more sensitive dimension [2]. In response, functionality and usability in design are no longer regarded as the most important issues for interaction design; emotional, aesthetic and pleasurable experiences are now thought to be also primary [3], [4]. However, this subject should be carefully approached as there are gender issues that are crucial to the design of products to enable emotional interaction. Crozier [1: 113] claims that the relationship of women with products is different from that of men because 'men placed greater emphasis upon instrumental and use-related reasons whereas women made more use of the relational and emotion-related categories'. Hence, the emotional issues involved in male and female product interaction may be completely different. However, these differences seem to be changing as response to the changes in societal gender behaviours. In some cases, it is true, gender is not a design issue at all. Nevertheless, for some products, gender may be an important consideration. There are obvious products where gender is the main factor for designers' inspiration. The perfume bottle is a common example [5].

Gender and self-identity are key issues in the design of male grooming product, but as yet, design research has not yet properly investigated this area, despite the fact that we are witnessing the emergence of a new type of product and mode of consumption. According to Mintel reports on the consumption of men's toiletries [6] and deodorants and bodysprays products [7], the market for male grooming and shaving products is growing. These new products claim to fit the profile of the contemporary men. Owing mainly to massive advertising campaigns prompting new consumption behaviours, men are now more likely to be conscious of products in general and, perhaps surprisingly, of personal care products. A quick look at supermarkets and mega stores shelves reveals the range of male grooming products, packaging design and brands. Although this field of enquiry is still relatively new, an increasing number of studies on emotion and design regarding other products related to male consumption, such as cars [8], have been made, with the aim of establishing new design paradigms. Despite the studies of consumers' emotional responses, the evaluation of specifically male affective responses to product shapes remains an open question. To investigate men's interaction today requires dealing with the new psychological paradigms of male roles and behaviour in contemporary society. An element of this investigation must consider the role of product semantics and the meanings and attributions men bring to this relationship.

In order to access men's responses to product shapes, it is vital to consider specific changes in the make psychology which include that the male role is socially and psychologically constructed rather then biologically shaped [9: 35], [10: 109]. Some researchers assert that masculinity is social constructed and that the traditional understanding of male roles in society is currently in crisis [11] and that new social pressures have caused conflicts within the traditional ideology of masculinity. Embarrassment at expressing personal feelings and yet, at the same time, awareness of the need to be caring and supportive to the family creates a conflict in men's mind and behaviour. It was found that until 6 months of age, boys are more emotionally expressive than girls; after that they are educated to suppress their feelings [2: 262]. As a consequence, the traditional male role is based on the suppression of the expression of feelings from a very early age. Nevertheless, Levant [2] argues that new social pressures, the contradiction of gender roles in contemporary society, and the violation of previously

socially constructed gender roles have unveiled another dimension for male social role and behaviour. In the family context, for instance, men are now expected to be more emotionally supportive, warm and caring [12]. In *The New Psychology of Men*, Levant [2] argues that men are more and more concerned about their new socially-constructed roles and their behaviour is changing in many situations. As a consequence, traditional masculine behaviour in product consumption and use is transforming. In response to this new male behaviour, the contemporary market has assumed a more aggressive strategy to reach this new 'sensitive' man, believing that he is now receptive to a more sensitive and emotional approach to his health and appearance. As a result, supermarkets and newsagents display a wider variety of products exclusively for male consumption, such as shampoos, shave oils and magazines. These products are displayed in packaging with sophisticated designs, indicative of substantial investment in this market area. A word to define men who assume behaviour that once was associated to women has even been coined: the Metrosexual [13]. Used widely in marketing, the term refers to a group of men who live across the world not just in big cities, but in a global environment, where TV and Internet can be easily accessed. More recently a new term was presented to replace the Metrosexual men: the Ubersexual [14] - some people would say that there is no big difference between them. Apart this branding argumentation, it would not be too premature to say that the new socially constructed gender roles, the crisis of masculinity and the birth of a sort of 'sensitive man' are bringing about male emotional attraction to, and satisfaction with, product shapes which have been hitherto associated to women.

It is thus clear that the design of male personal care products (and of other products traditionally related to male consumption) must now be investigated for their emotional connections with consumers. The role of products as representations and mediators of meanings has aroused the interest of some researchers [15], [16]. Applying semiotic approaches, these studies examine products as complex sets of signs and analyse their roles in the communicative process with users. The emotional dimension of meanings in product shapes also requires deep attention to psychological issues. Hence, to study the meanings that product shapes trigger in men's minds implies combining the insights of Semiotics into product attributes as signs mediators of meanings with the insights of Psychology into the complexity of contemporary men's consumption behaviour and interaction with environment and products.

3. Brief Discussion on Combining Research Methods

Over the last five years, many studies regarding the investigation of consumers' affective responses to product attributes have been published. Forlizzi et al. [17] found that users usually pay great attention to product form, one of the most studied product attributes. Depending on the particularities of each study, a specific method of investigation may be required. Ergonomics would be the natural tool for the study of emotional interaction, but it still focuses mainly on the pragmatic interaction of users with the physical attributes of products [18], [19], [20]. Ergonomists traditionally emphasise usability and satisfaction in terms of physical comfort; emotion is not an issue at all. Nevertheless, emotional issues have aroused the interest of researchers in the field of design and interaction, encouraged by discussions of affective human factors [21: 177]. However, despite some publications on design, emotion and affectivity [22], [23], [24], the investigation of emotional relationships with products is at an early stage demanding specific methodological approaches according to each subject of study. One of the main challenges is related to methodological issues as it is difficult to identify qualities that can be characterized as the qualitative dimension of interaction. The diverse methodologies described in the literature provide evidence that the investigation of affective interaction remains relatively uncharted territory. This is not surprising, considering the multiple variables involved in the investigation of emotion and affectivity, and the fields that give theoretical and methodological support, such as Psychology, Semiotics and Ethnography, just to quote some of the most common. However, establishing research methods which produce useful and reliable data for designers is of major importance.

Design is usually defined as a multidisciplinary activity. Although they work with teams of engineers, marketers and, depending on the subject, even psychologists, designers - it is becoming increasing clear - should nevertheless have an understanding on the aimed user's profile. Traditionally in the design field, the methodology is often related to the creative design process where practitioners paid great attention to pragmatic issues such as ergonomics, production processes, materials and consumption, among others. These still remain key concerns for design practitioners, maybe because social and psychological issues are more difficult aspects to incorporate into the design process. More recently, however, the emotional, 'subjective' side of design has become an exciting research area requiring different approaches in order to achieve an understanding of user and consumer. Designers usually are concerned with the communicative and psychological issues of product colour, but do not usually pay the same attention to product shapes regarding communication. In opposition, designers are now required to understand the users' emotional interaction with products, and this requires a psychological understanding of human behaviour. Hence, designers increasingly work in a broad perspective, using information from many fields. Material culture, for instance, embraces a range of disciplines including Anthropology, Design Studies, Cultural Studies, History, and Museology to explore artefacts and social relations. Geismar et al. [25] say that 'archaeologists, geographers, architects, artists, and historians, as well as anthropologists, are all interested in the place of the material world within their fields of research'. We might include designers in this list. Informed by Material Culture, design studies can approach the meanings that artefacts may engender through the relationship with consumers before and after purchasing, and during consumption [26].

Marketing is another important partner for designers. Marketing studies of new products may provide important information about the symbolic relationship of consumers with products and the impact of product signs on consumers' preferences [27]. So, whilst material cultural studies explore methods of approaching artefacts and social relations, and marketing focuses on methods to investigate consumers to offer product suppliers an accurate understanding of consumers' preferences, design appropriates knowledge from both fields to construct its own methodology.

Naturally, the particularities and traditions of each study area demand specificities of research methodology. Thus, one of the main challenges that design researchers in this new field face is the construction of appropriate methods of investigation. A review of journals publications and conferences proceedings on design issues reveals the wide range and combinations of disciplines and methods used by design researchers [28]. The debate about the exact nature of design research is a hot topic reflected in discussion lists on the Internet. The topics debated suggest that design research is a large house under construction, underpinned by different theoretical foundations.

3.1 Combined Methods, Emotion and Design

Despite the various methods and models that have been applied to the investigation of the emotional relationship of consumers with products, there is a lack of publications devoted specifically to men's responses. For this reason, the study discussed in this paper cannot be other than experimental in nature and the process of designing the method empirically constructed. The majority of studies currently published apply different methods to access both male and female responses [29], [30]. The investigation of the emotional interaction with design is relatively new, but current thinking suggests that the methods for exploring the affective dimension of interaction may be classified as empirical and non-empirical. Empirical methods are thought to be particularly appropriate to investigate emotional-based interaction [31]. Despite the recent number of publications on emotion, pleasure and design, affective interaction remains a field requiring empirical exploration to gather more data and robust information based on the observation of consumers' behaviour and responses. Hence, empirical methodology is required to enable concepts and proposed models to be fully tested. Jordan (2000) describes and analyses some empirical and non-empirical methods. For him, the private camera conversation is a useful empirical method for gathering data as a result of asking participants to talk about products whilst manipulating them. He goes on to describe two versions of this method. In the first version, the participant is left alone in a room talking to a video camera and completes a list of tasks. In the second version, the investigator remains in the room with the participant. The first version has some advantage over the second that the participant could feel intimidated by the presence of the investigator. On the other hand, if the participant deviates from test objectives, an investigator who is present can bring the participant back to the aim of the experiment.

Silverman [32] points out that video allows the researcher to access the participants' non-verbal as well as their verbal signs normally expressed in daily life. Video is

therefore a powerful tool for investigating the affective interaction of men with product shapes, as their lack of verbal expression may be balanced by the recording non-verbal expressions and gestures. Taylor *et al.* [33: 175-187] note that video is direct, believable, involves active engagement and is richly descriptive. As such, it is a useful tool at the formative stages of devising methodology design, where it can be used to record pilot tests; video might provide information that can be used afterwards to refine the approach.

Research methods applying video, participant observation or ethnographic methods [34: 291] can produce important data on emotion and design. Spradley [35: 51] argues that in ethnographic investigations, researchers do not simply observe but may also participate. Bryman [34: 298-300] cites the three roles identified by Gans, that an ethnographer may adopt in experiments: *total participant, researcher participant* and *total researcher*. According to Bryman, Gans' classification allows for the fact that ethnographers may adopt not simply one role but elements of all three. In the total participant role the researcher immerses him/herself completely in the situation observed. In the research-participant role the researcher is semi-involved. In the total researcher role the researcher observes without involvement in the situation. The possibility of combining aspects of each role makes participant observation an attractive method to access affective interaction.

Traditionally design practice is based on the assumption that designers have the power to determine the best decisions for the design of effective products. This may drive designers to deviate from the users' real needs. Ergonomics is still one of the main pillars that provide substantial information about users. However, traditional Ergonomics lacks considerations about emotional factors. Participant observation may contribute to a balance between both pragmatic and emotional dimensions. Jordan [31: 150-153] argues that despite the ethical issues and the focus on finished products, field observation is one of the most useful methods to investigate pleasure through products in real circumstances. Observing people allows the investigation of many aspects of behaviour. However, Jordan points that one of the major problems in field observation or participant observation of emotional interaction is the gap on how to collect affective responses and meaningful associations to products.

Nevertheless, the observation of interaction with finished products may be applied in combination with other methods such as questionnaire and/or interview. In this sense, participant observation can be part of the research design process and not necessarily the main research method.

There are at least two categories of questionnaires suitable for emotion and design studies [31: 153]: *fixed-response questionnaires* and *open-ended questionnaires*. The open-ended questionnaire is particularly useful when the designer researcher has clear aims for the study, but has yet to establish the main issues for investigation. In fact, the open-ended model may be used and linked with the fixed-response model. For instance, the investigator may use an open-ended questionnaire to aid in the construction of fixed-questionnaires.

The interview is often used in design studies and widely applied to participant observation [34: 312]. But here again, apart from graphic and informational design features, it is more often applied to elicit pragmatic, functional, usability and marketing-related information rather than emotional related data such as affectivity and pleasurability in industrial design studies. Bryman [34: 106-110] describes different kinds of interview, among them the *semi-structured* and *unstructured* models. Design research aimed at gathering qualitative data about emotional interaction may apply these models with benefit, considering the diverse profiles that participants' behaviour may exhibit. On the other hand, the flexibility of the unstructured interview allows the investigator to adapt questions according to the interviewee's replies during the course of the interview [34: 313].

Jordan [31: 160] says that interview has some advantages in comparison to questionnaires in that it may prompt people to respond to questions related to pleasurability. He argues that direct contact with respondents, the possibility of giving additional explanations to the interviewee, and the prompt return of responses outweigh the disadvantages of questionnaires. However, depending on the research, the choice of a single method is not required. For instance, it is possible to combine interview with observation, video or audio recording [32: 98], or use interview findings to inform the design of a subsequent questionnaire. The flexibility gained by using mixed methods may be crucial in investigating emotion and design. It is even possible to combine both qualitative and quantitative methods. In this case, Creswell [36] points to the importance of defining a specific strategy for data collection in terms of sequential implementation. In other words, a decision should be reached regarding whether qualitative or quantitative data collection will be applied first; whether priority should be given to quantitative and qualitative data analysis; at what stage data collection, data analysis and data interpretation will be integrated; and finally which theoretical approach will be used [36: 208-211]. Combining methods may be of great value for design studies, but should be handled carefully. The possibility of using both methods provides the flexibility emotion design researchers may need to translate affective responses into quantitative or qualitative data or deal with both at same time where necessary.

In the quest to access the emotional dimension of signs in product design, researchers are adopting a range of models and approaches. Currently, one of the most widely applied models is Kansei engineering [37], [38], [39], [40][1]. This is based on the observation of users' behaviour when perceiving objects. Pleasure – clearly related to the emotional dimension - is one aspect measured by Kansei. Kansei's main characteristics can be described as: 'a subjective effect which cannot be described by words alone; a cognitive concept, influenced by a person's knowledge, experience and character; a mutual interaction between the intuition and intellectual activity; entails a sensitivity to aspects such as beauty or pleasure; and is an effect for creating the images often accompanied by human mind' [41: 221]. Lee et al. also emphasize that 'Kansei implies that human behaviours can change dynamically, and indicates that flexible and dynamic approaches are needed in the various fields of study'. That means that combining research methods and crossing knowledge from fields such as Semiotics, Psychology and Material Culture, for instance, are recommended for emotion and design investigation.

Another model applied to investigate meanings in products is the Semantic Differentiation (SD) model [42: 76-124]. This model aims to measure meanings and is based on the juxtaposition of bipolar meanings presented in a scale with levels of strengths. The meanings are presented as questions to infer the users' choice. The SD model is proposed as a means of gathering quantitative data about feelings. It has been used in some design researches to translate the affective responses of consumers to product attributes into quantitative data [29], [43], [44]. The study presented in this paper aims to combine the inherent concept of the Kansei model together with the SD bipolar model. However, since it is at an early stage, only the empirical process of constructing the research method is described here. Clearly, it cannot yet report on the final stage of the study (the application of a questionnaire incorporating bipolar responses to likely meanings and associations made by men), nor the final conclusions from the study.

[1] See more references on Kansei in the section category *Kansei Science, Kansei Engineering* on the Journal of the Asian Design International Conference, Vol. 1, 2003.

4 Experiments and Test Design

This part of the paper describes the process of formulating the preliminary experiments; applying the tests; and the dynamic course of successive changes to subsequent tests designs based on the direct observation of the participants' behaviour and responses. The experiments are intended to reveal the variations of meanings in products beyond those related to functionality and usability. The main objectives of the experiments were to provide data to develop a final hypothesis and to devise a means of testing this as part of a doctoral study. The main objective of the research is to investigate the meaningful and emotional relationship between male consumers and product shapes. It is expected that the research outcomes will provide an overview of male behaviour and meaningful interaction with products. The study, and the experiments themselves, have been constructed as the result of a process where the results from earlier tests underpin the formulation and application of further tests. Thus, the last test differs from the first one. The experiments were designed to achieve the main research aim, but each test has particular objectives. The tests and the results helped to devise outlines for the research questions and hypothesis, which will serve as the basis for the formulation and application of the final test.

4.1 The First Pilot Test

The main goal of the research is to access the affective dimension of interaction. However, the first test explored both concepts of connotation related to emotion and denotation related to functionality and usability. This strategy was expected to provide a clear differentiation between function-related meanings and other meanings. With this in mind, the first test was designed based on the assumption that there are two classifications for signs

regarding meanings in product shapes: denotative and connotative signs. Denotative signs are those that are in the first order of signification, while the connotative signs are further signs deriving from denotative signs [45]. In products design, the denotative signs are those designed to trigger meanings that are supposed to be identified in some way by users. These are signs related to product functions and to what it stands for. On the other hand, the connotative dimension is related to the subjective possibilities of interpreting the signs in products, such as aesthetics and emotion [46]. According to these conceptions, the first test was designed based on the following hypothesis:

1. There are denotative and connotative signs in product shapes. The denotative signs are related to function and usability, whilst the connotative sings are related to aesthetics, emotion, affective and other types of subjective association made by users through interaction with product shapes.
2. Some configurations of product shapes are more effective than others in communicating function and usability through denotative signs. On the other hand, some configurations are more effective than others in triggering emotional, affective and/or aesthetic meanings.
3. It is possible to find the meanings triggered by product shapes through questionnaire and interview.

4.2 Products Tested

The set of products chosen for testing were packaging for food, drink and cleaning products. Packaging can be defined as a product to be used for the containment, protection, handling, delivery and presentation of its content. This test focused on primary packaging shapes which are designed to come into contact with the contents (e.g. jars, bottles and boxes, and they can be made mainly by plastic, glass and cardboard). The main function is to contain and to protect the product that will be consumed and to allow access to its content. Therefore, it mediates between users and the product inside.

Designers and marketers have long highlighted the role of packaging in improving communication with consumers. However, communication in packaging design has mainly been focused on the graphics, branding and information design. Thus, two-dimensional features have been studied more closely than three-dimensional form. This lack can be observed simple by looking at shelves in supermarkets. Packaging shapes practically 'disappear' under a huge amount of printed elements. A very close observation of some packaging suggests that if we remove all the printed elements, the shape itself would appear simple as a physical support lacking functionality, usability and emotional features. Despite the fact that functionality is still an important concern for designers, the potential of packaging to establish emotional relationships with users should also be considered. Like many products themselves, packaging is a living artifact that establishes relationships with people. This contrasts sharply with the instrumental approach to products as tools created for users to complete tasks [47: 19]. The new definition of human factors [21: 176-177] identifies products not just as something to be used properly, completing tasks, but as an effective character with an important emotional role in users' life.

Packaging does indeed play an important role in users' daily life. It can improve the relationship between products and users or damage it. Some important institutional projects such as Faraday Packaging Partnership[2] in UK have invested in the investigation of packaging shapes and their meaningful roles. As well as serving functional ends, packaging should also make the experiencing of products pleasurable. Some packaging is re-used even when its content has been consumed. It is not so uncommon for users to reuse packaging jars, bottles or boxes for different purposes. In Brazil, for instance, refills are common for many products (e.g. coffee). In this case, the packaging is a permanent object in the kitchen and its form is an important attribute, as is the case with the shape of plates and cooking utensils. Sometimes they are even reused as decorative objects. In doing this, users change the product meaning from a functional to an aesthetic one, a sort of play akin to the readymade art of Marcel Duchamp. But even before the realization of this post-use potential, some packaging may trigger different meanings in users' minds. One area of concern today is the wastefulness of packaging. Users are encouraged to keep or reuse packaging. Ways of making packaging design more effective whilst using fewer resources are urgently required by the industry. Hence, the relationship of users with packaging should be analysed regarding its meaningful and emotional dimension.

This test used different packaging with different designs and materials. In order to concentrate the participants' attention on the shape, all products were painted matt white paint because this reflects the full force of the spectrum. White is usually associated with purity and uncompromising, and as with all colours, can trigger different meanings in different contexts (e.g. cleaniness, hygienic, and sterility). Visually, it gives a heightened perception of form that can be useful for testing shapes alone and emotional associations linked with them. However, Barnes et al. [29] alert us to the fact that this procedure should be approached with caution, because consumers experience all aspects of product as a whole. Hence, isolating one attribute such as shape may affect consumer perceptions. This is an issue for all design studies that seek an understanding of interaction and the translation of research data into a language accessible to practitioners.

To isolate product attributes requires the consideration of many issues, but designing a product is also about designing attributes. It is therefore necessary in research design to find a compromise between complexity of consumer perception and simplicity of data gathering; thus, studying products by isolating attributes may be useful. Product form plays an important role in consumer perception and interaction. Sevener [44] found that among the aesthetic qualities of products - properties such as colour, form, material and graphic elements - 'form' has the highest pleasure inducing effect in consumers. Forlizzi *et al.* [17] also found that 'form plays a critical role in allowing people to talk about their relationships to products'. The untying of product attributes and the investigation of their impacts on consumers should be investigated to establish the reliability of this method.

4.3 First Test Process

The first test was designed to gather both female and male responses. In addition to verifying the differences between the responses, the test helped to find out how male responses could be accessed. The test comprised two sections. In the first section, a semi-structured and open-ended questionnaire was applied, in the second a semi-structured interview. In order to access the denotative dimension, a six-pages questionnaire was used. On the first page, the participants gave some personal details including age, gender, highest academic qualification and nationality. This test was applied at Staffordshire University to a group of 11 post-graduate students (five males and six females), with an average age of 27. The first question appeared on page two: 'which two shapes do you feel are the easiest to understand how to grasp? Circle the part of each of the two shapes where you would grasp it'. The participants were directed to observe the 11 products displayed on the table around which they were seated. Photographs alongside each question represented the products.

The second question was: 'which two shapes do you feel are the least easy to understand how to grasp?' The third question was: 'which two shapes do you feel are the easiest to understand how to use? Circle the part or parts of each of those two shapes where you would touch and handle'. The fourth question asked: 'which two shapes do you feel are the most difficult to understand how to use?' And the fifth question was: 'what kind of products and/or brand would you associate with the displayed shapes?' The main aim of the questions was to obtain responses regarding shape properties used to communicate denotative meanings related to function and usability.

In the second section of the test, an individual interview was applied with the aim of accessing connotative associations with product shapes. Based on the responses to the questionnaire, the interviewer asked one question only, which was: 'take a look at the shapes you chose as the easiest and the least easy to understand how to grasp and to use. Now, say what kind of thought, feeling, idea or any kind of adjective you would associate with the shapes you choose. Be free to say anything. You can compare the shapes you choose.'

The responses resulted in the expression of associations connected with the product shapes. Despite being the smaller percentage of the sample, the male group voiced more associations with the shapes then the female. Men expressed 19 associations whilst women offered 12. Furthermore, men made 13 associations that can be defined as connotative and 3 related to denotation. On the other hand, women made 6 associations related to connotation and 4 to denotation (Table 1, above).

Gender	Denotation	Connotation	Neutral[3]
Men	Difficult to understand, easy to understand, appealing for touching.	Weird, odd, modern, fashionable, soft, curious, boring, cute, unique, individual, nice, mysterious, easy-going	Different, strange, interesting
Women	Easy to use, balanced, proportioned, obvious	Negative-feeling, solid, silly, boring, dumb, crazy	Different, simple

Table 1. Associations expressed by participants in the Test One interview

[2] The Faraday Packaging Partnership's laboratory for affective design and the University of Leeds Keyworth Institute have investigated consumers' affective responses to packaging design. For more information: www. faradaypackaging.com.

[3] Expressions that did not relate directly to function, usability, emotion, or that could trigger ambiguous meanings.

4.4 Analysis and Implications for the Second Test

The test results gave the insight that men actually experience emotional relations with product and also that they can express feelings that product shapes trigger, and in this case, bearing in mind the small sample, even more then women. The results proved that concentrating on men's responses - as well as being a valid response to the current social, marketing and design context – is a relevant research approach.

The questionnaire succeeded in accessing the perception and interpretation of form with regard to its functionality and usability: participants expressed their perception of the shape by relating it to their understanding of these two characteristics. They also expressed how they associated the shapes with different products and brands. Except for one participant, nobody had any queries about the test. Afterwards it was found that the test was very clear and easy to understand for all participants.

The interview section also proved to be useful in accessing other meanings related to emotion. It was especially important to confirm that connotative meanings can be gathered from men. However, some adjectives they expressed were frequently associated with functionality and usability. Terms such as 'difficult to understand', 'easy to understand' and 'appealing for touching' were recurrent in male responses. One major problem detected had to do with the sequence of the two sections of the test. The interview responses were strongly influenced by the questionnaire applied before. As a consequence, the denotative-based questions in the questionnaire influenced the connotative-based questions in the interviews. The interview was audio tape-recorded and it was found that neither men nor women objected to having their responses recorded, and no embarrassment was noted during the interview. However, it was observed that when responding, some interviewees expressed themselves through facial expressions and gestures as complements to oral expression. In view of this, it was concluded that video-recording might be more appropriate then tape-recording.

The first pilot test produced the following outlines for the second test:

1. To limit the experiment to men.
2. To combine participant observation, the open-ended questionnaire, and the unstructured interview.
3. To concentrate on one type of product rather than different kinds (and in particular a product intended for male consumption).
4. To use video ethnography.
5. To focus on the emotional dimension of interaction.
6. To define the main features of the shapes according to, for example, a scale from straight to curved shapes.
7. To apply the test in an environment that allows participants to focus on product shapes.
8. To paint the test products with a neutral colour widely applied to products for men.

4.5 The Second Pilot Test Model

Based on the analysis from the first test, the main objectives of the second pilot test were:

1. To collect adjectives used by male consumers for the shapes of products for men.
2. To identify adjectives related to the connotative dimension (and more specifically to affectivity and emotion).
3. To verify the value of mixed methods such as the interview and video-ethnography to access male responses.
4. To establish parameters for the final test.

The second test was carried out in just one phase where participants were invited individually into a room to interact with the products and asked to express any adjectives or feelings associated with them. Participants were free to interact with the products, but were asked not to open or use them immediately. At the end of the interview, however, they were allowed to interact however they wanted. The test took place in a room specially set up with all products displayed together on a table, around which participants moved freely. The experiment was recorded on videotape and the questions were open-ended. The sequence of the questions varied: initially, five questions were prepared. However, the sequenced tended to depend on how the test developed. Nevertheless, all participants responded to the same content, and thus the results reflect the average responses from all participants. The directions and the questions stressed the following topics: a) how the participants handled the products (without opening them); b) the expression of any adjectives, sensations, and associations connected with the product shapes; c) the identification of the shapes with male and female products (and those that can be used by both); d) the identification of those shapes that seemed

Fig. 1. (A) Approaching, (B) grasping, (C) inspecting closely, (D) inspecting at a distance, (E) comparing, (F) making analogies, (G) having fun, (H) trying out

easy to understand how to use; e) a guess at which products were packaged in which shapes; f) which shapes were the most attractive and the least attractive; g) finally, participants were asked to open and use the products freely.

4.6 The Second Pilot Test Characteristics and Outcomes

The second pilot test first required the identification of the products. The products for testing were grooming products for men sold widely in UK. The product shapes were clustered according to the following configuration: predominantly organic, predominantly geometric and hybrid. Hsiao et al. [43] found that organic surfaces and straight lines are potential influence factors in the emotional relationship of users with products. The hybrid shapes are those that did not present predominance of either organic or straight shapes. The product shapes were totally covered with grey paint, a neutral colour frequently used for this sort of product. An analysis of existing products found that the most common colours are: black, dark blue, dark green, silver and grey. The grey colour was chosen because it is a neutral colour which allows the perception of the shape features. Sixteen products were chosen to test on a sample of fifty men with an average age of 26.

4.7 Video Analysis

Despite their appreciation of the value of video-ethnography in design studies, Taylor et al. [33] argue that this is a relatively new approach and that some adaptation to the design context is needed. The present test is fundamentally empirical and explores the possibility of just such an adaptation to its particularities. The analysis of the videotapes was based on the following guidelines:

1. The sequence of choice of the products. This gave some clues about preferences.
2. How many times participants refer to the same product, with the assumption that this may denote preference or interest.
3. The observation of variations in body attitudes towards physical contact with products. This could be related to affective responses.
4. The body expression when handling a product. This could give some hints on how men feel when manipulating different shapes.

Analysis of the video demonstrated some patterns in participants' behaviour towards product shapes. The primary analysis identified the following main actions (fig. 1): approaching, grasping, inspecting closely, inspecting at a distance, comparing, making analogies, having fun, trying out. It was observed that this sequence of actions was carried out by at least four participants.

5 Findings of the Second Test and Recommendations for the Final Test

A sort of partnership between testers and researcher characterized the seamless process of formulating the problem and the questions based on the responses from the participants during the tests. The investigator was present during the tests, and it was observed that his presence did interfere in the participant performance, but apparently not in a negative way. Observation of the test and subsequent analysis of the video reveal that participants did not express, physically or orally, any embarrassment or intimidation about expressing emotional associations in relation to the products.

Some of them did find it difficult to express associations, but for reasons other than the researcher's presence. The majority of the participants did not show any stress during the tests.
The range of associations expressed in the second test included: boring, common, pretty, fashionable, modern, traditional, nice, friendly, strange, odd, smart, interesting, male, female, grotesque, weird, funny, stupid and some other associations. Nevertheless, participants also expressed many associations related to function and usability, such as obvious (how to use), uncomfortable (to grasp), smart (functional system), appealing to touch, ergonomic. Sometimes the expressions of the adjectives were emphasized by body language. The analysis of body language and facial expressions is, however, a difficult task, since it requires identifying both obvious and subtle expressions. Nevertheless, analysis of the video revealed that sometimes (but not always), different participants expressed the same adjective in different ways. This could reflect patterns in male behaviour regarding affective interaction. The video also revealed that some shapes are more frequently chosen, and helped to identify the similarities in shape grouping made by different participants. It also demonstrated patterns of behaviour towards the manipulation of the product shapes. By applying a questionnaire alone (or any other non-video based method), these aspects would not be observed and recorded. However, despite the fact that video-recording therefore appears to offer a promising research method, more tests are required to verify this hypothesis.
As in the first pilot test, the second test demonstrated that this specific research thesis demands a method which enables access to male-specific affective behaviour when interacting and expressing associations at different levels. Its results revealed that the combination of video, interview and participant observation is a reliable strategy to gather relevant data. Hence, the recommendations based on the findings are:

1. To combine video, unstructured interview and open-ended questions.
2. To continue to focus on male subjects.
3. To apply the tests in an environment that interferes the least with the respondents' product perception.
4. To test products painted with a colour normally found in the products tested (preferable a neutral colour).
5. To test men 15+ in age.
6. To test products from different categories.
7. To use psychological insights into male behaviour as a basis for the construction of test methodology and analysis of data.
8. To adopt the following premises for the final test hypothesis and method: men interact meaningfully and emotionally with product shapes; some product shape configurations are more likely than others to trigger emotional responses by men; and combined methods are a suitable research strategy to access men's meaningful and emotional associations with product shapes.

6 Conclusions

The combination of methods appears to be a useful tool to gather data on emotional responses by men. As in design practice, design research requires contributions from various fields such as Semiotics, Psychology and Ethnography in a dynamic process, especially when dealing with meanings, emotion and gender. This will mean breaking down barriers between paradigms and subjects and to work collaboratively with others, and this in itself introduces complexity into the research process. It is only in this way that we can develop new knowledge about these very complex design issues and questions.
However, the sequence of application of methods from these fields should be handled with caution. When accessing responses on denotation and connotation it should be observed the strong influence that one has on the other. It was discovered in the tests with men that if denotative questions occurred before connotative questions, the second were more likely to be a complement to the first rather than representing connotative meanings. Hence, when accessing the affective interaction of men with product shapes, it is recommended that tests should concentrate on connotative questions.

Video, unstructured interview and open-ended questions represent a powerful combination of methods with which to explore design issues. Video gives a vast amount of information about the behaviour of men when interacting with products. The way men touch and handle products to express subjective associations is different from the way they interact with the functional features. In contrast, the unstructured interview is helpful in stimulating participants to accomplish the test tasks. In an empirical study that embraces a dynamic approach to methodology formulation, the interview model is able to accommodate a fluid response to the actual progress of the test and a rescheduling of the question order.

This paper has also highlighted issues around the dynamic construction of methods which is required when previous research is relatively sparse and where a particular research question – in this case, male responses to product shapes – requires a specific combination of approaches. The research described here is still in progress, so the deliberations here necessarily lack final conclusions derived from definitive test data. At this stage, the research has begun to raise interesting questions for exploration, such as how and why product signs trigger men's emotional reactions, whether the attraction is instantaneous or staggered at different emotional levels, and whether attraction and emotional response is inherent – 'hard-wired' into the male brain - or the result of a socially-constructed male identity. Moreover, it is clear that if transient self-identity is a driving factor behind our meaningful associations with shapes, it is vital to understand the impact of different methods when testing this important aspect of design.

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Wellington Gomes de Medeiros
Universidade Federal de Campina Grande, CNPq,
Staffordshire University,
Faculty of Arts,
Media and Design,
Flaxman Building,
College Road,
Stoke-on-Trent, ST4 2DE,
United Kingdom

W.g.medeiros@staffs.ac.uk,
Wg.medeiros@uol.com.br

Philippa Ashton
Staffordshire University,
Faculty of Arts,
Media and Design,
Stoke-on-Trent,
United Kingdom

P.c.ashton@staffs.ac.uk

Chun Ting Wu, Malcolm Johnston

The use of images and descriptive words in the development of an image database for product designers

The development of image database, imagenexus, was based on the role images play within the product design process and information within the database was structured in three divisions: specification, characteristic, and emotion. The three divisions construct a model of the information which an image conveys. Imagenexus allows designers to creatively use their images and also to locate images moods or emotions more precisely. This paper presents the evaluation results of imagenexus.

1. Introduction

Images are a very important element in many design activities, e.g. graphic design, architecture design, fashion design and product design.

Product designers use images to assist in exploring design concepts before the design development proceeds (Baxter [1]). Also many product design methods involve images, for example, mood board development, user photo diaries, and 'The Visual Inconsistency Search' (Jones [2]). Images are used as references, inspiration material, communication material or for presentations.

Any image can be used in the design process not only those of products. However, they are all used to define the context for designs and to inform the creation of individual design (Eckert & Stacey [3]).

Coates [4] stated that products convey three different kinds of information that can be classified in order of the degree of freedom they permit the designer: essential information, collateral information, and discretionary information.

He explained that:

- Essential information is the product's very reason for existence, e.g. a watch indicates time.
- Collateral information exists alongside essential information to supplement it. It is always optional. Coates indicated that the designer has more discretion in shaping sources of collateral information, as long as it does not hinder the effectiveness of any essential information, e.g. the numbers on a watch face.
- Discretionary information refers to the designer's freedom to have a product created. Coates indicated that whether or not a product conveys essential or collateral information, it always conveys discretionary information. Discretionary information in a product is a means of broadcasting personal values, beliefs and attitudes, e.g. iMac conveys a brand value more than its essential information.

'Discretionary information' is the important information conveyed by products which represent brand names and the visual image of a corporation. According to Mooij [5], a product's 'association network' also relates to: the product's attributes, users, place (occasions, moments, moods when using the product) and value.

When searching for an image, designers might need to represent any of these qualities. A literature review and series of interviews (see below) were carried out to identify the information needed for an image database and to collect keywords for the database development

[6,7]. Pilot interviews were held with product design professionals in Taipei and MA product design students at Central St Martins College of Art and Design.

2 Image Information

In 2001, a survey was conducted of 17 professional product designers whose experience ranged from 3 to 35 years in London. Its focus was on the use of images throughout the design process.

Analysis of the designers' responses showed that product design is used to establish the value of a product and its brand, as shown in Fig. 1. Product value may be divided into physical and context. The physical value is represented by a product's format and features while function and characteristics are represented by the product's context value. The format is the product's physical properties such as colour, material, form, and texture. The function is the product's purpose which is a requirement of the product's users and where it is needed.

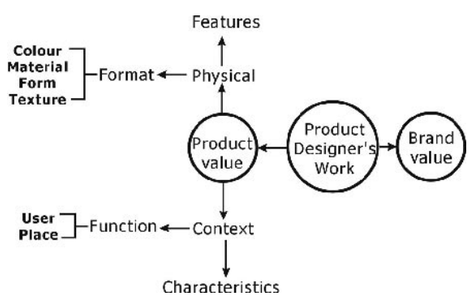


Fig. 1. A model of product designer's work as identified from the survey.

The information represented in Fig. 1 reflects the work of both Coates and Mooij. The survey confirmed that images serve a vital role in the design process and identified various ways in which designers store and retrieve them.

2.1 The three divisions

The research showed images convey three different kind of information. Which have been grouped under three divisions named: Specification, Characteristic, and Emotion.

Specification

Its information is about product properties and market segmentations. In this information division, the categories are: Colour, Form, Material, Texture, Gender, Age, Class, Places, Activities and Product Field.

Colours, Forms, Materials and Textures are the visual properties of products and the physical design elements. The categories of users', Gender, Age, Class, Places, and Activities, are the market segmentations used to define users. The product field is included because product types forms a fundamental way of classifying images.

Emotion

This information division is intended to provide users with a record of their emotional reactions to images. Most images are product images and the vocabularies to express emotions are very varied, so in order to provide an appropriate number of keywords to include different emotions. Desmet's study [8] of product emotions was adopted. It includes 14 members: Indignation, Contempt, Disgust, Unpleasant surprise, Dissatisfaction, Disappointment, Boredom, Desire, Pleasant surprise, Inspiration, Amusement, Admiration, Satisfaction, and Fascination.

Characteristic

This information division is a collection of descriptive words used to express the context of images. It includes 33 categories which were classified from words collected from the survey interviews.

2.2 The relationship between the three divisions

This three division model allows designers to define the relationship between an image's' qualities and its physical properties. This combination records what designers see and how they perceive an image (see Fig. 2).

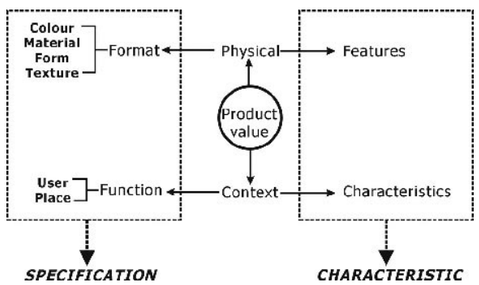


Fig. 2. The work of design with the divisions.

In addition, the categories within the characteristic division encourage designers to look more carefully at an image. For example, a "cheap" product could be one whose 'value' is cheap or whose 'price' is cheap; a "cold" image could be one whose 'physical sensation' is cold or whose colour/form is cold. As designers become more familiar with these distinctions, the better they understand what their perceptions are.

This three-division structure demonstrates the relationship between images and viewer, and also the relationship between properties and qualities. It assists designers in organising images more accurately.

3 ImageNexus

3.1 Introduction

The structure of ImageNexus is shown as Fig.3. There are three functions included: Define, Search, and Set-up.

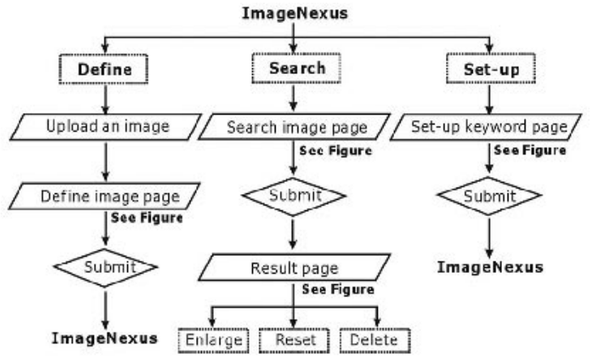


Fig. 3. ImageNexus structure.

The define and search pages have the same design as fig.4. The screen's five areas, are:

- Zone A
  This contains categories of the characteristic division. When one of the categories is selected, its members will show up in Zone D.
- Zone B
  This contains categories of the specification division. When one of the categories is selected, its members will be shown up in Zone D .
- Zone C
  The image is shown in Zone C.
- Zone D
  This shows one category's members when one of the categories of the specification or characteristic division has been selected.
- Zone E
  This shows members of the Emotion division.
- Zone F
  This is designed to allow users to add additional information about an image, such as the source of the image.

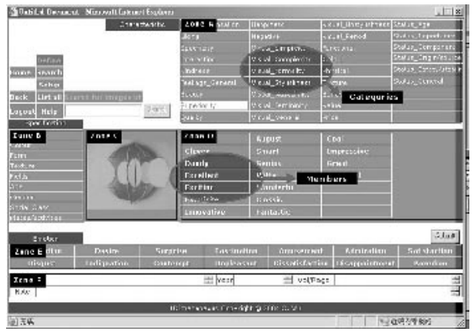


Fig. 4. Interface format of define page.

When a category is selected, ImageNexus uses different colours to show the category's state. As shown in Fig.5, when the category of Specification or Characteristic is shown in dark green, it means its members have been selected to define the image. But when the category of Specification or Characteristic is shown in white, it means the category's members are now shown in Zone D.

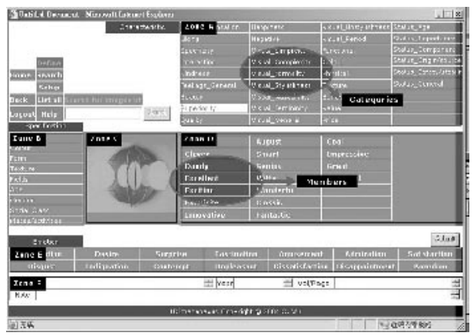


Fig. 5. Selected categories and members.

3.2 Methods of evaluation

In order to examine the usability of ImageNexus and test the understanding of the use of the three-division model to define images, usability tests and expert review were used. Web Design for Business [9] suggests that

usability tests need between five and ten people who are representative of intended users of the site, but are not familiar with the project, for an hour. These users should be asked to try to achieve certain goals which are typical of the user goals the site has been designed to facilitate. Therefore it was decided to run an evaluation workshop with five to ten people who had product design backgrounds. At the outset of the research the pilot and main interviews showed that both professionals and MA student designers use similar design processes. However, it was decided to carry out the usability workshop with MA students, who had had at least one year of prior professional experience. In these tests no significant variations were recorded between the student group's responses and these of five professional product designers who agreed to act as 'expert examiners' working from their offices.

3.3 Aims of evaluation

The aims of the evaluation were:

- To evaluate the user's understanding of the design of the database interface;
- To evaluate the user's understanding of the system structure;
- To evaluate the user's understanding of the three divisions and the categories;
- To evaluate the value of the database.

In order to achieve these aims a questionnaire was included with tasks in the evaluation workshop.

3.4 Participants and procedure

Eight postgraduate students and five professional designers participated in the evaluation. Five students attended the workshop (Fig.6) and one professional designer also participated in the same format. The other three students and four professional designers evaluated the system via the Internet and their evaluations were obtained by email and telephone. The times they spent on the system were recorded each time they logged in and out. The participants were:

- Five MA Industrial design students at Central Saint Martins College of Art & Design (CSM), UK
- Three MA Industrial design students at Sheffield Hallam University (SHU), UK
- Five professional product designers

MA Students workshop (CSM)

This took around 2 hours. Five participants were asked to define the images provided for up to 90 minutes, to search images and to complete questionnaires. A brief induction was given before the workshop started. Instructions were provided on both screen and paper. The database was operating on a remote host and each participant was given a unique identity number in order to record their results separately. As a reward, each participant was offered a copy of the system when the research is finished.

MA Students (SHU)

These participants evaluated the system via the Internet but otherwise their procedures were the same as the evaluation workshop with CSM MA students

Q1	Introduction to ID-Imagenexus is Clear/ Not clear
Q2	The three divisions of image information are Adequate/ Inadequate
Q3	The information provided for defining an image is Good/ Sufficient/ Poor
Q4	Which division is the most useful to define images?Specification/ Characteristic/ Emotion/ Additional Notes
Q5	Is the characteristic division comprehensible to you?
Q6	Is it easy to find the right keyword?
Q7	Is it a useful application for you?
Q8	Which division did you use the most to define a search?Specification/ Characteristic/ Emotion/ Addition Note/Search Box
Q9	Was it easy to define a search?
Q10	Was the search result sufficient?
Q11	What kind of additional information would you need to better understand the divisions?
Q12	What additional categories or members do you suggest adding?

Table 1. The questionnaire questions.

Fig. 6. Workshop photographs.

Professional Product Designers.

Professional product designers were treated as expert evaluators. They were able to try the system and complete their evaluation within a month. Each was given the ImageNexus web address and a unique identity number.

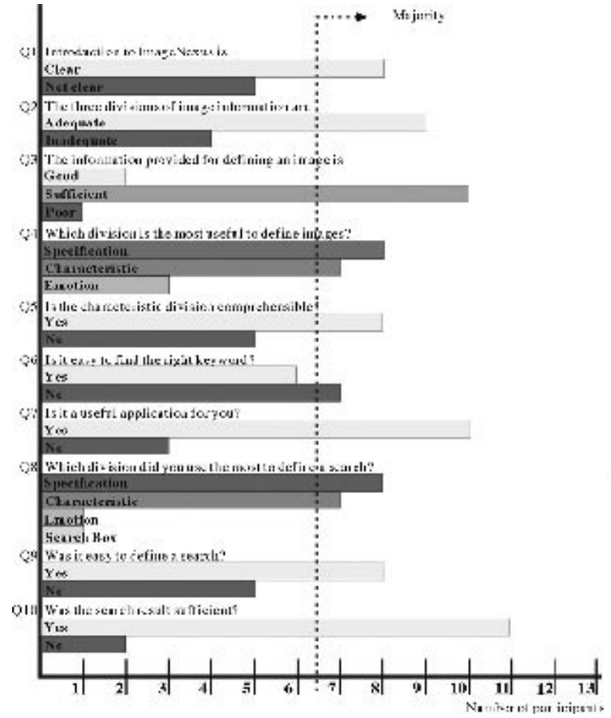


Fig. 7. Results of closed questions.

3.5 Analysis

The overall of the evaluation questionnaire are shown in Fig. 7. Analysis of the responses has been divided into two sections: (a) Usability evaluation; (b) Evaluation of the image classifications. Usability evaluation covers the first two aims of the evaluation which include evaluating the design of the system interface and the participants' understanding of the system structure. Evaluation of the classifications of image information focuses on the participants' understanding of the categories and the three divisions, and analyses the value of the database.

Usability evaluation. The questions covered and the results are summarised in Fig. 8. As shown, the results listed for 'Question 3' include the results of 'Good' and 'Sufficient' because 'Good' and 'Sufficient' are positive results.

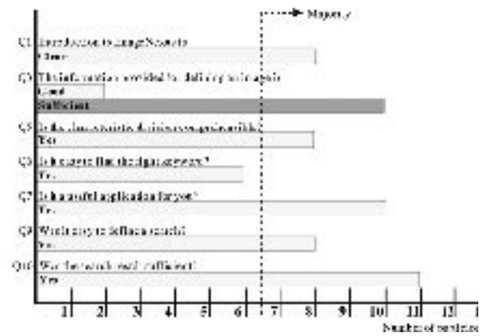


Fig. 8. Result of usability evaluation.

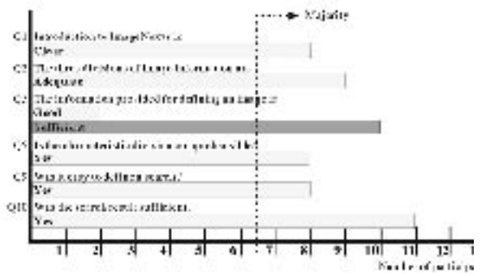
Fig. 8 shows the participants agreed that ImageNexus is understandable, useful and sufficient. However, comments from individual participants included: introduction was too complex, the Emotion division was unnecessary, the

database needs a considerably simpler and more usable interface. Most comments were anticipated or can be incorporated in a future version. For example, one of the major comments was that the "introduction" was too long and complex. The participants suggested the use of images to explain and demonstrate the procedures; fewer words, more images.

The major comments on the question "Is it easy to find the right key word?" were about the number of categories and keyword members, and most student participants indicated that there were too many of them. The participants said they would need to personalize the categories and keyword members for further use. However, one of the professional 'expert' evaluators thought that the depth of information would help designers look more deeply at the image. The system would assist them in evaluating images more carefully before showing them to their clients.

There were only 3 participants who did not think it was a useful application. One (student) gave the reason of having to personalise the category members; one (student) did not have any idea how it could be used and what it was for; one (professional A) claimed that the he/she found only some keywords were useful to define images.

Evaluation of image classification. This section includes evaluation of the users' understanding of categories and the three information divisions and evaluating the value of the system. The questions covered and the results are summarised in Fig. 9.



divisions and categories.

Fig.9 shows the participants agree with the classification of image information. Their comments were the same as the previous discussion, that too many categories meant that time would be needed to remember where a keyword was. There were no disagreements over the information structure for an image.

The suggestions were mostly about the interactive functions with the database, such as having a "date of entry in database", and a "list by" option, such as list by "material" etc. Furthermore, only 3 out of 13 participants indicated that the names of Characteristic categories were confusing and not comprehensible. The confusion was caused by there being categories within the Specification and the Characteristic divisions sharing the same name, e.g. Colour.

Fig. 10 shows the results of two different groups. Comparing Fig. 7 and 10, it shows that Specification was seen as the most useful division both in defining and searching images. Characteristic is the second most popular one. However, the Characteristic division was the most useful for professionals and the Specification division was the most useful for students.

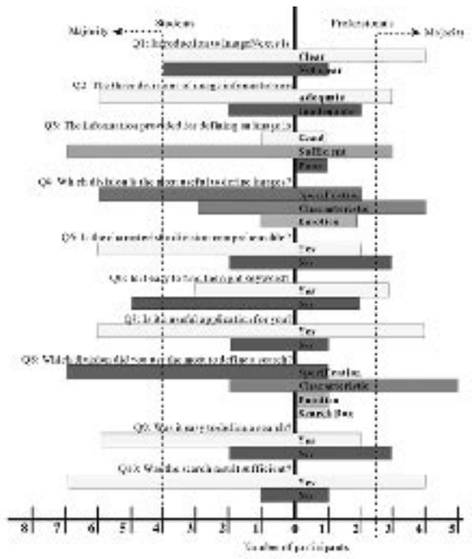


Fig. 10. The results of two different groups.

Discussion

The results show that the database was accepted and appreciated. Although there were comments on the number of keyword members, it did not affect the value of the system.

It was anticipated that participants would need to personalise the keyword members. The set-up page has provided the function for participants to organise their own members. One issue to arise here is that the 'default' members may need to be made changeable, because the original option was that the users could only add new members into each category, they were not allowed to delete default members.

To improve the usability of the database would require experts (such as an interface designer and a programming engineer) to participate in the development. This would allow the issues raised to be addressed and more functions to be added.

It was anticipated that because the evaluation focused on participants' understanding of the system, first time users could feel intimidated by the large number of keywords. The feedback comments from students confirmed this but not from professional designers.

3.6 The usage of ImageNexus

Product designers search images for inspiration or for communicating with others. The results from the interviews indicated that designers have a mental concept of the images they search for. Generally, they go through magazines or books for images they need. In recent years, their image searching has relied more on the Internet. The advantage of these methods is that the resulting unanticipated images can provide designers with inspiration; however, according to the survey, the frequency of this kind of inspiration is low. The disadvantage is that designers need to spend a lot of time either browsing magazines or books that they have seen before, or checking over thousands of images on the Internet.

ImageNexus was set up to assist product designers in organising their image collection most effectively for their use. As a result, ImageNexus not only provides designers with a means of storing their images, but more importantly also helps them to extend their image mapping with words. For example, when they search for 'beautiful' images, the system would show them other associated words: 'attractive' or 'fascinating'. This function assists designers to have further insights into their projects, because it indicates other possibilities. It helps to define where a design project theme can go and stimulates creative thinking.

ImageNexus not only allows designers to use their images productively, but also has no effect on their enjoyment of browsing magazines or books with a cup of tea/coffee. ImageNexus assists designers in organising their images for future use. It does not replace the need to find new images by an established methods.

The value of ImageNexus grows for users with extended use as they understand more fully the structure and experience the associations they make. As one designer said, the real value of ImageNexus is when it has a large number of images.

4 Conclusion

ImageNexus encourages designers to creatively use the images it contains. For example, when they select images to show to a client in relation to a mood or emotion, they need to be very specific about the mood they are choosing, so that no ambiguity arises. In this way, the communication levels between designer and client will increase, resulting in less confusion and a more appropriate design solution being provided.

A project brief is not normally only about the characteristics of the product but also includes other specifications (e.g. target market) which clients often see as more important. The three-division structure of ImageNexus helps designers to fulfill these requirements. ImageNexuse assists designers to locate their moods or emotions more precisely. It allows them to understand the difference between their intuitive reactions and their interpretations of images. For example, the intuitive response to the characteristics of Fig. 11 and 12 based on their colour or texture could all be defined as 'original' or 'nature'; however, they are very different in their real colour/texture. If they were presented together as 'original', they would cause confusions to others. The Specification and Characteristic division of ImageNexus can assist designers to distinguish them.

Fig. 11. Image of 'original' & 'nature' 1
(Source: Digital Vision, image No. 1818035)

Fig. 12. Image of 'original' & 'nature' 2
(Source: INVIEW September 2002, p.82)

ImageNexus's keywords can also inspire designers in their use of visual and verbal vocabulary both in the idea generation phase and for presentations. For example, to represent a concept of 'masculinity' which includes 'energy', 'sporty', 'technical', 'mechanical', 'animated' and so on (see Fig. 13).

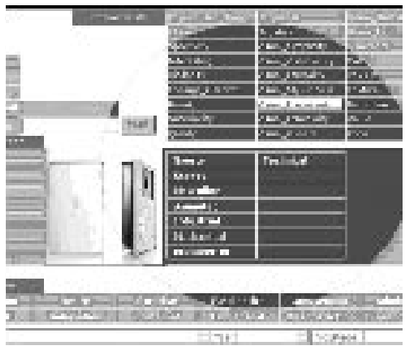


Fig. 13. Interface of the Characteristic division of ImageNexus.

The concept developed by Donald Schön [10] of knowing-in-action and reflection-in-action is supported by ImageNexus. He indicated that the work of the professional practitioner reveals in its recognition, judgments and skill, a pattern of tacit knowing-in-action. Knowing is ordinarily tacit, implicit in the patterns of action and in the feel for the involved events. Reflection-in-action is the unexpected outcome of knowing-in-action and is a subconscious result. In classifying images for ImageNexus designers utilise knowing-in-action behaviour in the conscious procedures of identifying and recoding keywords within the theme information divisions. When searching for images designers must consciously select keywords (knowing-in-action) but the results can be unexpected because forgotten images will be retrieved. Through extended use of the database reflection-in-action will play a significant role in both indexing and searching. The more familiar designers become with it, the more sophisticated will be their use of it, particularly in relation to the Emotion information division where emotional responses to image are recorded. This sophistication results from subconscious processes which develop intuitive understanding.

The essential role of ImageNexus is to store images for designers' future use. The more effort they put into indexing the images, the better the results they will get. ImageNexus also enhances the value of images because its categories can record all possible messages they can convey. An image will no longer be just a digital file. ImageNexus may also be used to store the photos from observations of product users. There are a variety of design methods which use such photos, such as visual diaries and user reactions [11]. Although, these photos are used to record evaluation of functional aspects, they can also remind designers about users' feelings and these can be indexed in detail by ImageNexus.

Recording moving images of a consumer's behaviour or a product's mechanical movement, for example, is common as part of the design development process. However, when designers store a moving image, it is normally used to record movements in order to investigate ergonomic or functional detail. Furthermore, classifying a moving image for future use requires defining the content of the 'movie' e.g. 'washing machine operation' or 'sequence of using a mobile phone'. This is different to the core purpose of ImageNexus which has been developed as a tool to assist designers in recording their responses to images not to record the images' content. As it is also the case that designers will remember a product's movement when they see it again it was decided that moving images should not be included in the ImageNexus specification.

ImageNexus is not only the result of understanding design methods and designer's perception of objects (product semantics) but also will make searching visual support resources easier within the design process while enabling designers to have a better understanding of their feelings and interpretations of images. In so doing it satisfies designers' needs as identified by the following researchers:

- Formosa [12] noted that an insufficient flow of information leads to inadequately designed products and he believes that information could enhance the design process; in the proper environment it will feed creativity.
- Lahti et al. [13] indicated designers frequently search for and use information to help them to construct new knowledge related to the design topic, simultaneously searching for new information that will help to determine design constraints and produce a satisfactory design.
- Monö [14] commented that a designer should aim at understanding product language better in order to be able to improve his design.

4.1 Indications for future work

Current image database improvement. In order to provide a better version, ImageNexus could be improved by working on:

1. Additional information categories

Additional information categories could be added to the database, such as:

- Brands: in recent years branding has become increasingly central to design. For example Gobe [15] stated that sensory design is the new branding power tool. It is one of the main concerns in marketing a product and as the interview results indicated, the front-end phase of the design process is heavily involved in marketing strategy. Designers are required to use visual aesthetics in enhancing brand value for their clients. Fig. 14 shows how images can be used to reinforce and enhance the perceived value of a corporation.

Fig. 14. Example of images used in enhancing a 'corporate image'-1.
(Source: Tangerine Product Direction and Design)

- Size/weight of product: size and weight are also part of a product'sphysical properties. As the alarm clock in Fig. 15 shows, it is hard to tell how big the clock is from the image. A category to record size/weight would help designers' perception of the product's reality.

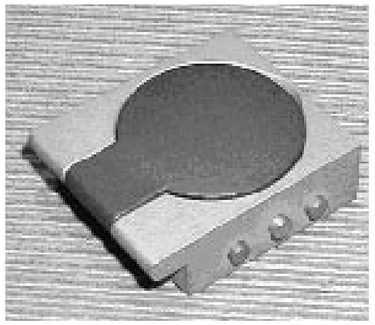


Fig. 15. An alarm clock. (Volume: 4x3x1 cm, weight: 400g)

- Sounds: sounds are an important part of a product, for example, the different click sounds on a keyboard represent different qualities/materials. Furthermore, for safety or the human factors, sound is a requirement of certain products, for example kettles require sounds as alarms to warn of water boiling. Sound is also attractive to people, and new information technology could help make recording sound easier. However, the question remains of how to search sounds, and what sort of keywords to use.

2. Additional function of interaction

A mood board function that allows designers to move images onto a design board would make the image database more directly involved in a design project.

Product design thesaurus.

Different words can be used to express the same things. For example, a 'circle' and a 'wheel' could represent the same things. A product design thesaurus would be a relationship network to assist the thesaurus method in the product design process because it could help to develop relevant visualisations. It could be developed as the Visual Thesaurus at www.visualthesaurus.com (Fig.16). In Fig. 16:

The word appears in the centre and is surrounded by words and meanings that are related to it.

Clicking on any word can transfer it to the centre and consequently see the words and meanings related to it. Rolling over a circle can show its definition and usage examples.

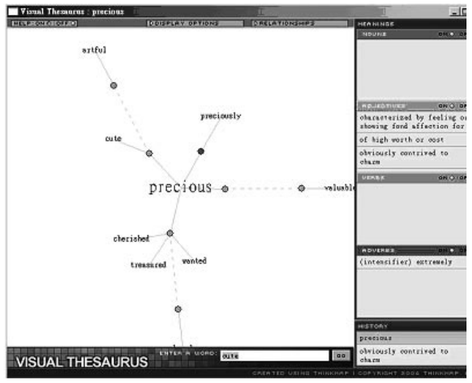


Fig. 16. Image of the Visual Thesaurus.
(Available from: www.visualthesaurs.com, Nov 2004)

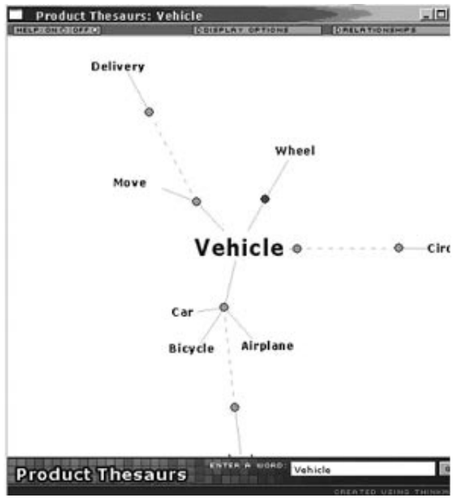


Fig. 17. The prototype of product thesaurus.

The difference between a product thesaurus and a visual thesaurus would be that the links between words are defined by the words' visual form, function, and meaning. See Fig. 17 for example.

The product/object appears in the centre and is surrounded by the word's meanings, functions, and shapes that are related to it (Fig. 17). Rolling over a circle can show its connection relations. The difference in a product design thesaurus is that the relationship between words is connected not only by meanings but also by functions and shapes. In addition, the words can be presented with images or links to relevant image databases. The visual thesaurus and other developments described would further enhance the value of ImageNexus to Product Designers as a creative and efficient tool.

Chun Ting Wu
Central Saint Martins college of Art & Design, University of the Arts London

ting0926@ms28.hinet.net

Malcolm Johns
Central Saint Martins College of Art & Design, Southampton Row London WC1B 4AP, UK

m.johnston@csm.arts.ac.uk

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Loe Feijs, Steven Kyffin

A taxonomy of semantic design knowledge

Abstract

Forms, either abstract or concrete always carry meanings. It is the responsibility of designers to make good use of these meanings, for example to make products beautiful, exploiting all the sensorial aesthetic languages, to stress the importance of certain values, or to improve a product's ease of use to create and facilitate richer experiences. It is important for designers to have access to and a full understanding of the structure of product semantics and the relevant types of knowledge so that they can effectively communicate the intended "design Ideas" or messages though the different aspects of any given "thing". In this article we undertake the construction of a scheme to classify the knowledge needed to respond to the wide variety of phenomena that determine product meanings. One of the central ideas is that different knowledge sorts are needed for understanding objects and for understanding people.

Key words

product semantics, semiotics, design, taxonomy, design education.

1. Introduction

In a market that is already saturated with competing products, the correct functioning and the technical achievements of products are mostly taken for granted. Yet the perceived added value varies widely amongst comparable products. The difference arises from the different meanings carried by the product's given form, where "form" is to be understood in a very wide sense (including behavior, color, materials, both physical and digital etc.). Products act as media which convey ideas, information content and emotion-loaded messages. A product is a carrier of information, somewhat comparable to the way a radio-frequency carrier conveys speech and music or a printed text conveys a story. To properly employ a radio-frequency carrier, one needs knowledge of modulation techniques (like AM and FM) and coding schemes (like RDS and DAB). To create a book, one needs several types of skills; not just knowing the alphabet but also natural language grammar, the meaning of words, composition principles, narrative structure and even human relations. In view of these analogies it is important for designers to have access to and a full understanding of the structure of product semantics and the relevant types of knowledge so that they can effectively communicate the intended "design Ideas" or messages though the different aspects of any given "thing", in what ever form it is re-presented and in what ever "context" it is received.

Important works on product semantics have been written: *Design: Geschichte, Theorie und Praxis der Produktgestaltung* by Bernhard Bürdek [7], *Products as Representations: A Semiotic and Aesthetic Study of Design Products* by Susann Vihma, and many others. Recent are *Designs You Don't Know What To Do With* edited by Siu King Chung & Phoebe Wong [18] and *Semiotics in product design*, a monograph by Sara Ilstedt Hjelm [17]. Although serious knowledge transfer takes place during studio-based teaching, in the educational context, and through the natural development of any practicing designer, most knowledge is incomplete at best and merely unconscious at worst. The systematic structuring of knowledge and the means to support it application, as can be seen in mature scientific fields, is simply not available at a similar level in design semantics. The knowledge which is needed should reflect the 'message' or idea, the elements of the language use to communicate it, commonly referred to at the 'thing-s' and most importantly the people, singly and socially, who receive it (the message and the thing-s).

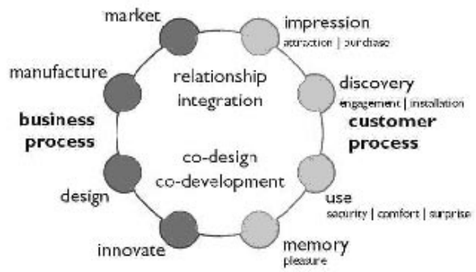

Fig. 1: Aspects which require semantic consistency through the design phases.

In this article, let us assume that product semantics in industrial design is in a phase comparable to biology in the early days before Linaeus' *Systema Naturae*. Of course, people had significant knowledge of plants and animals before, but the new taxonomy, or classification scheme, proved very instrumental for an efficient structuring of knowledge. It paved the way for subsequent steps, to be taken by Darwin, Mendel and others.

Product semantics is a complicated field for several reasons.

1. Firstly, there is great richness in semantic fields, i.e. what the messages are about. The semantic fields include instructions for usage, wealth and status, durability, attitude towards sustainability, personal life-style, group membership, etc.
2. Secondly, there is a great richness in possible shapes, colors, materials, textures, movements, interactions and other "form" elements of products (color, form, material).
3. Thirdly, the meaning of a product is context and user -dependent: an object in a museum tells a different message when put in a home, a car, a church etc. It also depends on the local culture, the personality and the education of the observer, and the period in which it is observed (seeing a stereo gramophone in 1958 is not the same as seeing that gramophone now).

The richness of the semantic fields is also visible from the diagram of Fig. 1. This diagram illustrates the "touch points" of the object and system. All these issues require semantic consistency through the design phases.

Fig. 2: Simple cups communicating their value, cultural context and social relational role.

To demonstrate the second reason, i.e. the richness in form elements, Fig. 2 illustrates that the color, form and material of the simple cups shown communicates their value, cultural context and social relational role ...assuming we can read the signs. Glass, paper, steel, plastic, ceramic, all have different connotations.

Finally, the third reason (context-dependency) is another way of saying that meanings are intertwined with culture. The diagrams of Fig. 3 and 4, which are used in Philips Design, show one way of depicting the processes of coding and decoding a message and the context-dependencies involved.

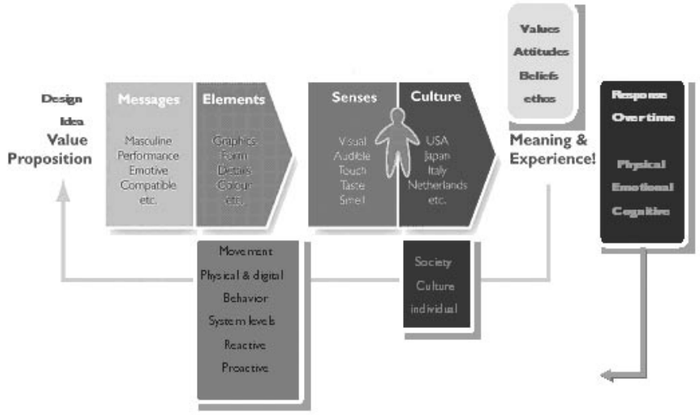

Fig. 3: Coding meanings.

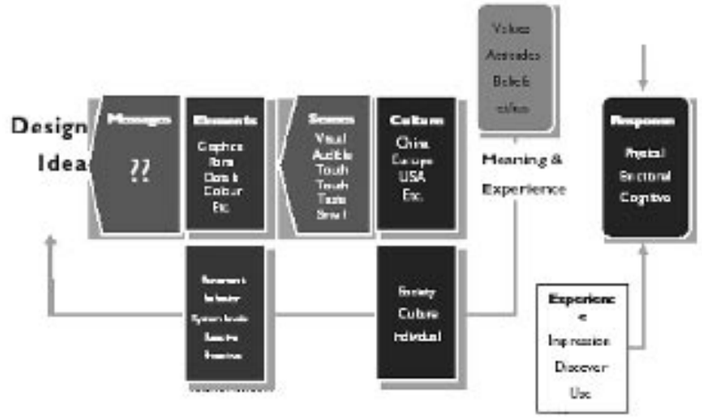

Fig. 4: Decoding meanings.

In the next section we undertake the construction of a scheme to classify the knowledge needed to respond to such phenomena.

2. Classification scheme

The following considerations must be taken into account.

1. there are relevant aspects of product semantics that find their origin in the technicalities of the product's function, its technical design, its manufacturing and it operation and maintenance. Important semantic knowledge is concerned with the product, i.e. the object, itself tells us about how it works on our behalf. Often this is referred to as the reading of function through form (Sullivan's slogan: Form follows Function).

2. there are other relevant aspects of product semantics that find their origin in the person or persons that see, buy or use the product. Important design knowledge is concerned with people, their body, their mind, with human culture and with human relationships. This can be described as how we read the object in our socio-cultural-economic-values contexts.

3. neither the objects nor the persons come alone. Products are composed relationally or systemically, so as to form more complex products, products that are dependent on other products (like the hammer and the nails, the telephone and the exchange, and so on). Moreover manufacturers and suppliers provide systems or product lines rather than single products. People also cannot be viewed as isolated entities, we exist as relational communities. More and more, the products most important to them are the 'tools' they use to relate to other people, to communicate. People form groups or communities and therefore the way people interpret products is influenced by group processes and human relations.

These considerations strongly suggest that we should distinguish between objects and people. Also the number of and the relationships between the objects and the people is very important. The role of an object considered by one person changes when the influence of more people is included in the context. Anton Andrews [3] presents this as a model with three levels of relational complexity, where this is expressed as a progression through three levels of complexity: immediate context (relationships between people and digital products or services), ecological context (internal relationships between the digital products in a system) and systemic context (relationships between larger networks of products and people).

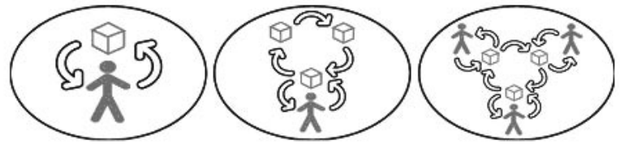

Fig. 5: Diagram to illustrate the progression in relational complexity.

Alberto Alessi *(Beauty can save the world)* has also stressed the importance of an object's communicative and sensory attributes. The success or failure of a product is determined by (1) sensoriality, memory and imagination and (2) communication. Alessi calls these the two *central* factors. The two other, so-called "peripipheral" factors are helpful for understanding the final evaluation from customers: *function*, that is, the functionality in relation to the archetype product, and *price*, also relative to existing products.

In considering how we should cluster the types of knowledge required or the systemic circumstances we would expect to use the knowledge to help us when designing for those circumstances, we have formulated several configurations. In the lattice diagram of Fig. 6 we present nine such configurations denoting the relationships between the things, the tings and people and between the people. Note that also certain extreme configurations containing only objects or people also appear; although these configurations are not about a communication situation, they do correspond to knowledge domains. Even the empty configuration refers to something useful. It represents the abstracted world where no people or objects exist, but merely the formulas to represent the relationships; the mathematical world. There are no separate configurations to distinguish two, three or more objects, and the same for people. Roughly speaking, we count "zero, one, many" instead of "one two three". It is always possible to refine certain configurations later. We do not include the formal derivation of the lattice structure of Fig. 6; it suffices to know that similar diagrams with more refined counting schemes exist. In the Sec. 3 we discuss each configuration in more detail.

The nine configurations have been numbered 1-9, starting from the central configuration: one object, one person. Configuration 2 is "one product"; this is what many designers are still concerned with, although understanding the user (configuration 3) is more and more important. Then from configurations 4 onwards, more objects and more users are introduced, until in configuration 8 everything comes together. The empty configuration gets number 9 (the knowledge sorts that belong here are not empty, however).

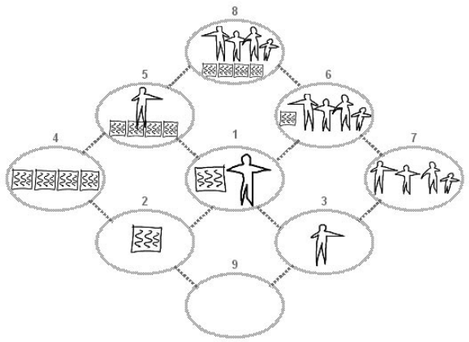

Fig. 6: Nine configurations of products and persons.

The nine configurations contain the same ingredients already visible in Fig. 7, a diagram originally proposed by Irene McWilliams at Philips to show the development of ambient intelligence. But whereas Fig. 7 shows a kind of progression from simple to complex, at least with respect to the nature of the objects, Fig. 6 does not pre-assume some order of development. The model proposed by Irene is called One-D to Ten-D: the Evolution of the Interface (6th Doors of Perception) [22]. Irene presented it as just a way of telling the story of the evolution of design, in

terms of electronic media. In contrast, our configuration lattice deconstructs the complexity arising in the fractal village sketched by Irene, where people are equipped with wearable technologies while decoding spatial references, interactivity, flow, and all of the different dynamics, over time. Each of the nine configurations may or may not be applicable for certain products and for certain situations. When applicable, a specific configuration identifies the relevant knowledge sorts. We adopt Fig. 6 as the central structure for our classification.

Fig. 7: Moving from people with no objects towards Ambient Culure/Ambient Intelligence.

3. Configurations

Configuration 1: product and person

This is the configuration that is in the heart of product semantics and in the past has generated the majority of the knowledge gathered so-far. Knowledge from the following areas is relevant:

· applied ergonomics,
· gestalt theory and ecological perception,
· esthetics,
· tangible interaction,
· product standard and regulations.

Applied ergonomics uses knowledge about human measures, biomechanics, but also about the human information processing capacity to make sure products fit the human body and mind in an optimal way. Not only the static aspects are relevant (length of the limbs etc.), but also dynamic aspects (optimal movements). Optimization can be directed towards work efficiency, comfort or sustainability of product usage (for example R.S.I. prevention). Much work is being done in the HCI community, but only recently this started to get further than traditional computer paradigms.

Gestalt theory investigates how humans can perceive a unity from a complex of individual stimuli whereas ecological perception investigates active forms of perception, like three-dimensional vision through movement (Overbeeke and Strattmann 1986). Closely related is the understanding of *affordances*, the possibilities or even invitations offered by handles, grips, etc., based on the human motor skills. It is still an open question how to transfer the concept of affordances from ordinary objects to computerized products (Djajadingrat's *But how, Donald, tell us how?*, [9] referring to Donald Norman's work). Aesthetics benefits both from studies in visual perception [6] and art history. Straightforward application of geometric principles does not guarantee a beautiful product, but still knowledge is useful for analytical and historic purposes (see Sect. 3.9.) In the early days of designing interfaces for electronic systems, then having flat control panels, has lead to a revival of two-dimensional aesthetics (particularly attributed to the Ulm school, 1955-1968). At present we need to understand the aesthetics of movement and interaction. We also refer to the work of Djajadingrat [10], Frens, Wensveen, Hummels and Overbeeke who are pioneering this field. The field is expected to benefit from input from dynamic art, dancing, and animation.

The field of tangible interaction is growing fast because of the new demands put forward by the concept of Ambient Intelligence [1]. See the entire Sept. 2005 issues of *Personal and Ubiquitous Computing* (Vol.8 No.5, Springer-Verlag). The problem is no less than connecting the virtual and the physical. Paul Dourish [12] explores philosophical aspects in his book *The Foundations of Embodied Interaction*. The discussion of semiotics is postponed till configuration 9.

Configuration 2: one product

Although not strictly at the heart of the world of Designers, the Object as a singularity is implicitly, over the past decades, the heart of the designer's concern and therefore considerable amounts of knowledge is held here. With the onslaught of systemic solutions and therefore the need to design multiple connected objects in the context of content driven intelligent systems fully integrated into the lives of communities, open and closed, of connected people, this limited field of knowledge just does not provide the designer(s) with what they need to propose appropriate object-system solutions, which emerge and adapt over time.

However the technicalities of product conception, its function, the way it is manufactured, its operation, its maintenance play an important role in product semantics. Two arguments support this claim:

· First, J. Beljon, in his book "Zo doe je dat" (That's how to do it) [5] gives, in a systematic way, examples of how the way of creation of an object is still readable from the resulting form. If W is a way of creation (e.g. folding, splitting, stacking, etc.) of a certain object B, then we write W ⇒ B to denote their relation. In other words, W ⇒ B abbreviates that W leads to B. And then this is how an observer attaches meaning to B. From B he deduces or recognizes the way it was made. This way of creation is one of the meanings carried by the object: the object tells how it was made. Using mathematical function notation, **meaning**(B) = W. So for Beljon's indexes[1]:

if W ⇒ B then **meaning**(B) = W
(Form follows Manufacture)

· Second, *Louis Sullivan* created the famous slogan "form follows function". It has been, and still is, the topic of debate but by now the slogan has lost its claim of universal validity. Yet, the basic idea, makes sense for many mechanical engineering types of products. If F is a task or function to be performed by an object then the logic of engineering, the properties of materials and the natural laws of physics lead to a certain form of the object B. We write F Þ B. But an observer, reasoning the other way around, recognizing the engineering logic etc., attaches a meaning to the object. The object tells him or her what the object was designed for. is intended for. We write **meaning**(B) = F. So for Sullivan's indexes:

if F Þ B then meaning(B) = F.
(Form follows Function)

[1] Here the term "index" refers to the typology of signs proposed by Pierce. A symbol is a sign based on convention; it must be learned. An icon resembles the thing it stands for. An index has a physical connection to the thing it means or carries an imprint of its meaning (smoke is a sign of fire, an open door is a sign that someone is home, footprints are a sign someone has passed by).

Psychologically, indexes rely mostly on the human cognition system. This is where we understand, by a way of backward reasoning, were forms come from.

In Fig. 7 we give two simple examples to illustrate both principles. The first object illustrates form follows manufacture, the second form follows function.

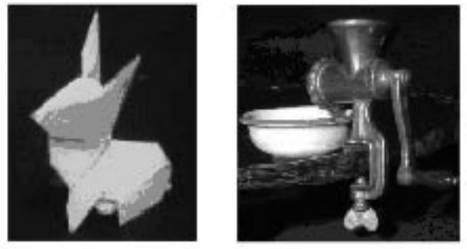

Fig. 7: Form follows manufacture (left) and form follows function (right).

For this configuration, what are the knowledge types involved? Roughly speaking, this is engineering knowledge.

· material science
· mechanical engineering
· manufacturing technology
· computer/aided design tooling
· software technology and operating systems

From the form follows function paradigm, certain knowledge has developed concerning the way pure form can express meaning. It is remarkable how well people read such forms. Not only the meanings of handles, grips etc. that suggest how they should be used (essentially the affordances that belong to configuration 1). But more sophisticated and pure is the design and reading of forms that express flow and direction, even when they are not meant to fit the human body but rather support more abstract concepts such as flow. Consider the two objects in Fig. 7. The left-most object is a camera: light flows into it. The rightmost object is a projector: light flows out of it (both Philips Design). It is only natural that now this body of knowledge moves away from a pure form-follows-function and becomes part of a cultural language. Gradually this knowledge crosses the boundary from configuration 2 to configuration 1, or even to configuration 6.

Fig. 8: Forms used to express light flowing in and light flowing out, repectively.

Precisely at the transition from configuration 2 to 6 we find examples how an object can really 'speak' about its cultural position, its value, how it performs and how it is used all at the same time. A very simple thing, such as a radio, can be a cultural proposal. See Fig. 9, left (a radio represented as a theatre, Kyffin, 1980's). The radio has all the ingredients demanded by the form follows function, but the theatre-based representation turns it more into a cultural proposition. And Alessi's lemmon squeezer (Fig. 9 right) is hardly meant for squeezing lemons, although it still suggests a form-follows-function approach. It is a cultural proposition too, about innovation and courage[2].

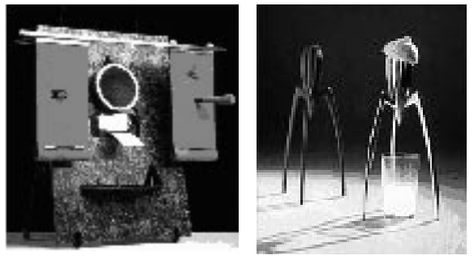

Fig. 9: Radio "speaking" about its cultural position, a theatre and Alessi's lemon squeezer.

Configuration 3: one person

A certain level of understanding of the human body and mind are indispensable for the proper design of objects to be used by humans. Conversely, the human observer will recognize some or all of the assumptions on the human conditions have influenced the design and interpret the product accordingly. The usage of human properties in a systematic way is called ergonomics. We should include both human body and human mind, without suggesting that these can be completely separated. We distinguish the following knowledge types concerning the human body and mind:

- anatomy,
- physiology,
- motor skills,
- human perception,
- human emotions and human needs,
- human information processing, which includes memory and cognitive capacities.

Configuration 4: multiple products

This includes the technicalities of interaction between products. A further subdivision of the relation between the products is needed, otherwise the discussion remains far too abstract. We distinguish:

A. tools in relation to the objects to be processed: manufacturing tools, design tools, including computer software.
B. products that belong to a system, either in a mechanical sense, e.g. objects that should fit together, or in an electronic sense, e.g. communicating devices.
C. products that are in a similarity relation because of mass manufacturing; the multiple products are more or less identical copies of the same design.

A simple example of A is a corkscrew, being a tool to open wine bottles. The knowledge types involved are the same as for configuration 2 (one product), but the viewpoint is precisely the opposite: for example, the meaning of a tool is the objects that can be made with it. The bottles and the corks are indispensable for designing or understanding a corkscrew. Conversely, when designing or using a wine bottle, there are alternative caps such as a screw cap and a crown cap next to the cork. In the semantics of a bottle and its cap there is a reference to the tools for opening it. A more modern example of a tool is the BUILT-IT system for direct-object manipulation by Fjeld, Bichsel and Rauterberg [15].

[2] In an interview with Danny Sutjaho [2], Alberto Alessi says: "Philippe Starck's fruit-juice squeezer is one of my favorite projects. He consciously exaggerates the existence of the decorative veil. It's an example of courage; it embodies the risk of innovation [...]. (Interviewer) I've heard it's quite difficult to actually get any juice into your glass. Aren't you afraid that customers will shun Alessi for not fulfilling their expectations of your products? "I hope not. No, I'm not afraid. I think it's too important for us; it's our destiny, to be experimental. All right, the legs are weak and may break if the thing falls, but it works as a squeezer. I would never use it to squeeze oranges, though; I have an electrical product for that. If someone buys a Philippe Starck squeezer to squeeze oranges, they're stupid. They're not customers for Alessi. It doesn't make sense to take care of these people."

An example of a product in the second sense (B) is a LEGO brick. More interesting examples of B type are products belonging to a system of communicating devices. For communicating devices, the knowledge type of software engineering and operating system standards plays a role here, as in configuration 2 (one product), but for the electronic aspects, power supply considerations, compatibility of plugs and wirings etc. comes in. For the communication aspects also telecommunication technology, standards of plugs and signal exchange and data exchange are relevant.

Examples of C are all products that are mass manufactured. The difference between B and C is shown in Fig. 10, where the telephones to the left form a *system* (B) and where the telephones to the right are all similar because of *mass manufacturing* (C)[3].

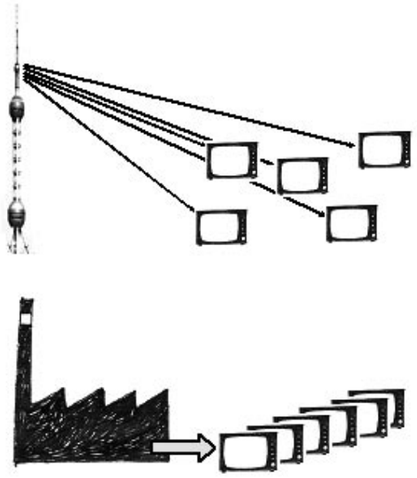

Fig. 10: Two different examples of "multiple products" (telephones).

A similar comparison is shown in Fig. 11. The main difference lies in the nature of the telecommunication system that connects the products. In Fig. 10 the system is meant for person-to-person communication whereas in Fig. 11 it is for broadcasting. Of course, present-day communication systems are much more complex, but the principles and the knowledge sorts are still essential; they have to be complemented with media theory and media-related research.

[3] We thank Kees Dorst for the phone, factory, and tv drawings.

Fig. 11: Two different examples of "multiple products" (televisions).

Configuration 5: multiple products, single user

This includes the technicalities of interaction between products. A further subdivision of the relation between the products and the user is needed. It makes a difference whether (I) the user is faced with a multitude of products from which to choose in a shop or in a catalogue, or (II) when he has acquired the products and now had to deal with them in an operational situation. The first and second item below belongs to (I), the second and third to (II).

- Product distinctiveness. Comparable products are often manufactured with the same technology and from the same sub-components, so the distinction between different products and even between products of different brands has to be added artificially through the addition of features. One of the consequences of this is known as "featurization". It is assumed that, when faced with a choice of similar products, the prospective customer will prefer a product that has something extra; in practice many of the extra functions are not used however and the actual experience of usage suffers from the extra buttons, handles, menu's etc. The creation and communication of product distinctiveness is usually part of marketing.

- Product-family design. This is in a certain way the opposite of the previous. Often a manufacturer wants to

establish a certain similarity between all of his products and an even stronger similarity among certain subsets of his products range. The advantage appears particularly with manufacturers having a good reputation: they want the prospective customer to recognize the product and raise the expectation of certain quality characteristics.

· Multiple products in a single space. Relevant knowledge comes from interior design; the problem that arises when too many products, each with its own form-language are together is sometimes referred to as *semantic pollution* (Thackara, Marzano). But the same problem can also be approached from an economic point of view, sometimes referred to as "attention economy": attention of users is considered to be a scarce resource and so the value of a product, image, movie, web-site etc. increases when more people see it.

· Products connected electronically, either in the same space or not: this gives rise to a set of problem known as *feature interaction*. The problem appeared first in connection with new services provided by telephony exchanges, follow-me, conference calls etc. But by now the problem also appears with remote controls for audio-video, home-automation, etc.

Configuration 6: one product, multiple users

One could consider a room, a house or a public space as a product, in the sense that it is explicitly designed, usually by an architect. These examples show several aspects of the one-object/multiple users configuration. A room, for example, establishes a relation between the people that are in the room. The confined space brings the people closer to each other and shields them from interference from outside. Thus it supports communication and social activities among the people in the room. There are also inherent difficulties due to the sharing: people have to negotiate their position or territory in the limited space, they have to take turns in speaking, set up agreements on objects, noise, smoke, temperature etc. in the room. The room is said to be a shared resource. Even if we leave the design of rooms and buildings to the architects, the two issues of something supporting *communication* and something causing conflicts due to sharing remain highly relevant for many design problems that do fall within the scope of industrial design. The two issues are discussed separately below:

· Products that support communication, in the sense of exchanging information: this includes radio, telephone, and television, but also the more complex systems under development today such as awareness systems, interactive web-sites and on-line games. No doubt, media theory is of the utmost importance for understanding such systems. For these products however, the concept of configuration 6 (one product, multiple persons) is imprecise and needs further refinement (see below).

· Products that cause sharing conflicts: the simplest example is the area of a road-crossing; either the traffic regulations or the traffic lights guarantee mutual access. But often the sharing conflicts and their resolution are more complex because the "product" is not a single physical object but something more abstract; also the notion of uniqueness can be understood in a variety of ways. This is what is often called the *paradox of the commons* (Manzini). In game theory it is called a *prisoner's dilemma*. Considering the natural resources of our planet, for example Buckminster Fuller (*spaceship Earth*) and the Club of Rome asked attention for the problem of resource sharing.

To refine configuration 6 (one product, multiple users) in case of media products, we refer to Fig. 12. The telephones are mass-manufactured (configuration 4, multiple products). An individual telephone gets hooked-up to the telephone system, where it inter-operates with phones of the same or other manufacturers. This entire telephone system provides a service to its users, for example person X who can talk to person Y through the phone. This is a one-product, multiple-persons configuration. Knowledge and experience concerning human communication are highly relevant (discourse theory, theories about trust and common ground). But if we zoom in further, we see that there is another multiplicity: the telephone and the telephone system support many telephone conversations, and in this sense they are media. The telephone is a medium for contents, viz. the conversations. This is where the real importance of telephones comes from. As McLuhan puts it: "*the medium is the message*." Each medium affects the rhythm and the patterns of human communication and thus of human life.

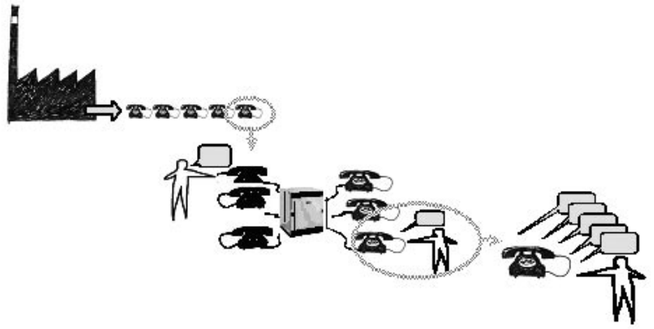

Fig. 12: Unravelling the "multiplicities" for media products.

This is precisely why ethnography and ethnomethodology are being introduced into design. It is important to understand the rhythms and patterns of people's lives before inserting some media-related product into their lives and to study the impact of new products once they are introduced.

Many models have been proposed to deal with the resulting complexities. We mention two of them. The first is a model of successive development stages of the global economy. The first two phases are mostly about the material aspects of the product, in the third and fourth, the "products" are gradually becoming more virtual.
· commodities,
· product economy,
· service economy,
· experience economy.

The second model is in use inside Philips Design; as shown in Fig. 13, it illustrates the four levels at which the users can be understood. At this point, we are already gradually moving into knowledge about people, which is the topic of Sect. 3.7.

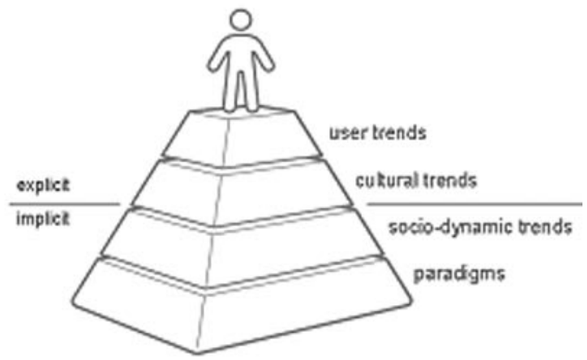

Fig. 13: Diagram to illustrate the four levels of user knowledge.

Configuration 7: multiple persons (no product)

What is the relevant knowledge that comes from multiple persons and their interactions, but not directly involving the products? Several knowledge types play a role:
· Psychology of human relations.
· Sociology, that is, understanding how society is organized. Relevant topics are: social stratification, and social mobility; racial and ethnic relations; education; family; social psychology; urban, rural, political, and comparative sociology; sex roles and relations; demography; gerontology; criminology; and sociological practice (source: Wikipedia).

The psychology of human relations plays a role when designing telecommunication systems. On the one hand, people have certain communication needs. Good telecommunication systems support that need. On the other hand, people have certain privacy needs, which are prone to be violated by new telecommunication solutions. Designers need to address these conflicts and the products should show how they support both needs. Whereas the psychology of human relations is to a certain extent universal, many specific data are determined by culture and the geographic, political and historic development of a society or group within a society. Sociology studies this and thus complements the universal knowledge with specific knowledge of what happens in practice.

The two abovementioned knowledge sorts are scientific disciplines, but there is also knowledge needed of another, perhaps more volatile kind: culture, trends, and fashion. This is illustrated in Figs. 14-16.

Fig. 14: Three different 'user' expectations of a phone.

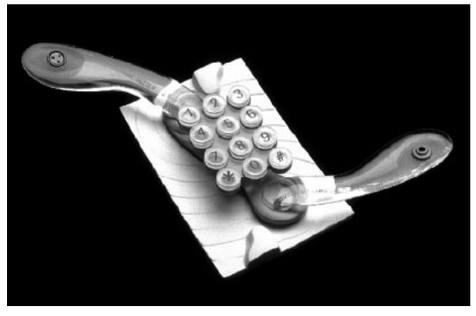

Fig. 15: Two more different 'user' expectations of a phone.

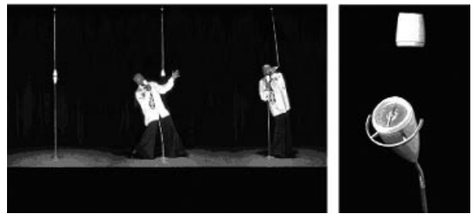

Fig. 16: Telephone as theater.

A telephone is not just a telecommunication device, it is at the same time a cultural proposition which raises its own specific user-expectations. The telephones shown are a standard office phone, "Mobile meets landline", "As in China 2005", "Phone as wallet"", "Phone as performance status symbol", "Phone as theatrical prop", respectively. Finally Fig. 17 shows a phone as body jewelry.

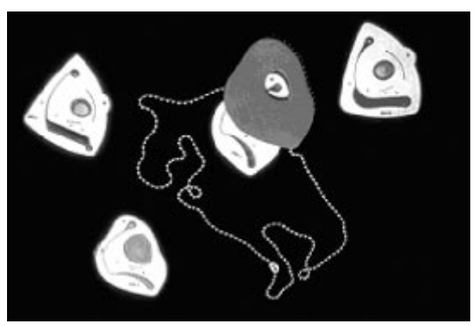

Fig. 17: Telephone as jewelry.

Although we do show objects (so perhaps this is somewhat about configuration 6 as well), here it is important to see that the added value is mostly cultural value, much more than material or functional value.

Configuration 8: multiple products, multiple users
Branding belongs to configuration 8 because it is essential for a brand that many people know it. The value of a brand depends on the number of people that recognize the brand. It is the goal of brand designers to communicate a set of values associated with a range of products and let the brand act as a compressed form of that and make it known to a large target audience. But conversely, a single object, a single product cannot constitute a brand.

Also the history [13] of design belongs here. The history of design cannot be concerned with the details of a single object, it is about the relative positioning of designed objects in the whole "language" of alternative proposals. This knowledge is part of culture, it is neither absolute nor objective. Whether a design becomes famous or not is determined by social processes. The facts and assumptions may be interpreted differently in different communities and at different times. It is useful for designers to be equipped with such knowledge.

Configuration 9: abstract knowledge
This is the empty configuration. One would expect that there cannot be any knowledge except when it is about either people or objects, but at least there is mathematics. Also philosophy, which is not even meant to be put to the test through physical experiments at all, can be associated with the empty configuration. After detailing the mathematics, we obtain the following list:

- geometry,
- algorithms,
- game theory,
- semiotics,
- structuring principles,
- design process,
- philosophy.

Geometry plays a role in the aesthetics of 2D and 3D form. Examples are the golden ratio, Van der Laan's plastic number and symmetries (friezes, tilings, Escher, etc.). A typical example of how such geometric knowledge is used analytically is shown in Fig. 18 (source www.essencedesign.nl).

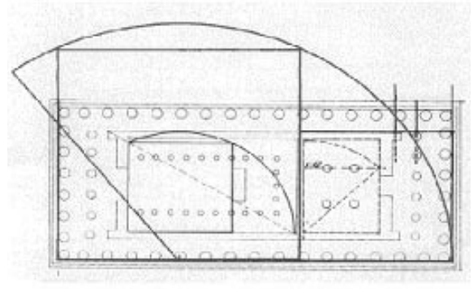

Fig. 18: Parthenon Athens with inscribed the golden mean proportions.

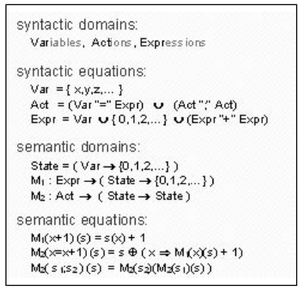

Fig. 19: Equational modelling of syntax and semantics of a programming language.

Algorithms are essential for the design of embedded software, data transformations, animation effects and user interfaces. In John Maeda's "design by numbers" geometry and algorithms get combined.

Game theory is at the heart of many games such as chess, go and games of strategy. Many of these games provide an attractive play (at least for certain people), either through board-games or as a part of computer games, mobile games and other interactive products. The theory lies also at the heart of economic theory and sustainability problems (Manzini's *Paradox of the Commons*).

Semiotics is the theory of signs. We mention jut a few of the most well-known ideas [8]: Pierce defines symbols, icons, indexes, etc. Eco [14] defines *ratio facilis* and *ratio difficilis* as different ways of creating signs. Other important semioticians are Barthes and De Saussure. Around 1990, there was a strong research interest to connect semiotics and product design, Butter, Krippendorf 19,20] Bürdek [7] and Vihma [28,29] being leading authors. After the explosion of computer usage, the Internet and mobile telephone networks in 1990s, we expect that product semantics get linked to media theory (think of Marshall McLuhan's *The Medium is the Message*, and Pierre Levý's *Qu'est-ce que le virtuel?*). The existing theories of form and relatively simple telecommunication patterns discussed in Sect. 3.2 and Sect. 3.6 (Fig. 12) need to be extended to incorporate the complexities and virtual designs of cyberspace as well.

Mathematics offers also tools to help structuring semantic information, such as meaning functions and structure-preserving mappings. This approach is particularly far developed in computer science (*Denotational Description of Programming Language*, see e.g. Gordon [16]).

The equations of figure 19 describe the semantics of a simple programming language with numbers, addition "+", assignment "=", and sequential composition ";". This is enough to have a very precise definition of the meaning of a computer program such as

```
x = x + 1 ;
x = x + 1
```

Joseph Goguen has pushed the mathematical approach further, even using it in user interface design (see http://www.cs.ucsd.edu/users/goguen/projs/semio.html). It remains to be seen however whether the present design community finds such approaches helpful; the algebra is quite non-trivial.

Considerable knowledge is being gathered about the design process. The idea is that some of the creative steps in the design processes cannot be fully understood, but that it thus makes extra sense to study the way the process is organized, the way teams are built and to collect best practices. We do not consider this to be configuration 6 because the designer is in a completely different role than the user. Classical studies concerning the design process are by Christopher Alexander's *Notes on the Synthesis of Form* [4], Donald Schön's *The Reflective Practitioner* (1983), and Nam P. Suh's *The Principles of Design* (1990). More recent are the works by Kees Dorst [11], Nigel Cross, Larry Leifer.

Philosophy plays a role as well. It is the discipline where matters of ethics and esthetics are discussed when experiment or experience does not provide any further help. Sometimes the value system underlying all kinds of design decisions stays implicit, although in fact it is determined by an adopted philosophy.

4. Concluding remarks

As Bürdek puts it, product semantics is in the heart of the design discipline[4] In view of richness of phenomena to be taken into account and their complex intertwining, as shown in this article we strongly agree. But not everybody agrees; some consider the field as finished or old-fashioned[5] . In our view, it is a fascinating field and it is worthwhile to deconstruct the processes and the meaning functions of contemporary design. The role of the virtual is growing fast, resulting in an unseen complexity where the virtual and the physical become intertwined. We need all the structure we can get, even if we have to make a step back first laying proper foundations. We hope that this article is a meaningful contribution to that.

In the final version of the paper we will add more references to the field of product semantics, of course. We also plan to be more explicit about the motivations for the choices made and about our own position in the field.

The authors like to thank the anonymous reviewers for their suggestions (most of which will be implemented in the final version). The authors would like to thank Kees Dorst, Philip Ross, Kees Overbeeke, Matthias Rauterberg, Tom Djajadiningrat for the help and discussions that contributed to the research reported in this article.

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Loe Feijs
Department of Industrial Design
Technische Universiteit Eindhoven

Steven Kyffin
Philips Design
and
Department of Industrial Design
Technische Universiteit Eindhoven

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Mirja Kälviäinen

Action, movement and bodily relationships in products

Abstract
This paper analyses different sorts of interpretations of action, movement and bodily relationships in products. Human interpretations of products involve questions concerning product function such as 'what can the product do?' and 'what can I do with the product?'. They also consist of perceptions and understandings of the way to use the product. Human body- and movement-related interpretations do not, however, end in concrete functions and actions, but also extend to symbolic and social interpretations. Humans as social creatures interpret products as other human beings. We also use these humanistic product interpretations when we assess the qualities of the owners of certain products. An important social aspect of perceiving action, movement and bodily relationships in products is, furthermore, that we contemplate the making process and the actions of the makers of the products.

1. Introduction

This is a short analysis of the different forms of action, movement and bodily relationships that people interpret in visual products. This analysis is based on many years of encounters and studies with the human-product relationship. Cognitive usability and the psychological behavior of people emphasizes that with visual cues embedded in products it is not so important what is actually there but what we perceive from the product. What actually catches our attention and how do we interpret it?
The human-product relationship seems to consist, at least, of the following categories that we use to perceive and interpret action, movement and bodily relationships in products: function, way of use, symbolic meanings.

2. Function

The first of these categories is simply:
What can the product do?
It is usual to try to see from the product what kind of functions it can perform. This calls for visibility of function in the product. There is a need in human beings to see what could happen through the product, even if the person looking at the product might not be the one actually using it.
As technical products have become more and more digital this visible function aspect of products has in many cases disappeared, and there have been many arguments that it needs to be put back into the products. In spite of digitalisation it is still easy to find examples of this kind of product. Washing machines with a glass window in which you really see that your clothes are being washed clean by the machine are making a comeback. A traditional toaster lets you watch how the glowing panels are making the bread hot and crisp. This aspect of product understanding works also with smaller parts of the product function. All the hand tools and electronic plugs where you can see how two parts fit together represent this aspect.

[1] Norman 1988.
[2] Gibson 1979.

Usability psychologist Donald Norman has introduced the concept of 'mapping' to explain how we cognitively understand what the visual product might do. The product should be consistent with the mental mapping of functions and the relationship between different functions in accordance with learned models and space relationships. This means that, for example, the buttons that speed things or make them brighter should be placed higher and the buttons that slow things or make them dimmer should be placed lower down in an interface.[1] The idea of mapping is an important part of how we see what the product can do and how we can do things with it.

Figure 1. Mapping and movement to the right direction is combined in this tap. Hot water comes naturally from moving the handle up and cold water comes naturally from moving it down. The natural moving directions are, furthermore supported by marking the hot water with red color and the cold water by blue color.

Once we have understood the function of the product we must also ask:
What can I do with the product?
Many products perform their function without the user, at least after some initial operation from the user, but there are still a lot of products that need more continuous action from the user to perform the task in question. In these products it is vital to see what you could do with the product.

Some situations seem to require psychologically real physical action. In emergency situations people act upon primary instincts connected to the oldest parts of our brains. Instincts urge us to act physically. In usability tests in a big Finnish factory it was evident that it did not seem that we were doing anything about the emergency situation if we just gave a number code to the computer or pushed a small button among some other buttons in a small interface. There was a need for a concrete, big and imposing handle for emergencies so that it really feels that it has an effect on the situation. When you actually pull a big handle with physical effort and movement it feels more that you have really done something to rescue the problem at hand. So it might not be enough that the product does something: you need to physically feel that you yourself do it.

The question of what you can do with the product is related to the psychological concept of affordance introduced by Gibson 1979. Affordance suggests that we do not categorize products through product names but rather through an intuitive bodily understanding of what we could do with them. If there is a knee level flat surface we intuitively understand that it is a place to sit down, even if it is not actually a chair of any sort.

Figure 2. This garden carriage was designed so that the shovel would serve as the handle to push the carriage around. In a usability test users did not understand this function but took the shovel off and started to use it with normal swinging movement.

This also leads us to realistic aspects of the life of the products that designers and companies create. It is very usual that in addition to designers also people use products in their environments for different purposes than they were originally created. These products can often be useful for many more and different purposes than they were designed for. This is, of course, a useful option in the life of the products, but it can also be dangerous. The products might get broken when misused and they can cause dangerous situations when they are used for different purposes from those for which they were actually safety tested.

The possibility of misuse leads also to the question of products that originally have the purpose of play. Then our question changes into:
Does the product invite you to play and try out different possibilities?
There can be features in products that invite you to start some playful functions. There can even be features that when moved do unexpected things that invite you to try more experimentation to see what happens.

Interaction with products is the key function in many forms of play. If you know that a product is designed for playful use you expect to find interaction possibilities either with the product itself or in its use together with other people. Of course, you can play with products that were not meant for playing. The misuse of a product can be playing with it, which is typical action for young children. Humans are playful creatures. Play is evidently not only a property of digital game-type products. There is the possibility of play in many other products and even in product constellations. With a set of creative tableware you can set the table in many different ways, and you can even 'play' by collecting these pieces of tableware.

Figure 3. Lego has produced one of the most interactive solutions ever with the module structure. It is typical that the children first build the suggested and designed item from a box of Lego pieces. Then they mix the pieces with their old ones and start creating their own constructions for their own imaginative plays.

An interesting and underused way of promoting interactive actions is to make things go astray from the normal or make people feel something is wrong and needs to be mended. A brilliant way to show this was work by a design student presented at the 1999 London Young Designers show. A student had created a product, or perhaps a situation, where the user coming home could detect that there was a phone message because a painting on the wall was askew. This fault in the environment, that would intuitively ask for correcting actions from the user, would tell very efficiently that there was a message, and also prompt the user to take the action of correcting the painting and remembering to listen to the message.

3. Way of use
This leads us to the question of what needs to be done to make things happen:
How can I do things with the product?
In encountering a product we not only wonder what function the product can perform, but we think what actions should we make to actually make the product perform this function. In usability this is of course the main question. We should be able to see and understand easily how to achieve efficient performance with the product. It is possible to find many examples of how the product fits with the human body, and the functions of the body, so that it would be rather easy even for a person not familiar with the product to figure out how to use it. Luggage might have a handle at the level of your hands and wheels at the bottom, and these features of the product allow and invite you to pull it behind you comfortably. Normal scissors have holes to fit your fingers in and it would be a very natural act for human beings to open and close your fingers as you do when you use scissors.

Of course one of the most important aspects of what you can do with the product is how we have learnt to use certain things. The product itself may not actually tell us through visual features that match our body how to use it. We, or even our ancestors, have had the product for a long time and we have learnt the mechanism of use of the different parts and features that the product has. This is the cognitive model of use that the product implies for us. People understand the whole model of how the product works, or they try out different parts of the function process one by one. If you understand the whole model at once, of course, it makes things easier. For each part of the use process it seems evident through usability studies that some feedback, or interaction from the product, is important to inform the user if their model or step by step actions have been correct.

A good example of the effects of the cognitive model is the use model of phones. This is influenced more and more by the model of mobile phone use. The Finnish usability professional Irmeli Sinkkonen investigated the case of an inhouse phone system with telephone machines that resembled mobile phones. Users were likely to start using these phones with the cognitive model of the mobile phone, not with the mental models connected with an inhouse phone system. This, of course, caused problems in use.

A product can lead to previous cognitive models for action, or it can tell us by visual impressions and forms how to use it even without any previous models. An interaction designer coming from San Francisco to Finland presented five years ago observational videos about a traditional Finnish väärävartinen viikate, bended scythe. This is a product from agricultural tradition, a big curved hand tool used for cutting the hay or crop. In the videos from San Francisco the office nerds were able to understand how to hold this tool, what body position you should use and how to move with it in under a minute. The tool has a long development history and has eventually been created to match the human body and movement so gracefully that it was easy to understand it even when you had no previous knowledge about the tool or about the work you do with it.

Figure 4. Finnish väärävartinen viikate, bended scythe, provides information for the user how to adjust it with the users body and movements.

[3] Miller – Kälviäinen 2001; Kälviäinen –Miller 2004.

The question of right body position and movement brings us to the embodied experience we have from products. A soft, fluffy blanket asks you to caress yourself with it, to wrap the blanket around you and tug yourself inside. In our study of easy chair categorisation with sorting exercises respondents were asked to categorise products through visual features, but they actually did something else. The 'visual features' interpretation of the chairs came out as embodied experience of 'how can I use this chair?' and 'how it feels to use it?'. As people were asked to sort chairs visually they did it with such categories as 'is this chair comfortable to sit in or not?' and 'is it big enough for my body?'.[3]

4. Symbolic meanings
This leads us to ask also the question:
What are the connotations of action and movement of the product form?
In the semantic interpretation of products we often divide denotative, functional and connotative abstract and symbolic meanings of the product. In an interview project about craft objects my respondents saw a traditional Finnish knife as a nice device you can use when sitting around and working with small wooden items. With the sharp blade and nicely hand-fitted handle they saw the possibility of this kind of free time action. The symbolic meanings were ideas of nostalgia with relaxing time to do idle things sitting in natural surroundings. Some older people saw different possibilities in the same tool. They connected the tool with the Finnish tradition of fighting and even killing people with this tool. In this case the connotative meaning was that it is a symbol of anxiety and fear.

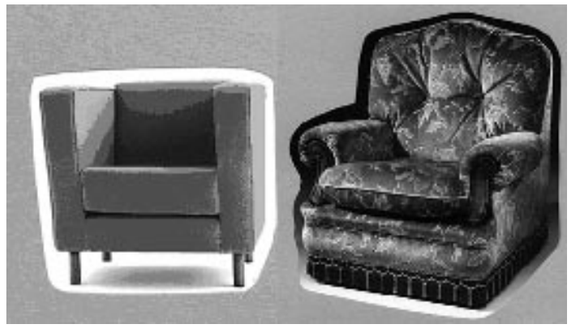
Figure 5. Finnish hand knife looks like a rather had fitting and innocent object and for many has nostalgic and romantic connotations of action. The blade and knowledge about the knives bloody history can also remind of unpleasant actions.

Connotative meanings are also interpreted through the process as seeing products as human beings. We humans are social creatures and well equipped through evolution and growing up through socialisation to act with other

people. This requires good skills for interpreting these other humans. So we easily see actions, movement, personalities, human orientations of life, moods, and emotions in products through interpreting products as human-like. Alessi and many other producers have used this human tendency very intentionally in their product forms. This anthropomorphic interpretation is not, however, restricted to products that clearly resemble human features. Embodied, humanistic, understanding of products can happen with many kinds of forms. In our associative minds we use, for example, metaphors with people and how people move to interpret products[4].
A product standing in an upright position reminds us of active qualities and a product lying, lazy and relaxing ones. A product that has a large stand reminds us of a person standing with both feet realistically on the ground. A product wide in the upper part, opening up to the sky, might bring connotations of idealistic people to mind. These connotative meanings may even point to the mind and body connection that is a hot discussion issue in many human connected research areas.

Figures 6 and 7. Products may remind us of the human bodily movements or they may resemble important human features such as faces. In interviews this CD – player was easily interpreted as being energetic, unstable, violent and selfish.

The humanistic interpretation works even further. We use products as signs of how we want to look in the eyes of other people, and other people interpret the products we own as signs of us, even if we do not intend it to be so.[5] The owners of products showing speed and activity are easily seen as people having these qualities, and the owners of inactive products are seen as comfort seeking. The chair categorisation research mentioned earlier is a good example of this product owner analysis. Modern unpadded models of easy chairs were connected to young urban people who do not have time to sit down and the traditional padded big easy chairs to older people who seek comfort and just sit around in their living rooms watching television. [6]



Figures 8 and 9. A chair, that belongs to a young, urban person with no time to sit down and a chair for an old person seeking for comfort and sitting beside a TV all day long.

Understanding products meanings as part of social interaction brings us to another sort of question:
How has the product been made?
The acts of other people in the making of the product are an aspect of bodily relationships, movement and action that can be interpreted from visual products. This is an often disregarded area of product action understanding. It becomes especially evident in craft products that in different ways remind users of the people that have influenced the making of the product.

Craft materials often have their origin in nature. They prompt ideas that someone has made an effort in collecting or picking the material. Also the production techniques used in the making are contemplated through the marks of human hands that are often seen in craft products. For example wheel-thrown ceramic products were valued in the interviews because of the marks of the maker's fingers in the surface of the product left through the making process. The touch of the human hand and awareness of the action of production makes the product more valuable than a mass produced, machine-made product would be.

It seems that understanding of the making process gives assurance to the product user. The knowledge of the history of the production technique makes the product more pleasurable. The knowledge that there is a lot of effort put into the making of the product makes it more valuable. The perception of its being hand made gives the product value as unique. The touch and action of the human hand makes it even more valuable as it is a source of relationships with other people. This becomes most valuable when someone close to me has made this product especially for me. The product can become, through the marks of the making process, as a symbol for this close relationship.

Figure 10. This ceramic can is an example of the way you are able to see the marks of the makers hands and actions in a product. Through the hugging theme that has been chosen for the bunny figures on top of the can, it tells is also about the feeling of closeness to the makers of craft objects that many of their users have.

The combination of technology with the feelings of closeness promoted by the involvement of important people in the making of products is a still underused solution, for example in welfare technology products. A research project for the Ministry of Trade and Industry conducted by the D'ART Design Research Centre in 2004-2005 revealed that, at least in Finland, these sorts of solutions have not been used. This is despite the fact that in the user studies craft objects in general, and the ones made by people close to you in particular, have special value and are appreciated so that you want to keep them in sight in important places and carry them with you. They give feelings of roots and connectedness, which might be especially important in welfare products, and could provide that social interaction which is only poorly achieved by technological means. A Japanese product aiming at this effect is a soft toy cat meant for monitoring the health situation of elderly people living at their own homes. This solution of providing a social pet relationship does seem rather inauthentic as real social interaction and emotional bonds can be conveyed by products through the maker connection described above.

5 Conclusion
The possibilities of seeing and understanding action, movement and bodily relations in products are varied. Evidently there are lots of possibilities for applying these possibilities in product development and for building suitable user interactions for different purposes. Not all the possibilities are used efficiently, for example, in making the use of technical products a pleasurable experience. There are also new possibilities that come from combining the categories of interpretation described above.

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Mirja Kälviäinen
D'ART
Design Resource Centre
Sirkkalantie 2 A,
FIN-80100 JOENSUU

Mirja.Kalviainen@ncp.fi

Remzi Ates Gürsimsek

Future directions in product semantics: new media objects and cyberspace

Abstract
The profession of industrial design and, generally, the act of *designing* is one of the key concepts of modern culture; by being both the manipulator and the product of the culture itself. In this text, the central motives behind this manipulation process and its reflections on contemporary visual culture mediums will be investigated within the perspective of New Media Theory. Since the modern society's perception of the world is mostly constructed on visual experiences, it is unavoidable for design to influence be influenced by these applications of contemporary media.

Furthermore, with the introducing of computerization and new concepts such as "customization" of "interactivity" as its consequences, current definitions of the terms *user*, *object* and *product* may have to be extended. I will try to explore the subject matter by determining the key aspects and principles of New Media and then, seeking its reflections on contemporary design practices. Instead of making assumptions and forecasts about the future of the subject matter, this study aims to elucidate the recent conditions and tendencies within the relation of two fields and to initiate a new discourse on the semiological and historical motives of this cultural formation.

What is new media
Since the central intention of this study is to explore the affects of new media sources to existing conventions of products and the profession of industrial design, identifying the boundaries of subject matter becomes essential. It is obvious that every period has its particular mediums of cultural communication and the definition of "new" media alters (or evolves) through these periods by introducing new technologies, devices and styles

My study about New Media will be mainly based on the following definitions and principles (most of which are put forward and argued by Lev Manovich in his book "The Language of New Media"). One definition of New Media may be "Translation of existing media sources – including graphics, moving images, sounds shapes, spaces and texts – into numerical data accessible by computers"[1]. However this definition has two major deficiencies about the nature of new media objects. The first one is the about the variety of processes that are available on computerized media sources, which are obviously not limited just with the translation procedure. The second problem is about the origin of new media objects. Digitally encoded objects may either be transferred from an existing analog source or be created inside the system by special software. The connotations of these two types have differences in terms of both nature of their existence and the power of the user over their originality. Thus, a broader and more detailed definition of New Media may be constructed as follows: "Creation, storage, classification, accessibility, manipulation and distri-bution of binary-coded media objects through pre-programmed algorithms." The introduction of such a unified media source affects cultural conventions severely, just like the invention of photography introduced a new concept which was a significant breakthrough: (instantaneous) still image. The application of this particular concept within new media may be interactivity or spatialization of time (which may be explained by Web sites and digital video compositing software; the former spatializes time by introducing the virtual landscape to the user to surf inside for a particular reason, the latter does this by visualizing time fragments/frames in a branch-type, linear and multi-layered inter-face which enables the user to surf within cut and pasted pieces of visual material). In his famous essay "Postmodernism and Consumer Society", Fredric Jameson refers "the transformation of reality into images and the fragmentation of time into a series of perpetual presents"[2] as two essential features of postmodernism, which will also be one of the central arguments of this text.

Rather than signifying a certain period of time, our usage of the term "New Media" refers to a (not so -) specific set of paradigms about cultural reproduction, visual representation and communication. Since we mentioned that every era of modern (western) culture have their particular mediums of mass media, I am more interested in the affects of these mediums and their first introductions to the collectively agreed system of cultural values, than the historical analysis of these mediums classified by evenly distributed time periods.

Principles of new media
As I mentioned above, the definitions and main principles of New Media for this study will be based upon the determinations of Lev Manovich's "The Language of New Media". The significance of Manovich's book comes from the standpoint of the observer in his studies, because the author prefers to describe the existing conditions of computerized media rather than forecasting the future. I believe this kind of an investigation is also crucial for a research study aiming the profession of industrial design within the context of new media.

Manovich classifies the main principles new media as mentioned below:[3]

- **Digital Representation** New media is fed by binary coded visual information, whether these materials are created inside the media system or converted from analog media. By numerical representation, new media objects become programmable. Input is sampled and quantified. This is mentioned by the semiotics theory of Roland Barthes, which assumes that all communication requires discrete units to be a meaningful whole. Manovich explains this theory by the cultural conventions of modern mass society after Industrial Revolution (which is influenced by Fordism).
- **Modularity** This is referred as the fractal structure of new media object. Unlike the modularity in the product design, this modularity may contain contextually irrelevant pieces of objects to create a meaningful whole because all elements may still remain their individual iden-tity. These elements are also composed of digital objects (pixels, polygons, NURBS, etc) so the context may change although the object keeps its originality. World Wide Web may be an interesting example for this.
- **Automation** This principle mainly aims to reduce the need for con-stant human control over interfaces. This is a low-level automation compared to AI studies, but this function of software may also have important extensions on Emotional Experience studies in design field. Manovich also gives computer games as an example to automation of HCI over the software.
- **Variability** This principle is mainly associated by the first two and is also thought to correspond the "postindustrial logic of production on demand and just in time delivery"[4]
  The concept of variability also comes with "customization", which defines the logic of our post-industrial society. Customized interfaces or smart HCI modules cannot be thought separately from the expecta-tions of our society. This may give key clues about how new media and popular culture are associated, and how one drives the other mutually.
- **Transcoding** The computer has to represent the information in its own specific way and the user can also access to the material in this specific method. All cultural data must be "computerized" to be in the field of new media. This creates two distinct dimensions of culture and representations.
  Manovich calls these dimensions as "cultural layer" and "computer layer". These two layers, obviously, influence each other in different areas and combine continuously to create a hybrid culture. This may explain why these primitive HCI models still resemble the existing forms of VCRs, books or desktops.

[1] Lev Manovich – The Language of New Media (MIT Press Cambridge, 2001 – p. 20)

[2] Fredric Jameson – Postmodernism and Consumer Society (from his essays of Whitney Museum Lecture, 1982)

[3] Lev Manovich – The Language of New Media (MIT Press Cambridge, 2001 – p. 27-48)

[4] Lev Manovich – The Language of New Media (MIT Press Cambridge, 2001 – p. 36)

Cultural interfaces

Considering the fact that media objects communicate us through some visual (or sensual) interfaces, we may assume that cultural interfaces have their roots deep in the cultural values and consumer habits. Baudrillard mentions that "… it is the difference of choices between one society and another and the similarity of choices within the same society which force us to consider consumer behavior as a social phenomenon."[5] One important fact that Baudrillard did not mention while arguing the socially manipulated nature of consumption is that this differentiation may also occur through periods of time and by the changing trends. The primitive interface design of the first Macintosh personal computer (1984) may be a good example; being significant visual representation of modernist design values, such as clarity and functionality.

The relation between cultural values and mass media interfaces is a rather mutual one, in which both sides have an effect on each other. While visual interfaces and cultural communication devices are influenced by social structure of values, these interfaces also work as mediums of cultural change through time. We may explore the traces of this observation by shifting the context to a more political discourse on Marxist social construction and contemporary (computerized) culture; unlike the industrial society of the past, the post-industrial society of today has a combined understanding of "work time" and "leisure time". All these actions happen to be conducted through the same interfaces and so these interfaces may carry a considerable amount of cultural information. Through the ideals of K. Marx where society is no more manipu-lated with distinct time intervals in daytime, we may consider the same concept is realized just the other way around. Computers are not just "tools" anymore but "universal media machines" which is involved in almost every part of our daily lives.[6]

The social reproduction of values and unification of all communication sources in a single type of utility may also be determined as critical aspects of post-modernism. Jameson suggests two major key concepts for construction of postmodernist theory, which may also help us to explore the meaning (re-)production process in New Media design:

"… **Parody** capitalizes on the uniqueness of these styles and seizes on their idiosyncrasies and eccentricities to produce an imitation which mocks the original."

"**Pastiche** is, like parody, the imitation of a peculiar or unique style, the wearing of a stylistic mask, speech in dead language: but it is a neutral practice of such mimicry, without parody's ulterior motive, without the satirical impulse, without laughter, without that still latent feeling that there exists something *normal* compared to which what is being imitated is rather comic."[7]

In the light of these concepts, we may build an argument about why and how these contemporary (digital) interfaces of new media applications refer to our existing library of visual and sensual codes on earlier solid products of technology. These visual agreements are the legacy of pre-modernist and modernist era in which the distinctions between fragments of reality hasn't been blurred this much (i.e. the differentiation of work and leisure, or art and everyday life was more severe). Now that we are living in the beginning of the computerized culture, it is natural to combine these codes within a virtual interface by referring to the existing conventions. This is why Windows Media Player or Power DVD still has play/pause or eject buttons and we still have "My Com-puter" on our "Desktop".

This argument has also significant expansions in other forms of visual media, most importantly in cinematography since it is considered to have the strongest influence on our visual regime since the beginning of the century. We will have a look at an important figure in cinema studies in this point, Dziga Ver-tov's "Man With the Movie Camera", to comprehend the relations between cinematic language and the language of new media.

Man with the movie camera

"I am the 'Kino-Eye' (Cine-Eye), I am the 'Mechanical-Eye', I am the Machine; I can only represent the world as much as I can see it…" *Dziga Vertov*[8]

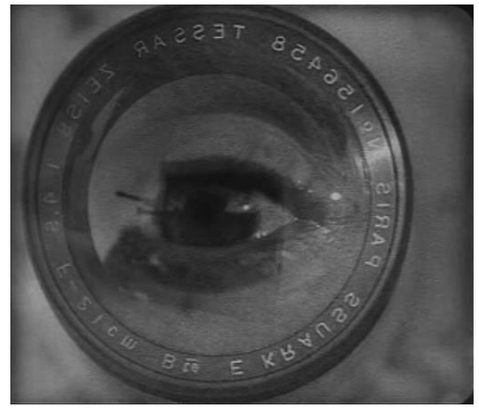
The movie's importance lies in more than one aspects for media studies. Ver-tov opposes the script, narration, acting and any type of fake decoration in film. By creating the "Kino-Eye" concept, Vertov introduces a new definition of cinematography.

[5] Jean Baudrillard – Towards a Theory of Consumption (System of Objects, 1968 – p. 70)

[6] Lev Manovich – The Language of New Media (MIT Press Cambridge, 2001 – p. 65-68)

[7] Fredric Jameson – Postmodernism and Consumer Society (from his essays of Whitney Museum Lecture, 1982)

Rather than exploring what Vertov represents in Man With The Movie Camera, we will focus on how he represents it. There are critical aspects of Vertov's film which also have considerable affects on new media applications of today, which also demonstrate Vertov's determinations on cinema (which was the new media of that era) managed to survive and develop until recent times through an evolution process.



The legendary image of "Kino-Eye", which also gave the name of the movie itself, is an important figure for our concern. Demonstration of the concept is obtained by the superimposition of two separate image layers. Although this is a rather old analogue technique of image manipulation, I consider it as a major method of meaning creation in visual media applications. The traces of this method can still be observed in contemporary image editing software (i.e. Photoshop) that are functioning on layer-based principle. Kino-Eye is a manifestation of how our visual culture apprehends manipulation of images by the codes of archaic cinematic expressions. Vertov also uses two layers of a same image to represent the collapsing of an old building (which is also thought as a collapse of an era). By the axial rotation of two similar image layers, he creates a higher meaning. In the light of these examples, we can realize how separate realities or repetition of images form contingent parts of a single image in cinematography.

[8] Dziga VERTOV – From the back-cover of "Man With The Movie Camera" (1929)

[9] Citation by Lev Manovich – The Language of New Media (MIT Press Cambridge, 2001 – Prologue. xviii)

[10] Roland Barthes – Semantics of the Object (DOMAINS, Colloquium at the Cini Foundation in Venice, 1964)

In the following screenshot, four image layers are combined with montage to enhance a spatial perception through relevant dimension of existence (mo-tions). The result is the "representation of a ballet theater". Distributing the focus of spectator between multiple fragments of the screen is a method of visual communication, which is still employed in cultural interfaces (i.e. MS Windows). Vertov uses the possibilities montage and cinematography ingeniously to reach to level of visual communication, in which he theorizes that *"… film can overcome its indexical nature through montage, by presenting a viewer with objects that never existed in reality."*[9] R. Barthes also suggests a certain *Shock of Detachment* in order to investigate and structuralize the signification of objects, and to avoid what he calls "The Obstacle of the Obvious".[10]

As we can see from Vertov's example, cinematographic experiments such as "Man With the Movie Camera" may provide us with important insights on how our visual culture became *tele-visualized* by media sources of material culture. But where does the power of this tele-visualization come from? How can our perception of the world become constructed on virtual representations and manipulated images? Answers to these questions may lead us to a discourse on the most dominant communication medium of new media: *the screen*.

The culture of the screen

"We know that the earliest artworks originated in the service of a ritual – first the magical, then the religious kind. It is significant that the existence of the work of art with reference to its aura is never entirely separated from its ritual function."

Walter Benjamin[11]

The tradition of viewing a virtual environment that is assumed to exist on the other side of a rectangular frame is a (relatively) old concept. It may even be associated with the Renaissance paintings, then photography, television, video and computer screens. The development of new visual media sources is a cumulative progress, in which the former versions still remain in existence but also keep up to an evolutionary alteration by the changing social context. Meanwhile, this changing of social habits and development of visual library of codes is caused by the introduction of new kinds of representation. For instance, with the invention of photography, the dominance of the painter on visual representation of reality has drawn back to a more artistic condition. Consequently, the marketing of photographic devices as everyday-use products (with the help of Kodak, obviously), created a society in which anyone can be the image collector, the artist or the "producer" in this new type of media. The reflections of early discourse on this paradigm shift (i.e. Roland Barthes' "The Death of the Author" [1977]) may still be an area of argument for contemporary new media, since computerized media applications provide user with the power of "customization" and "interactivity" and virtually make every user the "modifier" of itself.

Cinema is considered to be an important point in this issue because it represents the first motion image on screen. Computer screens and, as its follower, Virtual Reality interfaces are also breakthroughs in a different sense, which is because these technologies broke the fact of "imprisonment of the viewer". The camera, point of view (physically) and the viewer's virtually-represented self (literally) become mobile in the screen (or virtual environment). Consequently, "*control*" invades "*representation*" on the new media object. This conflict may also be read in the interfaces of audio-visual media (MP3s for instance) which represents control over a digital source, but still looks like a conventional mechanical device.

As the ordinary "screen" which is associated with a window into a virtual space is replaced with the "windows" as virtual instrument panels, Manovich forecasts and informs us about the "emerging of a new cultural meta-language" which depends on the viewers participation and control over the virtual environment.

Although the spectator becomes the actor in the virtual environment, she is still bound to the computer, VR station or the portable device. This immobilization of the spectator causes the mobilization of media devices that enables the user to be online or plugged-in everywhere. As new media objects tend to have easy and unlimited access in different versions for different needs and environments, Manovich's modularity and variability principles seem to gain more importance in social context.

The fusion of leisure with work in post-industrial society also caused other social changes and hybrid definitions about cultural communication. The distinction between author (producer of cultural objects) and the reader (user) is blurred. Most of the developers create their software to be usable and accessible to amateurs. Most of the computer games come with level editor pack-ages. Fashion industry also releases many designer-software for amateur use and major programs always offer optional menus, filters and plug-ins. However, all this interactivity in the field of software reminds us not authorship of the new media object, but the assembly process of discrete units in digital archive. Art and graphic design processes are also likely to be affected from this shift, considering the huge media or image libraries and pre-programmed filtering functions of Photoshop,etc.

Conclusion (semantics of the new object)

With the help of these statements, the definition of *new media* and *new media object* starts to get clearer. As mentioned above, new media objects have dis-tinct characteristics that make it new and there are certain ways to create, use, manipulate and distinguish them from our existing library of codes for conventional objects. All these principles and associations (and maybe re-semblances) form a new dimension of existence which may have different forms and processes for designers.

To begin with, the modernist understanding of *materials* may be in the verge of a spectacular alteration. The solid materialistic culture of material processing may consist of natural materials like wood, stones, ceramics or artificial substances like polymer plastics; but new media objects deals with the representations of these materials with binary codes and visual demonstrations. We may even think that this problem will also be defeated by new and innovative styles in the future. I do not suppose that upcoming versions of Windows Media Player or the toolbars will look like they are made of plastics or other conventional materials. All these contemporary forms are still designed by our existing knowledge on solid materials but this may not be the way it is now, in the recent future. Although it is not the focus of this article to forecast the pos-sible visual features of these emerging forms, it may be stated that contemporary media objects develop their unique expression styles first by reinterpreting its formers and consequently following a cumulative evolutionary pattern. A similar kind of pattern may also be observed by investigating the development in former types of creative and artistic performances; such as fine arts, cinematography and industrial design.

Another significant aspect of these contemporary objects may be realized by examining their (essentially variable) existential conditions and the reflections of these conditions on user applications. Due to the unfixed nature of new media objects, customization is always possible for the user in diverse attributes. Not only the material, but also the language, form and the behaviors of the interface on specific actions of the user can be varied. For instance, contemporary web pages and computer games can be programmed to contain alternative file sizes and detail levels by analyzing the connection speed, CPU power or the abilities of the users. Manovich puts out this nature of the new object as "New media object is something that can exist in numerous versions and numerous incarnations …. In contrast to a material object, the electronic signal is essentially mutable."[12]

In addition to the possibility of subjective variability, the method of possession for new media objects may as well be considered to alter some of the existing definitions in contemporary consumption theory. While the conventional object (or product, for our specific case) is supposed to carry the connotation of ownership, new media object transforms this connotation to participation and sharing; almost revolutionarily. Even though a considerable amount of materialistic possessions (computers, memberships, software licenses, i.e.) are still required to access this second-order utilization; the necessity of positioning these applications and connotations as emerging models of consumption establish one of the main conclusions in this paper.

"You cannot say where it is or describe its memorable shape and proportions or tell a stranger how to get there. But you can find things in it without knowing where they are. The Net is ambient – nowhere in particular but everywhere at once. You do not go to it; you log in from where you physically happen to be." *Mitchell*[13]

This new type of existence is now infinitely reproducible independent from its original copy. This may also refer to the Jean Baudrillard's theory of "Simulacres and Simulation" in which these autonomous copies create a new set of meanings and codes altogether. New object does not have to belong to an-other being (this association is also artificial, of course, as long as it has to be stored in a computer) because it is able to reproduce itself in various forms, sizes and versions, allowing the user to consume what, how, when and (last but not least) *how much* she desires to consume. Digital representations do not carry the connotation of uniqueness and ownership due to a basic fact that they are infinitely reproducible. Users participate (log in) to the virtual field to access the data. *Downloading* means creating an identical duplicate of the document. This may even lead to a new theory of *sustainability* (see *For Further Research*) in the generalized context of the social consumption theory, which Baudrillard theorized as below:

"Enjoyment is enjoyment for one's own benefit, but consuming is something one never does alone (this is the illusion of the consumer, meticulously sustained by the whole of the ideological discourse on consumption). One enters, rather into a generalized system of exchange and production of coded values where, in spite of themselves, all consumers are involved with all others."

Jean Baudrillard[14]

To conclude, we may say that we are in the edge (or beginning) of a considerable cultural paradigm shift. Similar to the effects of the introduction of photography or (most radically) cinematography, there will be noticeable effects of computerization and interactive representation on our world perception in recent future. As these cultural

[11] Walter Benjamin – The Work of Art in the Age of Mechanical Reproduction (from "Doing Cultural Studies :The Story of Sony Walkman – edited by P. du Gay, S. Hall, L. Janes, H. Mackay, K. Negus, SAGE Publications, 1997 – p. 127)

12 Lev Manovich – The Language of New Media (MIT Press Cambridge, 2001)

13 Mitchell (1995 – citation by Mapping Cyberspace – M. Dodge, R. Kitchin (Routledge, 2001) p. 8-9)

14 Jean Baudrillard – Towards a Theory of Consumption (System of Objects, 1968 – p. 78)

profession, I believe designers should be aware of the forthcoming social practices of this perspective with the help of other related fields (such as communication or consumption theories and semiology) to form a generalized theory of our time.

For Further Research

These conclusions and assumptions about the role of new media in design theory require reconsideration of some essential concepts of design practice. As mentioned above, the definition of "materials" may expand to include visual representations of contemporary materials, or new definitions for these new applications would have to be generated. The distinctions between these definitions of conservative solid objects and digital representations offer a challenging new area of design theory.

Similarly, the recent description of the term "Sustainability" should have to be argued in a parallel sense. With the growing materialistic value of information (data) in social context, sustainability may not have to be limited in such an ecological perspective, but be broadened to include the sensitivity on the con-sumption of information sources. A new discourse on "Sustainability of New Media Objects in the Age of Digital Reproduction" may be initiated (by revisit-ing Walter Benjamin's legendary work).

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Remzi Ates Gürsimsek
Istanbul Technical University, Turkey
Technische Universiteit Eindhoven, Netherlands

agursimsek@gmail.com

René M.C. Ahn

Meaning in motion: towards the creation of embodied movement

Abstract

Contemporary cognitive science and neuroscience offer us some rather precise insights into the mechanisms that are responsible for certain body movements. In this paper, we argue that this knowledge may be highly relevant to the design of meaningful movement and behavior, both from a theoretical and practical point of view. Taking the example of a leech, we investigate and identify the basic principles of "embodied movement" that govern the motion of this simple creature, and argue that the development and adoption of a design methodology that incorporates these principles right from the start, may be the best way forward, if one wants to realize and design movements with certain desirable characteristics.

1 Introduction

Bodily movements are inherently meaningful. They are parallel and continuous, and constantly reflect various aspects of the environment. Though they can be ambiguous and hesitant, and directed towards conflicting or multiple goals, as humans we are often able to make sense of the movements that we observe. This is most evident when we observe the movements of animals with more or less developed social and cognitive abilities. We interpret their movements in terms of different motivations. In fact, as we are biological beings ourselves, we have strong emphatic intuitions about the motivations behind the movements of our fellow beings. So we are able to recognize ourselves in the movements of others, and we can anticipate their timing, and even join in the rhythm of these movements, and this enables us to interact and cooperate with these others more fully. There is now even growing evidence that, at least for certain primates, there is a specific subsystem in the brain, "the mirror neuron system" that supports these processes, see [2].

But, despite the many technological possibilities that are now within reach, the movements that most modern electronic products tend to make share few of these desirable characteristics that are evident in the wonderful movement of bodies.

Movements that such products make are often rigid, they are almost never parallel, and they are directed towards a unique goal. Typically, these movements are oriented towards parts of the environment that are fixed, and thus the movements do not show any variations that might inform us about their underlying intention. Often, transitions between movements are sudden and can not be anticipated. As users, we may find it difficult to get a "feel" for such a product, as its uniform movements do not provide us with the subtle cues that we need to integrate perceived, possible and expected movement into a smooth flow of experience. A simple characterization of these movements might be that they largely fail to express their context.

Indeed, in many instances, a product can only execute

a few different movements that have been entirely preprogrammed, and users can only interact with it through strictly logical means, such as button pushes. This forces their users to break down their tasks into discrete and sequential chunks, thus largely eliminating the more playful and harmonious aspects of interaction. When a user interacts with such a product, it is also often the product that imposes its own timing on the movements of the user, and this timing sometimes wreaks havoc with the users own rhythm.

This deplorable state of affairs seems largely to persist, despite the many possibilities that modern technology now offers us. This is not just a matter of economic pressure. Programmable devices are cheap, and most products already employ such devices as the "heart and soul" that animates them. Sensors and effectors are also getting cheaper every day. And artifacts that have some sensors and effectors, and that contain a processor are very flexible, and, given enough memory, they could, at least in principle, be programmed to make the most wonderful and enchanting movements.

So why is it that despite the inherent flexibility of the technology involved, most products today exhibit behaviour that is most concisely characterized as rigid?

In this paper we will argue that this is a consequence of the fact that the way in which digital technology is being used to create movements often does not sufficiently reflect the insights into the mechanisms of bodily motion that present day neuroscience and cognitive science can offer.

Most modern products that execute some movements are controlled by some type of microchip, like a microcontroller. As this device needs to be programmed, the designers and developers that create the products movement will, at some stage, often translate the desired behaviour of the product into some kind of programming language. We will argue that programming a specific behaviour, and in particular, a "natural" behaviour, requires a specific approach: though programming languages are quite suitable to describe sequential and logical behaviour, but they do not, by themselves, immediately provide a suitable medium to express natural movements.

This should not come as a big surprise: we are all familiar with the fact that many types of natural behaviour, and especially those that involve bodily movement, are not easily described through language, not even natural language. Most of us have already experienced this when we tried to learn to ride a bike, to play tennis, or dance the tango. When we wanted to learn to master such movements, the verbal instructions of some teacher may have served us to make us attentive to a certain difficulty or to some desired characteristic of a movement that we want to make, but we still had to learn through experience how to overcome this difficulty, or how to acquire this wanted quality in our movement. Verbal instructions that try to tell us directly how to move are largely ineffective and tend to lead to clumsy results at best.

The principles of embodied movement

To see more clearly where this difficulty lies, we need to look somewhat closer at the mechanisms behind simple natural movements, some of which are now beginning to be unraveled by neuroscience, leading to new developments in cognitive science and robotics.

It has been established that many bodily movements of simple organisms are governed through rather direct pathways from the sensor to the motor neurons, which im-plies that no higher cognitive faculties are needed to orchestrate this movement.
Instead, these movements are continuously shaped by the stream of sensory signals that are experienced while the body is in motion. This can lead to surprisingly meaningful behavior, because the simple neuralnetwork calculations that transform the sensor signals into motor signals use **geometric information** about the body (typically about the positioning of sensors and effectors) to compute the desired movement that the motors need to execute.

Example

The example of a very simple type of bodily motion, that is evident in leeches, and whose mechanism has been researched extensively, will perhaps illustrate this.
Leeches will bend away when you prod them with your finger. This type of behavior is nowadays understood quite well [3]. The pressure sensors that register the prodding feed into a very simple network that controls the motor neurons responsible for the movement.

Interestingly, it turns out that the firing rates of all the neurons involved can be interpreted in rather precise geometrical terms related to the body of the leech.
When you touch the leech, the firing rates of sensor neurons encode the location of touch in terms of signals whose intensity expresses the projection of the prodding direction in the direction of the sensors. This results in signals of intensity $\sin(\alpha)$ and $\cos(\alpha)$, where α can be understood as the angle between certain a certain "hot spot" on the leeches' body and the location of touch. The weights of the simple neural network that computes the desired motor signals for the different motors from these firing rates can also be interpreted in goniometric terms, and the calculation that the network performs can be given a goniometric interpretation.

The leech has various motors that it can use to bend its tail, each with a specific preferred bending direction. To effect a movement in a desired direction, all these mo-tors need to receive signals of the right intensity, an intensity that depends on the projection of the motors' own bending direction on the required bending direction off the leech, i.e. away from the touch location. In this case, this means that the motor neurons of a motor with preferred bending direction β should fire with an intensity that is equal to $\cos(\alpha-\beta)$, thus compensating for the difference of angle between touch location α and bending direction β.

This computation is effected by a very simple neural network. This network continuously computes the motor signal for a motor neuron with direction β from the sensor signals with intensities $\cos(\alpha)$ and $\sin(\alpha)$. To do this it multiplies the incoming signal strengths by appropriate weights. Actually, it turns out that these weights are proportional to respectively $\cos(\beta)$ and $\sin(\beta)$, which means that the leech implicitly computes the desired signal strength as if it were using a goniometric formula:

$$\cos(\alpha - \beta) = \cos(\alpha)\cos(\beta) + \sin(\alpha)\sin(\beta) .$$

As all the motors get a fitting signal, this leads to a well orchestrated reaction of the leech as a whole: it bends away from the location of touch. So we see that, at least for this type of behavior, the leech computes the responses to a certain stimulus entirely in geometric body-related terms.

The picture that emerges from this example, and which is confirmed, refined and extended by a large number of other examples, [4][6] is that natural body movements are continuously shaped by the stream of sensory signals that are experienced while the body is in motion. The movement originates not in a single sensor signal (that encodes some objective disembodied condition) but from a collection of sensor signals that harvest information from different locations on the body while the movement is ongoing. It should be stressed that the geometrical relationships between the various sensors, as determined by their shape, orientation, sensitivity, and location on the body are extremely important. They matter so much because they determine the **relative strength** of the different sensor signals in response to some object or other stimulus in the environment. This notion of relative strength is crucial because it is not the presence or absence of some sensor signal, (or some other logical criterion) that is used to determine the movement that is executed.
Instead, at each moment in time, the current movement is determined by the up-to-date geometrical information about the location or direction of certain stimuli **relative to the body** as encoded in the vector given by the relative strengths of the sensor signals.

Thus, embodied motions are never directed towards "locations" in a static and empty Cartesian space, but they are always directed towards positions that are given relative to the body itself. That this motion can then nevertheless be directed to some external object or stimulus, is a consequence of the fact that the (changing) location of that stimulus relative to the body is encoded in the relative strength of different sensor signals.

In embodied motion, there is no explicit think/act cycle. There is no separate "observation" phase during which the organism inspects its situation to see what it should do, which would then be followed by an "execution" phase during which the movement that has been judged to be appropriate or applicable is subsequently executed.

Instead, the bodily sensors are functioning continuously, and the resulting stream of sensor signals continues to influence the ongoing movement. Of course, this has the important and desirable consequence that embodied movements do not follow a fixed trajectory, but can respond immediately and smoothly to certain changes in the environment.

So, once we understand and appreciate the nature of embodied movement, it is rather obvious why it is difficult or even virtually impossible to capture or describe such movement directly through the use of language. In fact, one can at least give three compelling reasons why language is simply the wrong kind of medium to ex-press embodied motion.

1. Embodied movement is **inherently parallel**, whereas language is always sequential, and strongly encourages sequential thinking
2. Embodied movement is generated from a **subjective perspective**, whereas language, which is also a medium of communication, tends to favor descriptions that are rooted in an objective and disembodied perspective.
3. Embodied movement uses **inherent feedback** ,while language encourage descriptions of movement in a descriptive style, specifying the actions that are to be taken before they are executed, thus making it hard to take changing circumstances during the movement into account.

Summarizing, we can say that there is a host of arguments that argue against the attempt to express natural movements directly in terms of sequential instructions in a programming language.

Why the principles of embodied movement are relevant to design

A thorough understanding and appreciation of the embodied nature of movement is, according to us, highly relevant to design for two different reasons.

First, it may be important for a proper understanding of the way in which users interact with products, and may thus help us to produce useable and appealing designs. For instance, if we appreciate that movement is guided by continuous sense perception, we will expect that products that undergo sudden changes can be quite hard to use, and may even lead to errors and oversights. That this is indeed the case, is for instance illustrated by the well known phenomenon of change blindness [5]. Also, de-sign is often concerned with the use of the body in interaction, which means that theories that might give us viable information on how the user's model of her own body is involved in the interaction with the outside world would be very valuable. Speculations about the role of the body model in the evolutionary development of higher cognitive faculties [1] are another reason to belief that a better understanding of body models may be crucial to the development of a theory of interaction. But though such considerations are of obvious interest and concern they are outside the scope of this paper.

What interest us here, is how we, as designers, can create animated products that exhibit some of the beautiful characteristics of natural body movements.
If such movements do indeed arise through the kinds of mechanisms discussed above, we should perhaps, in our effort to design meaningful and interesting movements, adopt a design method that tries to incorporate the principles of embodied movement right from the start.

Instead of searching for solutions where movements are prescribed by a central intelligence that determines the sequence of actions that the various parts have to perform, we could directly strive for solutions that harbor a number of ongoing parallel processes that serve to compute the motor signals for the various effectors. In accord with the theory, these processes should then either continuously and concurrently harvest sensor data, or transform sensor data into motor signals, or move in accordance with a motor signal.

From an abstract functional viewpoint, the most important design decisions then are the following:

- In what kind of environment do we place the artifact?
- What sensors do we use to harvest the data?
- Where do we place these sensors on the body?
- Which motors does our artifact have, and what movement do they perform?
- Where are these motors located on the body?
- What function transforms sensors signals into motor signals for a given motor?

Of course the answers to these questions depend largely on the effect that we want to achieve. Clearly, we are now not in a position to answer them by some kind of engineering approach. As designers, we can eventually only decide on the viability of our decisions through exploration and experiment.

What we need to support such exploration is a flexible and modular prototyping system that enables us to create simple bodies with sensors, effectors and customizable signal transforming functions. Designers could then experiment with the parallel, embodied, continuous movements that arise when this body is placed in a suitable en-vironment and the feedback loop is closed. Such a system should offer them the ability to mould this behavior by sculpting the form, or by slightly changing the spatial relations between sensors and effectors, or by trimming the functions that calculate the motor signals from the sensors.

This type of experimentation is not necessarily difficult to perform, and may lead to immediate results. For instance, one of the simplest methods to modify the behavior of an embodied artifact is by "filtering" the inputs of its sensors and thus changing the sense data that it receives. This can often easily be done by physical means: for instance, an optical sensor will acquire different characteristics, if it is placed behind colored glass or near a mirroring surface.

In fact, if we place a specific filter on a sensor, the effect that this may have on the behavior of the artifact may be easily visible and intuitively rather obvious. Therefore such actions are not only useful to a designer that experiments with the artifact: they are actually one of the means that now can be used to create a meaningful interaction that allows a user to change the behavior of the artifact.

This trivial example illustrates some of the attractive properties that embodied movement approach to design may have in store: when we tinker with the way in which sensors and motors influence each other (and, as we saw in the last example, the easiest way to do this is through the environment) the behaviour of an embodied artifact immediately starts to change. This means that there is a certain amount of context sensitivity that is found in the movement of an embodied artifact. Though the changes in the movement pattern may at first be somewhat strange and unexpected, one can often quite easily pick up the correlations with the relevant aspects of the en-vironment, and will often quite easily develop a "feeling" for the way in which a given artifact will behave in different circumstances. One gets in fact a feeling for the "character" of the artifact, which makes it possible to predict what it will do. It is this typical combination of context-sensitivity and (limited) predictability that designers might exploit to develop completely new interaction styles. For instance, one can interact with an embodied artifact like a lamp which can sense its own light, by simply moving it, or bending it, or changing, for instance, the reflective properties of the environment.

Present state of our investigations

At present, we are still considering the question how such a prototyping system should be realized, and which possibilities it should offer in order to enable designers to reap the full potential benefits of the embodied approach to movement. In particular we are performing software simulations to determine whether it is advantageous to also incorporate the possibility to use learning algorithms in a system that supports the design of embodied movement. There are good reasons to investigate this matter.

This relates to the dimensionality of the information involved in the realization of embodied movement. For it is clear that as the number of sensors increases, so does the dimensionality of the vector that carries the information about the situation that is available to the artifact. As sensors are nowadays extremely cheap and small, and keep getting cheaper and smaller, it is possible, at least in principle, to increase the information that the artifact might use at virtually no cost at all. And obviously the versatility and precision of the behavior of the artifact can increase with the amount of information that is available to steer the movement.

Redundant information can provide us with robustness. But apart from that, it is only attractive to use the information harvested by a truly large number of sensors to steer the movement of a given artifact, if there also is a practical method to determine the weights of the various connection strengths in the neural networks.

This is why the use of learning algorithms is of considerable interest. In principle one does not need any explicit information about the way in which the information about the situation of the artifact is encoded in its highly dimensional information vector to be able to make good use of it. In certain cases, the artifact might learn automatically how it needs to extract the relevant information, using techniques like reinforcement learning or simple linear neural networks.

At present, all that we have to judge the possible potential of such an approach are the results of certain simulation

experiments. Though software simulations are necessarily unreliable and are less flexible and less convincing as the real thing, we have got some first promising results, which show that the incorporation of learning algorithms is possible, and may indeed considerably increase the scope and potential of the movements that we can realize.

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René M.C. Ahn
Technische Universiteit Eindhoven, Faculteit Industrial Design,
HG 3.39, P.O.Box 513,
5600MB Eindhoven,
The Netherlands

r.m.c.ahn@tue.nl

M.A.J.t.Koppel, W.Walmink, Z. Amiralis, H.J. Ruiter, D.A.P.v.Gennip,

Semotion: mediating urgency through mechanical movement

Abstract

In this paper we explore movement as an alternative mediator of gradients of emotion. It is studied in a case in which four different mechanically moving objects express different levels of urgency related to catching a plane.
We discuss Move Boards, Acting out, tinkering and 4D sketching [1] as relevant design tools in addition to traditional idea generation tools.
From the user-test we conclude 3 out of 4 robots created a highly consistent result in the recognition of the intended communicated emotion without context and within context.

1 Introduction

Industrial Design at the Eindhoven University of Technology is concerned with the (technical) design of product functions, product meanings, and with product aesthetics of intelligent, interactive products. The majority of present interactive products focus on our cognitive abilities in interfaces that offer screens and 'binary' buttons as interaction mediators. As pointed forward by Djajadiningrat et al. good interactive products needs to include the user's cognitive, perceptual-motor and emotional skills, to go beyond interaction that feels 'stuck on' and PC-like, in order to realise products that offer appropriate interaction styles [2].
When adding emotions to interactive products we can increase its usability [8]; it could also play a key aspect for genuine intelligent behaviour that is able to adapt and interact with the user naturally [4].
For the convenience of this paper we distinguish emotional design in three aspects: the measurement of users' emotions (input), the product's handling with emotion (processing), and the product's mediation of emotions (output). In product design, the latter is often associated with the expression of behaviour.
While static physical objects only refer to three dimensions and only have an appearance, 4D refers to the addition of a (temporal) fourth dimension, time, which translates in active behaviour expressed through movement of the object. By using designed movement added to an object, one can increase the strength of its intended emotional message compared to its non-moving counterpart [4].
The scope of our design project was to understand how movement can be used as mediator of emotion (output) and explore the possibility to mediate different emotions with its gradations through movement to realize an interaction that is alternative to current PC-Type interactions and more appropriate (to its context and humans in general).
The context of the investigation is the airport, in which the designed movement is a mediator of the levels of urgency to catch your plane (i.e. relaxed, start thinking about it, get on your way, start rushing NOW).
In order to gain empirical insight in this case, four robots were built to be mounted on the hand-luggage trolley of Schiphol Airport. Each robot uses different states and

approaches the problem with its own 'language' but all with same purpose: expressing levels of urgency to catch your plane. To test the designed movement to its meaning, effect and whether it is possible to communicate different levels of urgency, a user test was conducted. The results are used to argue our view on movement as mediator in product design.
In this paper we will discuss our design process, our results and recommendations in respect to movement in (emotional) design.

This design research project was done by a team of 4 second years' Industrial Design students who each individually designed a working, moving prototype. It is the fourth in the Semotion (Semantics of Movement) project series. The project took a time span of 16 weeks, its learning goal was to get more empirical insight in alternative interfaces and the use of emotion in product design. The project 'restricted' us in the use of movement for the expression of urgency in the context of the airport, no GUI's were allowed.

2 Methods

In order to be able to design meaningful motion, several interesting methods can be added to the traditional static product design process. In this section we describe the additional methods we used. The first two methods that are described here are explorative, used in the idea-generation process. The latter two are meant for translating meaningful movement to mechanic constructions.
We would like to stress the importance to work throughout the design process with tangible, little working models as motion perceived in 2D (designed on a computer screen) cannot be compared with its 3D counterpart as the latter offers the possibility to walk around them, have influence of lights and more important have another emotional impact.

2.1 Move Boards

To get insight in the meaning of movement, people were asked to judge static objects on valance and arousal in the abstract expressive space [6]. It is a method to quantitatively rank emotion in a user test [7]. Another judgment on these same parameters by the same test participant was done when the object was showed in motion in a video. Insight was created by means of the impact of movement added to static form. From this exploration we realised that movement in combination with form has a higher consistency in association then static form (e.g. a static tree form might be associated with pleasance or stress a slowly moving tree is immediately associated with 'calm' and 'rest'). It proved to be a good method to understand the power and several characteristics of motion and how it can affect the form's semantics. This method can be used in the explorative stage of a process concerning motion.

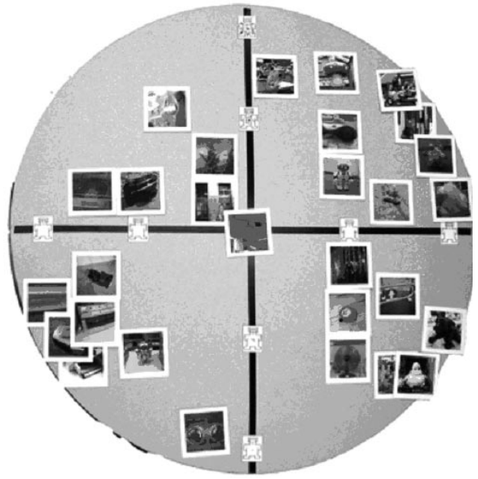

Fig. 1. The abstract expressive space; the x-axis represents valance and the y-axis arousal. The two combined represents emotion, e.g. Low Valance and High Arousal might represent Stress.

2.2 Acting out

The next step is to actively translate emotions and/or meaningful messages through bodily movement. The designer acts out the behaviour of the object to understand relevant expression and communication from the object's point of view. This works best when done in a small group and in a free-spirited way (i.e. no expectations of one another or of the session itself). Try to, step by step, reduce the degrees of expressive freedom: first utilizing the full body to do the movement, then just one or two hands and finally using an inanimate object in one hand. Trying to find meaning in motions that have just a few degrees of freedom makes it easier to translate these motions to mechanic constructions. Acting out has several advantages compared to static brainstorming: Firstly, the designer reaches an emotional state by his bodily expression, therefore he can better emphasize with the *user* and the *product* from which he will realise the relevant expression the *interaction* needs. Secondly, because the bodily expression also includes movement, the observer designers can attribute several characteristics of movement in respect to certain behaviour.

2.3 Tinkering

Tinkering is a method of brainstorming, based on fast modelling. Using simple everyday materials like cork, cardboard and straws, ideas about form, combined with movements and mechanisms can be explored. The documentation of the previous methods can be used as inspiration sources. It is an extension of acting out applied to an object. The designer thinks of how the behaviour he acted out can be translated to form and movement.

2.4 4D sketching

This 'sketching' technique takes tinkering one essential step further: electronics & (servo) motors are added to the models. With the same basic materials (cardboard, hot glue gun etc.), but with the addition of a micro controller and servo motors, it is easy to iteratively 'sketch movement' by uploading different sets of software to the microcontroller. Using tinkering materials enables the designer to quickly change designs and improve the motions, without spending too much time on visual modelling. The designer can focus on the essential after the somewhat explorative methods of Move Boards and Acting Out in applied Tinkering; the design of relevant movement.

Fig. 2. An example of a 4D sketch

3 Objects

The airlines suggest we pass customs three hours in advance for boarding time. The airport supports a number of activities and services to make sure the travellers have a comfortable and careless stay. We built four robots that used movement as a more pleasant, natural, powerful and relevant mediator of different levels of haste in respect to traditional cognitive mediators. The objects communicate different 'states' throughout time, e.g. "Think about going to the gate" and "Start Rushing Now!". The objects focus on the mediation of urgency, the input and the processing of the system is not considered but probably needed and feasible. Example inputs of the system might be GPS or the user's stress level.
The different approaches explained in the next section is the designer's intuitive result of the design process described earlier.

3.1 Wuddy

Wuddy is based on the power of human expression; the movements are inspired and closely related to human movements. The robot has three degrees of freedom: it can turn, tilt and open its 'mouth'. At key moments in time, a new state such as e.g. "start rushing now" occurs; it tries to attract the attention of the user in an anthropomorphic manner with in this case as goal to send him to board. In time between those key moments, Wuddy appears to be dancing. As time progresses the dancing differs to express the urgency. The dance starts very slow, with low amplitude, and in harmony. Next the dance becomes faster with higher amplitude, but still in harmony. In the final state the dance becomes random, utilizing fast movements with the highest amplitude and no harmony. By doing this Wuddy expresses panic.

Fig. 3. 'Woody' uses anthropomorphic expression in his mediation of urgency.

3.2 Licium

Licium is a robot built on abstract movements as well as abstract shapes. The robot consists of a frame containing beaded strings, it forms a planar, which is moved both vertically and horizontally to create a wave-like effect. The movement is directly triggered by two servo-motors, but is also influenced by gravity and oscillation as well. These additional factors cause the beads to follow their own path which is indirectly controlled by the behaviour of the user. The variations in urgency are mediated by varying the speed and amplitude of the moving beads. By increasing these parameters three predefined states are communicated with the following goals: the first state is meant to be very low-key, relaxing; the second is aimed at encouraging the user to go to the gate; the last mediates there's no time to waste, like a final call.

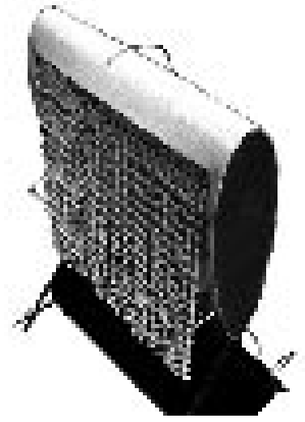

Fig. 4. 'Licium' uses a wave-like effect to express urgency.

3.3 Forest

Forest uses an abstract appearance to express urgency; no association was used in the design of the shape and movement. To create behaviour for Forest that is cohesive, consistent, perceivable and in the context of the airport, a personality [8] that resembles a travel agent is used to translate behaviour to movement. Forest expresses multiple emotions such as pride, politeness and dominance. The movement, caused by three rotating blades, expresses emotion by varying the relative rotation of the blades, the speed of the rotation and the stability of the rotation. A fast smooth synchronic running program communicates enthusiasm and pride ("Welcome to the airport!, there is plenty of time") while a slow stuttering a-synchronic movement expresses dominance ("I really insist you board now!"). Although the movement is modelled after a travel agent, neither shape nor movement is anthropomorphic. The unit becomes part of the handlebar of the trolley, it is placed between the hands so that the movement takes place in the private zone of the user. This was done to create a feeling of trust with user.

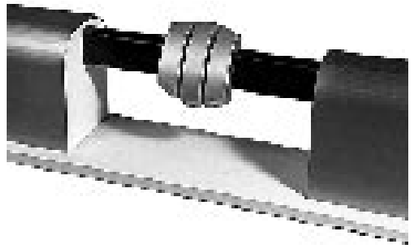

Fig. 5. 'Forest' expresses a combination of emotions by speed of rotation, the relative rotation of the blades and the stability of the movement

3.4 Squabbles

Squabbles consists of three similar looking objects, positioned in a row. Instead of mediating the level of urgency through a single object, this task now becomes a group effort. Two types of movement sequences can be distinguished: movement suggesting discussion between the three objects themselves and movement addressed to the user, in which the objects try to communicate a state of urgency. There are three states of urgency, 'relax/stand-by' (low urgency level), 'activating' (medium urgency level) and 'stressing' (high urgency level). The purpose of the intermediary 'internal discussions' is to raise the trust of the user regarding the correctness of the next level of urgency that is displayed.

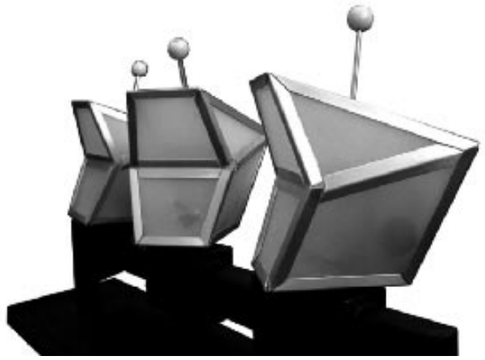

Fig. 6. 'Squabbles' communicates urgency by means of their internal communication and their collective efforts to help the traveller

4 User test

The user test was set up to test whether the robots are capable of communicating the correct message to participants, thus to verify if movement can be used to mediate different levels of emotion.
The user test consisted of two methods; the first method was used to understand the meaning of the designed movement without context. The participants were asked to judge the movement in the abstract expressive space (Valence, Arousal) extended with "Dominance" by filling in a form after they watched a state of the program of the object (e.g. state "you have enough time"). The participants were told neither about the purpose of the object nor the setting of the object. The order of the states throughout time was randomized to eliminate relative judgment. The focus of this method was only the movement. A typical test lasted around 5 minutes a robot with an average of three judgements (there are multiple states throughout the program).
In method 2, participants had to judge the different 'emotional' states of the object in relation to an urgency level on a scale from one to six. Beforehand, they were informed about the purpose and were placed imaginarily into the scenario of the airport. To gain more insight in their motivation of their choices we asked them to think out-loud about the expression and the association they made. The states were presented in a logical order, from not urgent to very urgent.
The total number of participants was 40 of which 8 participated in method one. The rest participated in method 2. The participants were a mix of students and employees of the university who weren't acquainted with the project.

5 Results

The test results show that the participants ranked the amounts of urgency displayed in relation to the other states with fairly high accuracy regarding the robots Wuddy, Licium and Squabbles. De-contextualizing and randomizing the order of the states shows no significant effects on the perceived relative levels of urgency regarding these robots (the final, most urgent state, is ranked lower on urgency compared to the test with context, however it is still recognized as the most urgent state). The fourth robot, Forest, had less consistent results. While the intended meaning of some movements of Forest were clear, the meaning of others failed. Randomizing the order of Forest's states had no effect on the ranking of the levels of urgency and only resulted in less explicit ratings.

6 Discussion

We start by discussing the results of our objects in respect to its intended purpose: mediating levels of urgency. We also compare mechanical moving objects with its cognitive counterpart as mediator of emotional expression based on our empiricism.
We end the discussion by recommendations and our experience in the design of movement in product design.

6.1 Results of the 4 robots

- There seems to be an apparent relation between the level of arousal of the object and the level of urgency as perceived by the participants. This could be explained by the fact that humans tend to get more stressed (i.e. increasing arousal) when the urgency-level increases. This human characteristic might be projected on the robots by the participants. Forest did not have such a strong relation between the intensity of arousal of the movement in respect to the level of urgency, because its focus was on mediating urgency-related emotions (the slow, stuttering movement was perceived as relaxed instead of stressed). This lack of a single clear parameter might explain the inconsistent results of Forest.

- Two of the robots (Licium and Forest) used mostly abstract movements and shapes, whereas the other two (Wuddy and Squabbles) based their movements more on associative movement. The linguistic motivation of the participants showed that associative movements offer many possibilities to add (complex) meaning to movement, but also shows an important pitfall:

associations can have completely different meanings to different people (e.g. the 'activating' state of Squabbles was both perceived as a happy dance and a militaristic parade). On the other hand, the exploration of the meaning of more abstract movements might give us more insight in the universal properties of movement determined by the visceral part of our brain (just as bright colours and rhythmic beats have an automatic positive affect [8]).

6.2 Mechanical Moving Objects versus its cognitive counterpart

One might wonder why our approach is different compared to its cognitive counterpart (reading from a watch or a screen) since both involve the 'reading' of information.
Instead of rationally telling how much time the user has left we use the emotional capabilities to mediate an equivalent emotional message: E.g. relax, you have enough time (considered the time left and the position you are). From the user test remarks we witnessed 'people' are capable of recognizing the intended emotional messages expressed through mechanical movement without knowing any rational data such as time and location. We feel that by presenting (emotional) information by using the interfaces we proposed, we created an alternative interface method compare to PC-Style screens and buttons, that is more pleasant, richer, fun, relevant and more closely related to people.
Since our proposed designs deals with emotional information we also feel that a screen showing movement cannot replace the mechanical moving objects. A screen is more related to our cognitive abilities because it is not 'real'. It also has a lower 'impact' because movement is closely interlinked with the third dimension and because physical objects share the same physical context with the user. Beside those conceptual reasons, it also has some functional benefits: one can walk around them and it could be used for tangible manipulation in future projects.

6.3 Recommendations & Experience

As reminder for the paper we state our beliefs around the use of movement as mediator of emotion based on the user test, informal user remarks and our design experience:

- Movement can be used to express emotion and gradations of emotions that can be recognized by different users.
- Motion added to static products immediately expresses behaviour, whether it is intended our not. One must realise this when movement has a functional character such as the opening of a cd-tray.
- Interaction based on movement is experienced as more natural, it is a more instinctive interaction that can take places on a visceral level instead of a cognitive level.
- We think that both the possibilities of abstract and associative movements (e.g. anthropomorphic) should be further investigated in the future, for both seem to have great potential.
- (Emotional) Information can move subtly from the background to the foreground and vice versa when using movement as interface.
- Movement as alternative interface is an enrichment to aesthetical interaction.

7 Acknowledgments

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M.A.J.t.Koppel,
W.Walmink,
Z.Amiralis,
H.J. Ruiter,
D.A.P.v.Gennip
Eindhoven
University
of Technology
HG 1.44 Den Dolech 2,
5600MB, the Netherlands

[author]@student.tue.nl

Matthias Rauterberg, Ben Salem, Dirk van de Mortel

From passive to active forms

Abstract

Based on the continuous increase in functionality of interactive prod-ucts, tangible user interfaces are coming up. We will address one important de-sign challenge: how to design the feedback of the internal state of the interac-tive product in a natural way. Although already several solutions are possible, we will introduce a new approach via smart materials. With smart materials the feedback of tangible I/O devices can move from passive to active forms. Based on a general concept of active forms we will demonstrate and discuss the state of the art of using smart materials to explore a new design space for feedback in human computer interaction.

1. Introduction

Nowadays, developing a new product or service means being creative and taking risks to explore new opportunities provided by upcoming technologies. But before any particular semantic could be mapped to a new syntactical form, we have to explore this syntactical design space first. Combining all kinds of new materials and advanced technology is part of the established engineering research agenda. Given new syntac-tical interesting combinations the next step is investigating possible meaningful map-pings of functionality (i.e. semantics) to these new forms. This is part of the research agenda of industrial design. But at the end to launch a successful product or service on the market these new combinations of form (i.e. syntax) and functionality or con-tent (i.e. semantics) have to be embedded in the behavioural interaction pattern of the customers (i.e. pragmatics).

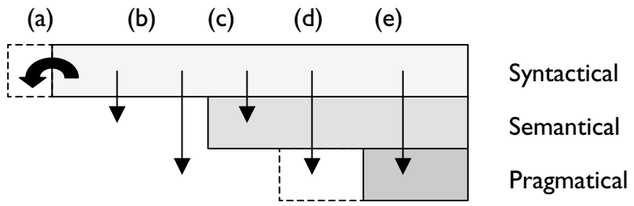

Figure 1. The 3 different levels of a product development process: from syntax to pragmatics.

We assume that functionality or content (i.e. semantic) can *not* exist without a prede-termined form (i.e. syntax). Although this assumption is debatable, we still think it is quite useful for the following discussion. We can distinguish six different situations to explore each level (i.e. syntactic, semantic, pragmatic) and to investigate the map-pings between them (see Figure 1, (a) … (f)). In situation (a) we *only* explore the syntactical level and try to find stabile or at least interesting combinations of new materials and/or electronics. The difference between situation (b) and (d) is that (b) is a *useless* mapping and (d) is a *useful* mapping of semantic to a new form. Usability testing can help to distinguish between both situations [16]. In situation (c) a company wants to introduce a new product or service on the market (i.e. pragmatic) and fails due to an inappropriate mapping between syntax and semantic. In situation (e) such kind of 'failure' can be repaired by intensive marketing and advertisement to extend the scope of the pragmatically level. Only situation (f) guarantees without extra effort a successful introduction of a new product or service on the market. User centered design increases the chance for achieving (f) [24]. In this paper we describe our pre-liminary results somewhere between situation (a), (b) or (d).

1.1 Exploring the design space

Looking back in history we can identify three major design styles: (a) mechanical style, (b) electronic style, and (c) mechatronic style (see Figure 2). At begin of the industrial revolution dedicated forms for a particular set of functionality was intro-duced and widely used (e.g., typewriter device). For each function a dedicated set of hardware controls was designed; the function-form mapping was almost 1:1. The internal state of the interactive device was perceivable in a limited, fixed and prede-termined form-function-state space. We call this period the *mechanical design style*.

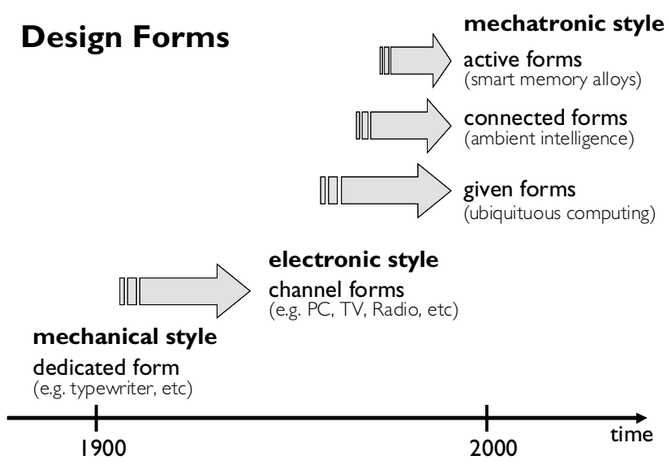

Figure 2. Historical overview of the major design forms and allocated styles (see [15]).

With growing functionality the mechanical style reached its limits. Above a particular threshold of functionality the new electronic style had to be introduced to overcome the limitations of the mechanical style. Most of the new functionality disappeared into the device itself and could only be accessed via a generic set of input controls (e.g., key pad, game console, mouse, remote control, etc.). The function-form mapping between hardware controls and embedded functionality was now 1:many. This lead directly to the concept of modes. A mode determines temporarily the actual semantic of the limited and fixed set of hardware controls. The complexity of the functionality had to be separated from the form in which this functionality or content was embed-ded. The form of the overall container turned into a *channel* and was mainly perceiv-able via the graphical form changes on a display (e.g., graphical user interfaces for PCs). We call this period the *electronic style*.

The latest development is called the *mechatronic style* in which we can distinguish three kind of forms: (a) given forms enhanced with additional functionality (e.g. ubiq-uitous computing), (b) connected forms of channel devices (e.g., ambient intelli-gence), and (c) most recently active forms (e.g., smart material). In the rest of this paper we will focus particularly on these active forms.

1.2 Smart materials as a new design option[1]

One new type of material is called 'smart material' [5]. With this type of material new applications can be realized: e.g., smart tennis racquet, smart dragonfly, the magic teaspoon, etc. A definition of 'smart materials' is still not set. However, words as *active* or *intelligent* are often used and smart materials are often grouped as material systems with unique properties. A good general description for smart materials is "materials that respond with a change in shape upon application of externally applied driving forces" [1]. This response in change of shape can be used to convert the en-ergy that is applied into desired motion or action [30]. Because this paper focuses on changes of shape of materials, following definitions and background regarding stress and strain terminology might be helpful.

Stress: The external forces (pull, push, shear, twist or bend) applied to a compo-nent result in stresses within the material. A stress is a measure of the force in a com-ponent relative to the cross-sectional area over which the force is applied. Stress is measured in force per unit area, for example, N/m2 (Pascal, Pa). $\sigma t = Ft / A$ where σt is the stress, Ft is the force, A is the area, and the subscript t denotes that the force and stress are in tension.

Strain: Strain is a measure of deformation (either elastic or permanent). Hence, strain in a wire denoted as ε, may be written as $\varepsilon = \delta / L$. Where L is the original length of the wire and δ is the change in length that occurs when the

wire is pulled by weight F.
In terms of stress and strain, Hooke's Law may be written as $\sigma = E\varepsilon$ where E is a constant of proportionality referred to as Young's modulus or the elastic modulus. The Young's modulus is constant of proportionality referred to as Young's modulus or the elastic modulus. Young's modulus is analogous to a spring constant that it is a measure of the relative elastic stiffness of a material [14]. The Young's modulus is the degree of elasticity and is the range for which ratio of stress to strain over the range for which this ratio is constant, i.e. up to the yield point. It is a measure of force that is required to deform the film by a given amount and is therefore a measure of the in-trinsic stiffness of a film [2].
Yield strength: Design stresses must be lower then the yield strength to ensure that a part does not fail by plastic deformation. Shear strength may be estimated from the yield strength.
Shear strength: Strength of a material is stress at which a shear-loaded member will fail [14].

1.2.1 Shape Memory Alloys (SMA)

Description: Upon motion application on e.g. Nitinol wire in a system, using a force (stress, with a bias) to get Nitinol after the detwinning phase and in plastic deforma-tion and thus elongated (strained). When a small current is applied through the wire, the temperature of the wire is increased due to electronic resistance. As the tempera-ture reaches austenite phase temperature, the wire contracts at a limiting upper tem-perature to the form stress-induced, which is powerful enough to lift up 4 to 5 times it's own weight. The reaction speed depends on the diameter of the wire and usually takes a fraction of a second. Higher temperatures will cause non-elastic formation and irreversibly destroys the wire. When the current is switched off, the wire cools down and depending on the wires' diameter the heat lost by convection. This will cause the wire to expand within seconds, hence straining the wire with a bias force. Within conditioned parameters the wire can contract and expand 4 to 5% for over a million times [32].
Application: SMAs can be used as semi-finished material in bars, rods, wires and strips. Several successful products have been marketed, such as scald protection in shower valves, air conditioner air flow control mechanism, and actuators to improve automatic transmission shifting and reducing pollution emissions in automobiles, and in medical devices.
Technical facts: Because Nitinol has being developed and used since the early 1970's, it is commercially available and it has proven to be the best SMA. Flexinol has been used to produce MuscleWires which has the following physical properties [32]. Density: 6.45 g/cm3. Melting temperature: 1300°C. Minimum bend radius: 50x it's diameter. Maximum recovery force: about 600MPa (= 106 N/m2). Recommended recovery force: 1/3 maximum recovery force (200MPa). Recommended bias force: 1/10 – 1/20 maximum recovery force (30-60MPa). Maximum recovery ratio: 8%, up to a few cycles. Recommended recovery/deformation ratio: 3 – 5%, for maximum wire life. Breaking strength: 10x maximum recovery force, expect deformation of 15-30% before breakage. Young's *Modules:* Enduring strain varies greatly. Low temp around 28 Gigapascal (comparable to lead), High temp: 75 GPa (comparable to alu-minum). Poisson's Ratio: How much narrows when pulled at each end (shrinkage under stress) This ratio varies widely; for Nitinol about 0.33 (same as aluminum). Magnetic fields: Nitinol is virtually non magnetic. Activation start – finish tempera-ture: 68 – 78°C. Relaxation start – finish temperature: 52 – 42°C. Resistivity: austen-ite approx. 100 Ohm/cm, martensite 70 Ohm/cm [17].

1.2.2 Electro Active Ceramic (EAC)

Description: Commercially most widely used piezoelectric ceramic is PZT, Lead-Zirconate-Titanate. Piezoelectric polymers (semi-crystalline polyvinylidene fluoride, PVDF) are usable under high temperature. Piezoelectric polymers and ceramics con-vert mechanical stress or strain into proportionate electrical energy. They also respond mechanically by expanding or contracting when a voltage is applied. Piezoelectric polymer and ceramic films also have pyroelectric properties, that is, they produce electric energy in response to heat. Piezoelectric polymers and ceramics are associ-ated with a low noise and inherent damping that makes them very effective receivers as well as broadband transmitters for high frequencies tasks [3]. There is however a big difference in properties between the piezoelectric polymers and the single crystals or ceramics such as high temperature [7].
Application: All 'watch beepers' are piezoceramic audio transducers, most battery operated smoke detector alarms, fish finders, some cigarette lighters, microphones, sonar headphones, many gas grill igniters. Micro actuators and manipulators for opti-cal, robotic, biomedical, electronic, and process engineering; small, lightweight, low power, solid-state actuators for aerospace and battery powered devices [21]. Com-mercial available as a thin bag filled with rows of piezoelectric material to make it flexible. They only have to be connected and can be used instantly, used as transducer or sensing device [10].
Technical facts: Density: 7800 kg/m3 Commercially available as small strips in va-riety of width (few inches), height, and thickness (µm-mm). More technical properties can be found in reference [21].

1.2.3 Ion-exchange Polymer Metal Composites (IPMC)

Description: Small strips of IPMC used as bio-mimetic (= mimicking biological system) sensors and actuators. These strips react very closely to the applied low volt-age, which results in bending that makes the material remarkably accurate and repeat-able [30]. They can be placed in the electrostriction group because of the electro-chemical nature of the actuation of this material. Used as a sensor, large displacement can be measured when sensing the output voltage occurs when mechanical bending the sample [31]. Because the principle of IPMC strips relies on movement of ionic charges to achieve displacement, solvency must exist, but they can operate in dry air when kept moisten.
Application: Used in robotics as grippers, tactile sensors, propulsion, and locomo-tion. In other fields e.g. stirrers, pick-and-place manipulators, diverters, pumps, rotary actuators, and relay switches. Commercial available as MuscleSheets, even though it completely exists of soft electro-active plastic [31].
Technical facts: IPMC materials are light and their response time is high, they have unique characteristics including low density, high toughness, large strain and inherent vibration damping. IPMC can work under low-temperature, wet and hazardous envi-ronments. MuscleSheets are low voltage powered, have a high response time and are capable to move 10 to 50 times their own (light-) weight. They can be used as sensors because they give a voltage as output when bend mechanically. The essence of the underlying iono-elastic response of such materials is due to Colombic electro-dynamic charge interaction amongst a dispersed phase of metallic particles that are charged either positively or negatively, mobile phase of cat ion such a hydrogen ions H+ (protons) or Li+, Hydroxyl anions OH-, and a fixed anionic phase such as an assembly of sulfonates SO3- elastically attached to the backbone of the polymer net-work macromolecules. The mathematical model is analogous to classical Euler-Bernoulli's beam theory modified to accommodate a non-homogeneous distributed electrically induced moment due to the presence of a non-homogeneous electric field in an electric material [30].

1.2.4 Terfinol-D

Description: This material is applied in a system to replace high frequency actuators and is placed in the field of magneto-strictive actuators. It supposes to be accurate in positioning of mechanical loads, accurate in force and speed and exceed solid-state actuator technology [12]. "A properly magnetically biased magneto-strictive actuator will operate at the frequency of the input current. A pre-stress system will optimize output and efficiency. The most important design consideration is careful engineering of the 'magnetic circuit'. The magnetic circuit consists of the solenoid coil to provide the oscillating field, permanent magnets for bias, and careful selection and shaping of the other parts through which the magnetic field passes.
A good magnetic circuit ensures the highest magnetic flux density in the Terfenol-D, and very uniform mag-netic flux in all phases of the actuator operating cycle" [12].
Application: In machinery used as tool positioning and control and as combustion engines fuel injectors; for hydraulics the replacement for pumps and valves and in aerospace for precise positioning [12].
Technical facts: Because they can be customized, all the equipment actuators have specific properties. Check the website for the latest details [12].

2 What are Active Forms?

It appeared to be quite difficult to define all relevant dimensions for a complete and coherent framework for *all* possible active forms [29]. To begin with we will there-fore discuss some relevant aspects and characteristics. First, we constrain the scope to objects with a physical form on a macro scale. Second, these objects should have an inherent dynamical complexity which enfold in the behaviors of these particular ob-jects. The functionality embedded in these objects determines their internal and be-havioral complexity. Third, we are focusing on objects on a macro scale which can be used in an interaction with a human user. These interactive objects should be able to express their actual internal state via perceivable form changes on the surface. Before we discuss these kinds of objects we will introduce already existing examples, al-though not satisfying all above mentioned requirements.

2.1 Active forms in nature

Active forms are quite common in nature. One of the best know example is water which changes the form according to temperature (i.e. solid=ice, fluid=water, gase-ous=cloud, see Figure 3). These three major forms of water (the three aggregate states) express clearly the internal state space on the surface. The transitions between these three different forms are fully reversible. Living organisms (e.g. humans) changes normally their form related to their age. These form changes are almost irre-versible. A mix between reversible and irreversible form changes are used by plants (e.g. trees). Trees change their appearance within the season cycle (the reversible part), but also along the lifespan (the irreversible part).

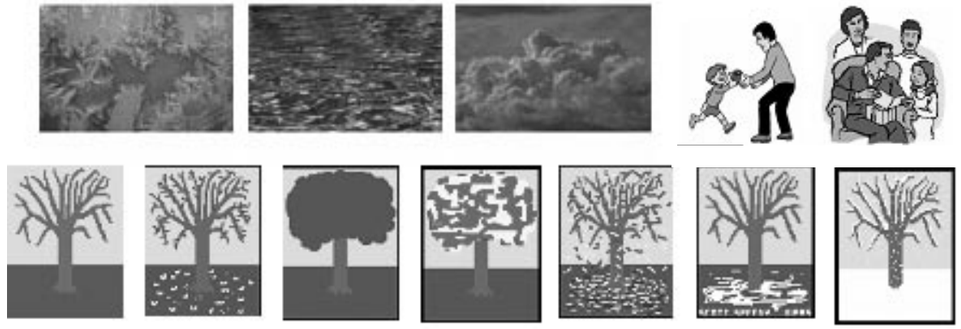

Figure 3. Three examples taken from nature: (a) left above the three reversible aggregate states of water, (b) right above the irreversible growth of humans, and (c) line below the [ir]reversible changes of a tree through out the seasons. (Pictures are taken from different internet sources)

2.2 Artificial active forms

One of the most popular artificial active forms is given as robots (e.g. humanoids). Of course there are many others objects as well that have similar characteristics (e.g. products for transportation, consumer products, etc) [11]. But among all these other options humanoid (and pet) robots have an exceptional position to be probably the most promising future input devices to provide access to intelligent environments [28] [34]. Human-robot interaction in daily life will be part of next generation interface concepts.

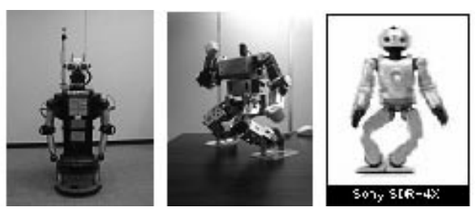

Figure 4. Examples of robots: (a) Robovie [20], (b) Tai-Chi robot [33], (c) Sony SDR-4X

One of the major limitations of this kind of active forms is their fixed physical ap-pearance. Although the internal state space transformed to motions can be unlimited, still the elements on the surface are static, only their positions in the 3D space are changing. Ongoing research is addressing the design challenge of giving humanoid robots a human-like face. This kind of design challenge is the primary target for our concept of active forms. The face should change according the intended non-verbal expressions. All know solutions are using so far elastic artificial skin controlled by hidden and embedded mechanical actuators [19]. What, if the surface could change by itself?

3 Active Forms as a New Way for Feedback

If we want to design a self changing surface of an interactive object we need material which can change their form by itself. This was our primary motivation to start ex-ploring the syntactical design space with smart material. So far we could identify the following three options.

Micro-Electro-Mechanical Systems (MEMS) are the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through the utilization of nano-fabrication technology. Although it is the system that is smart, this construction technique is very promising for the future [6]. For large batch pro-duction in comparison with Integrated Circuit's, MEMS are cheap.

Ferromagnetic Shape Memory Alloys (SMA): This material delivers high actuation and heavy-duty strain. The use for environmental interaction this material can be appropriate [4].

Shape Memory Polymers with SMA [8] based properties improved with particu-larly easy shaping, high shape stability, adjustable transition temperature, and, very large strain [22].

Figure 5. Input controls for access the multimedia content in an intelligent home environment. Left picture shows the unloaded state (adopted from [18]), right picture the loaded state.

We applied Nitinol as one SMA to the following design problem. Given a tangible, RFID tagged interaction prop [18] which is wireless connected to a multimedia data-base to get access to a particular subset of stored content (e.g., the picture set of the last holidays), how does the user know whether the prop is loaded or not [25].
Of course there is a quite simple and straight forward solution, attach a LED to the prop. If the LED is switched on then the prop is linked and loaded, otherwise not. But, how natural would it be if the shape of the prop would carry this information: 'slim body' for being unloaded state, 'fat body' for being loaded (see Figure 5)!

4 Conclusion

To build new tangible interaction devices, peripherals or autonomic robotics, smart materials could be used replacing classical motors operating on static forms. A great advantage is space reduction and material specific movement, which allows a system to respond naturally. Advantage of particular smart materials is their output response on mechanical deformation, which has the potential to create simple but advanced feedback signals without sophisticated electronics.

SMA: For the relative ease of use of SMAs with their worldwide availability, this material is suitable for the use in robotic application thus for the use of user-system interaction, most probably as feedback channel, used as actuator replacing a motor [9]. Using strain to move or set motion into a system would be the basic mechanism.

IPMC: MuscleSheets strips can be cut any size but the real advantage of this mate-rial is their bending capabilities of approximately 90 degrees. A disadvantage can be its difficulties to operate in aquatic or wet surroundings [13] [17].

Finally, we could open an entirely new syntactical design space, at least on the syn-tactical level for providing users with natural feedback [27] about the hidden internal state space of interactive products operated by complex functionality.

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Matthias Rauterberg,
Ben Salem,
Dirk van de Mortel
Department of
Industrial Design,
Technical University
Eindhoven,
The Netherlands

g.w.m.rauterberg@tue.nl

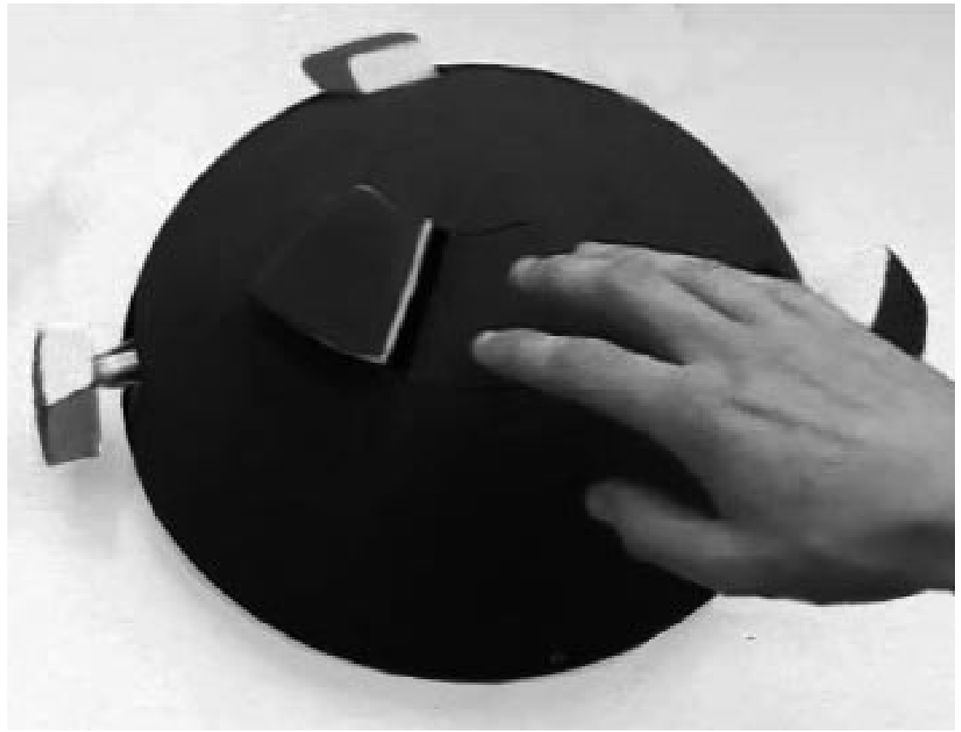
Dirk Volman
d.volman@student.tue.nl

‘Caos’

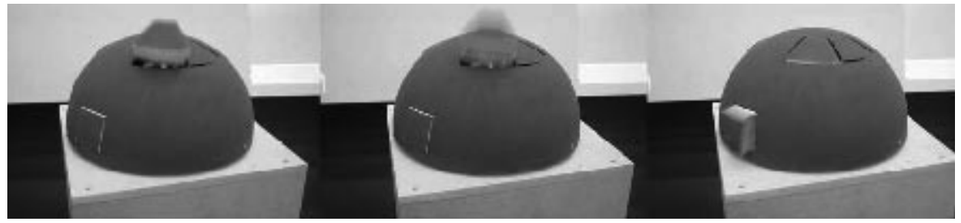
Semotion, the project
Most products we use nowadays are experienced as ‘dead’, they hardly communicate by movement. For example, when a printer is about to do a job, you often haven’t got a clue whether it will start printing or not, because it just lies still. Emotionally expressive products could improve human-machine interaction, making it easier and more natural, as Rosalyn Picard also states in her book “Affective computing” (Picard, 2001). After all, in human communication emotional expressions are essential for effective communication. But besides more effective, interaction could become more enjoyable when products speak the same language as people. Conveying emotional messages through movements is a subject that is still young. It does not seem to have been extensively studied experimentally. However, it is important to know what a particular movement means to people in order to send the right message. Of course, this is not the same for each person. How a movement is interpreted depends on personal factors, like the social and cultural background of the person. Systems that communicate with people via movement do already exist, for example robots. However, these movements are often very anthropomorphous (imitating a human) or zoomorphous (imitating an animal), like blinking an eye, nodding or waving with its arms. A major disadvantage of anthropomorphous designs is that when a product behaves humane, the user expects it to have human-like intelligence, and can be disappointed when he finds out that the product can only do a limited set of tasks (Wensveen et al, 2002). In a study christened ‘Semotion’ (short for ‘The Semantics of Movement’) a group of students, from the department of Industrial Design (Technical University of Einhoven) tried to find some generic elements of more abstract movements, generated by only a few motors. They designed and developed five robots, each of them expressing its own emotion. Their function is offering the user an object, in this case a mint.

Caos, the panic robot
One of the designed robots was ‘Caos’. Round and purple, this fearful little bugger is just minding its own business holding the mint inside. When touched however, Caos startles. He violently pushes random sections of its shell outwards and retracts them again, to finally extend all of them simultaneously. Finally the mint is ejected. Caos waits and finds the reason for his panic is resolved and falls back into a rest.

Panic, its choreography
The following dynamic characteristics of panic were found and studied when developing Caos: Firstly, its movements spring from a single point. Secondly, the movements lack focus, because one knows something has to be done but does not know where to begin. This worsens the panic only further. Thirdly, the movements that are initiated create counter-movements, because one doubts the initial move was effective. Each counter movement creates a counter movement which creates a counter movement and so on. Finally, one startles again as one realizes the problem is solved after all.



Caos in action



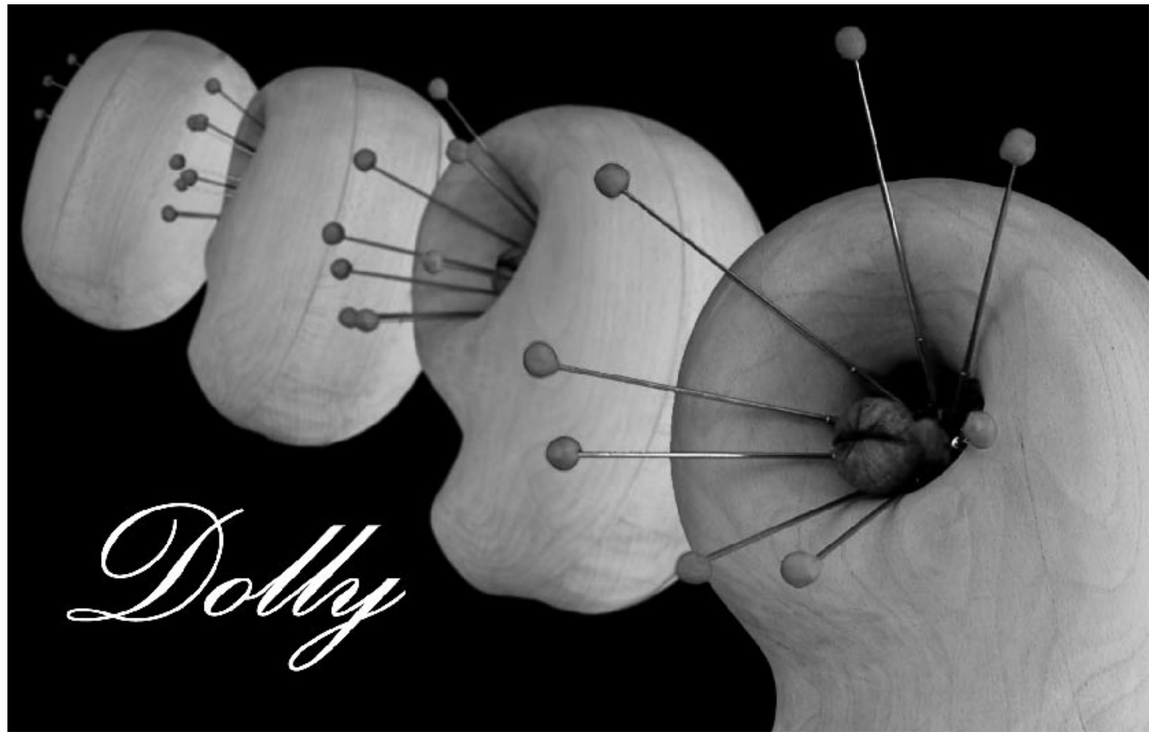
An idea of how Caos moves

Conclusions, of the project
To conclude, the experiments with the objects showed it is possible to design an object to express a certain emotional field. The preciseness of this field (or even particular emotion) seems to be dependent not only on the intensity of the emotion mend to be expressed, but moreover of the absence of other emotional expressions. Additionally, there is one more very important factor that determines which emotion will be seen, which is timing. For example, if Caos is just ‘telling his story’ without a specific action of the subject, it was almost impossible for the subject to understand Caos’ ‘emotional state’. When Caos reacts only after being touched by the subject it was clear Caos expressed panic. Timing is crucial for the context of an emotion. The project made clear even the exploratory emotional expressions that were investigated are useful in the design of products. Almost all the subjects reacted strikingly positive to the objects, they laughed and startled because of the objects. It is clear that the objects strengthen the contact between subject and object, the user and the product. This is what the Semotion project definitely was about.

Jan Hoefnagels
J.M.A.Hoefnagels@student.tue.nl

From Dolly with love

Demonstration proposal



Dolly
Ever got a gift from someone who appeared to be in love with you? This paper is about Dolly, a vending machine which tries to give you that typical feeling of being a loved one. Dolly hands you a walnut while showing her affection. She actually falls in love with you, but you were only after the walnut.

The Project
Dolly is one of the five expressive walnut vending machines which are the result of a project about exploring the semantics of movement, Semotion in short. Although classical industrial design is familiar with the semantics of form, the semantics of movement is an uncultivated area. Because the newness of the area the project involved a creative process with design tools that can be considered less explored therefore.

During this creative process, which started with choosing a certain emotion, we finally evolved into 4 dimensional models, 3D models with movement as a 4th dimension. These 4D models came into being by experimenting with story telling, collages, acting and 4D sketching. 4D sketching is a technique to 'sketch' moving interactive products. This moving interactivity is achieved by adding actuators like servo motors and simple sensors to a 3d (foam) model. The sensors and actuators are connected to a microcontroller which contains a simple program to transform user input to moving output.

About love
Dolly is a robot capable of expressing the emotion of love, but what is this love? One thing we can be sure of is that love isn't necessarily reserved for lovers; love can exist in very different relations like the love from a mother for her daughter, a brother for his brother, two best friends, an owner for his dog.

Just the same the translation of your love for another can take on very different forms as well. There is a world of difference between teasing and comforting, though strange enough, they are both forms of showing affection. And what do you think of cats when they nuzzle up to you? Are they showing their love or are they claiming territory? We probably all think of these things as showing love. But what is the movement that shows love? Briefly put: there isn't one, and there are too many.

When you show love or affection, you can do anything from giving comfort to playing or teasing the loved one. This can lead to dozens of different patterns of movements, and dozens of different definitions on the movement of love. Dolly's movements are a bit of both comforting, and teasing. A combination of smooth slow movements with no large speed changes, gives the impression of comforting. Sometimes Dolly moves in curved turning motions going past the person whom she shows affection for, giving the impression of teasing, playing with or nuzzling up to the person, like a cat.

The demo
During the demonstration you can experience Dolly's behavior and the way she falls in love with you. You will see how Dolly wakes up from her sleep after getting user attention. She will tease and comfort the user and finally open up and give the walnut. The satisfied user will eventually leave Dolly. In the end it was all about the walnut. She will get back to sleep, disappointed about her love not being answered.

Conclusion
Experiments already showed that Dolly's love is not always perceived by the user as such. The interesting thing is that the project proved that this moving behavior amplifies the richness user product interaction. A richness that cannot be simulated using screen animations or sound only.

Lieke Bömer, Bas Goudsmit, Lissa Kooijman, Jing Wang, Philip Ross

Expressing human values in lighting interaction

This demonstrator shows a series of four interactive lights designed to elicit expressive interactions. The lights serve as design explorations that help evaluate the specific design approach of expressing human values in interaction. The designs are made by bachelor students in the context of the Personality in Interaction assignment, conducted at the department of Industrial Design at the Technische Universiteit Eindhoven (Ross & Lee, 2005). In this assignment, students designed lights to express specific personalities in interaction. One of the theoretical frameworks used is the structure of human values (Schwartz, 1994). This demonstrator shows the innovative and expressive designs that resulted from this approach. The following description elaborates on the four lights in relation to the human values most salient in their design.

Light #1: Staircase lighting eliciting creative interactions by Lissa Kooijman

Lissa Kooijman's lighting system is constituted by an array of light spheres on strings distributed over the staircase. These spheres allow a myriad of different interactions that result in different lighting compositions. The spheres' basic behaviour is to light up when touched. One way to make compositions is to selectively touch the spheres when walking the stairs. Dynamics are added to the composition by varying the strength of touch. By gently pushing the spheres, they swing into a calm rhtythm creating a calm and slow play of moving light and shadow in the staircase. Pushing the spheres fiercely results in a vigorous play of light and shadow. After not being touched for a while, the light spheres turn off. When two balls touch, internal magnets make them stick to each other, which provides additional ways of composing staircase lighting schemes. In addition, the lights behave dynamically. After touching the first sphere, the lights follow a person walking the stairs. Kooijman's lighting concept allows new dynamic lighting compositions to be created every day by, making climbing the stairs a pleasant creative effort, instead of just a physical one.

Figure 1 and 2: Lissa Kooijman's staircase light targets creative interaction by offering the possibility to create new lighting compositions every time the stairs are climbed.

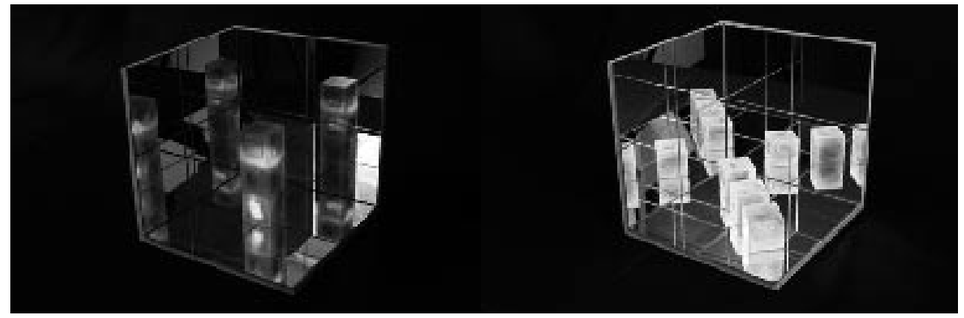


Figure 3 and 4: Jing Wang's light triggers curiosity by rewarding interactions with beautiful lighting effects, while giving little feedforward.

Light #2: A table top light to elicit curiosity by Jing Wang

This light's main interaction elements are three semi-transparent light cubes, placed in a cubic space delimited by three mirrors. The cubes are equipped with colored LED's but do not give away their lighting effects until they are combined with each other. When placed together, the cubes sense the relative position to each other and generate specific dynamic lighting effects for specific configurations. This way, different ways of stacking or aligning the cubes result in different dynamic coloured lighting effects. The uniform semi-transparent cubes give little hints of their orientations, so the resulting lighting effects are almost always a surprise. The cubes invite a person to try out different combinations and reward the efforts with unexpected and beautiful light schemes. The three mirror surfaces multiply the effect of each interaction, adding to the beauty of the effects. The lack of feedforward for actions, combined with the reward of beautiful effects after each interaction is likely to trigger curiosity when interacting.

Figure 3: Lieke Bömer's light allows easy personalization of appearance and light intensity through a system of spheres that light up when placed on top of one of the bars.

Light #3: Lieke Bömer's standing light expressing Self Direction

Self-direction is a combination of values that include 'choosing one's own goals' and 'creativity' and 'freedom'. Lieke Bömer incorporated these values in her design by allowing instant control over both light intensity and lamp appearance. The interaction with the lamp is straightforward. A collection of bars constitutes the body of the lamp. Spheric light objects lay at the foot of the lamp. Located at the foot, they are in their off-state. The spheres turn on when placed on one of the rods. The lamp offers free choice of which object to combine with which rod and how many objects to use. This way, the light incorporates in its interaction the self-direction values 'creativity', 'freedom' and 'choosing one's own goals'.

Figure 4: Bas Goudsmit's light triggers associative skills through loosely mapping interactions on his flower like device to lighting settings of several living room lights.

Light #4: Bas Goudsmit's flower lighting device

Bas Goudsmit created a light to express creativity in interaction. His lighting system is constituted by a set of lights distributed in a room, linked to a flower-like device that controls them. Manipulation of the flower petals gives control over the living room lights that collectively create different atmospheres. The intensity of the different lights, which gives the atmospheric effects, is loosely coupled to the expressions made with the flower petals. This way, the system triggers the associative skills of the person interacting and likely triggers his or her creativity.

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Tobie Kerridge

Media Mediators: exploring movement in the home

Electronic objects are increasingly used in our daily routines at home. Together, these linked appliances comprise a digital ecology, interdependent and constantly communicating, sending and receiving data between themselves and a range of services and products that lie beyond the home. This project explores how the movement of these objects can be customised by individual users to create a language of interaction that is personal and relevant. Philips Design, the research partner for this project, is interested in the potential for open and configurable appliances, building on their core brand values of sense and simplicity. By offering products with an additional channel of movement for feedback and expression, users can experience a more human level of control and understanding, allowing intangible exchanges of data to become meaningful and less complex.

Moving meaningfully

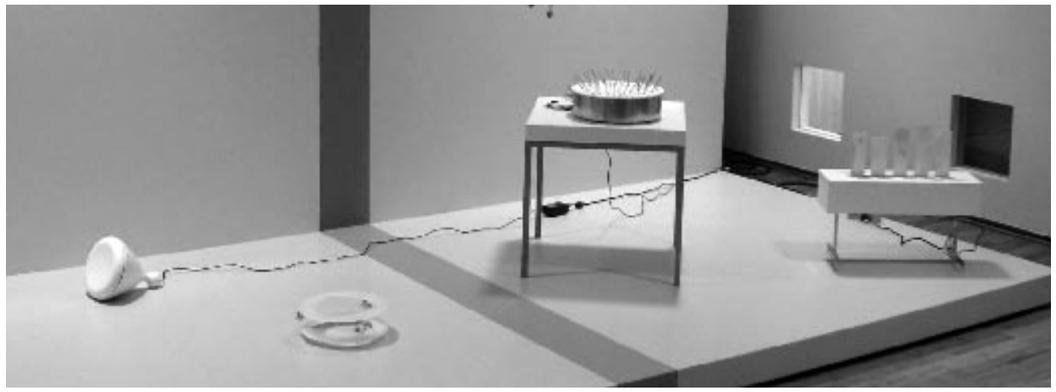
The project began with a study of motion, producing films that surveyed the cultural and emotional experiences of movement in objects. The next step explored movement as the product of mechanical capabilities and computational tools. This phase enabled the assembly of a rich set of resources to create flexible and expressive behaviours and provide insights and tools that would lead to the design of a set of prototypes. The core aim of this research was to explore the types of relationship that can emerge between a user and an object capable of movement in order to gain knowledge of how people interpret movement and how they would like objects to behave. To achieve this, the research targeted technically creative individuals with a passion for a particular domestic hobby such as robot building, music and animation. They were asked to have close input in developing the prototypes and then adopt the objects to create their own systems of movement within their homes.

Open concepts

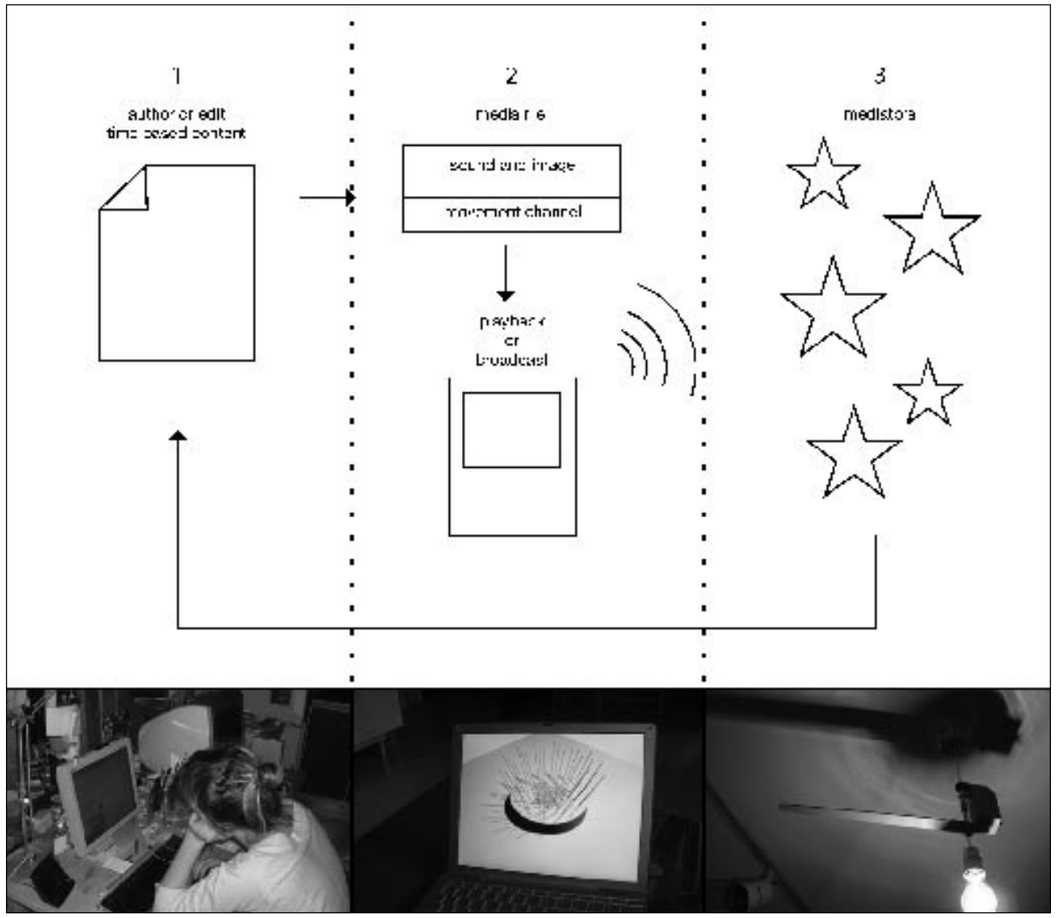
Four design concepts were prototyped, designed not to be prescriptive, but rather as a starting point for open discussion. All were designed to react to data chosen by users. Roll sits on the floor and spins like a top. Cake sits on a table and has spines arranged like candles that raise and lower. The five openings of Paper feed decorative strips in and out of the object. Drop suspends a disc from the ceiling that travels to the floor and back. The users were encouraged to choreograph the objects to reflect their individual choice of data.

Demonstration

We will set up the 4 prototypes and a computer and demonstrate a variety of systems our users have developed to control movement.



Above: Media Mediators installed at Philips Design in Eindhoven



We will encourage our user group to design their own systems. In this example,an animator creates a short film.
The movie file contains a video track, a sound track, and a third channel that contains movement commands.

Steven Kyffin, Loe Feijs
steven.kyffin@philips.com, l.m.g.feijs@tue.nl

emoPhone, close encounters of a new kind

Explore of what it means to communicate emotions through a medium, a telephone. Sending and receiving emotions in a very pure form. Either express loving kindness, happiness, anger, confirmation, or negation, all represented by the simplest emoticons. The receiver is informed through the movements of the small dish, flexibly positioned on a cushion. Simple. It rotates, it nods, its movement gets stronger, the emotion fades away. Even the concept of long distance communication is left out of the demonstrator and thus suddenly the emoPhone becomes a tool for personal, face-to-face communication. It becomes part of new rituals. Drinking a cup of coffee? Take some sugar, perhaps? Please have a look at my business card. See, here is my watch ... angry? Perhaps time to move on. Come and explore the magic qualities of the emoPhone installation.

There are two different embodiments of the installation, one with a dish, the other with a bowl. Both will be presented. The telephone is a traditional model, just to show that from technology, there is nothing new. No numbers, no speech, the handset invites the sender to choose an emotion.

A.W.M.B. Rulkens
Eindhoven University of Technology,
Faculty of Industrial Design.
Den Dolech 2, HG1,
5600MB Eindhoven,
The Netherlands

A.W.M.B. Rulkens
a.w.m.b.rulkens@student.tue.nl

EOS: play with that light!

Why not create a luminaire for the living room that lets you express yourself and gives you as much freedom in the interaction as in choosing the appearance of the lights in your living room?

The concept

Interaction with light has always been about pressing buttons and turning dimmers. This project proposes a different way to interact with light. Use your whole body to play with it, manipulate it, squeeze or stretch it, whatever you call it. Based on the ideas of Form Movement1 and Rich & Tangible Interaction2, the object gives people as much freedom as possible to tempt them into seeing what they can do with the light and with their own bodies. Movements are the key element in the interaction with light; movements of your own body have movements of the light and its properties as effect, and vice versa: body & light should resonate3.

The model

The EOS concept implements this idea in a 2m high fully working prototype. EOS presents you with a surface that you can feel and touch, that you can push and pull, that guides you in your movements as much as you guide the light. It is a matrix of wires, arranged in a hyperbolic shape that captures the movements of the hands and translates them into light. This light is flexible; it can take any size, shape, intensity or position. The only limit on the movement of the light is the implemented interaction styles.

The interaction

At the moment, three ways of interacting with it are possible. You can focus your whole attention on the light: this 1:1 interaction translates to two-handed movements (it's between you and me, light...). You can change the position of the light by using two hands to 'grab' it and drag it up or down. You can change the size of the light by leaving the symmetry of your hands opposite each other and stretch them out (see how far you can go...). However, you do not always want to focus on the light and give it your full attention, so to get the light ready for a relaxed setting or make it bright for cleaning up the room, the intensity can be changed with a one-handed sweep motion. The different modes of interaction can be experienced while using the design.

The process

The creation of the prototype and the application of the concept have been the end result of a free-shaped design process; inspiration for ideas and prototype building have been the key elements in this. through iterations the concept changed and crystallized into what it is now. It is not finished however; the possibilities for investigating full-body, playful interaction have never been more apparent than now...

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Jun Hu
j.hu@tue.nl

Move, but right on time

Introduction

We have entered a new media era: passive television programs become interactive with the red button on your remote control (Bennett, 2004). Video games come with many different controlling interfaces such as dancing mats, EyeToy® cameras, driving wheels and boxing Gametraks™ (In2Games, 2005). The D-BOX® Odyssee™ motion simulation system even introduces realistic motion experiences, which were originally designed for theme parks, into our living rooms (D-BOX, 2005). In the vision of Ambient Intelligence (Aarts and Marzano, 2003), the next generation of people's interactive media experience will not unfold only on a computer or television, or in a head set, but in the whole physical environment. The environments involve multiple devices that enable natural interactions and adapt to the users and their needs.

However involving multiple devices might also have a negative effect. It might increase the complexity of interaction. The environment together may become difficult to understand and to control. To ease the situation, embodied characters, such as eMuu (Bartneck, 2002) or Tony (Bartneck and Hu, 2004), may be used to give such an environment a concrete face. These characters have a physical embodiment and may present content through their behavior and interact with the user through speech and body language. They can even be used as input devices.

Timing and Meaning

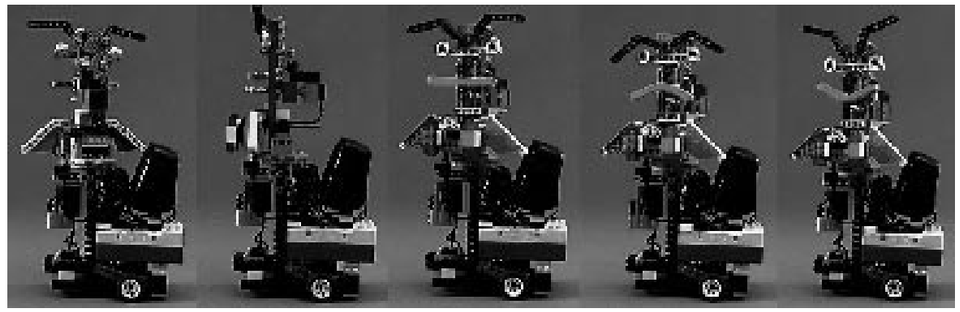
This robot, Tony, is not more than just a toy. Built from Lego Mindstorms bricks, it does have a face and a body. If certain body parts are touched, it can make a smiling face, or draw a long face. It can also turn its body left and right. Great, with these mechanic movements, this toy is already a nice toy, a toy that moves.

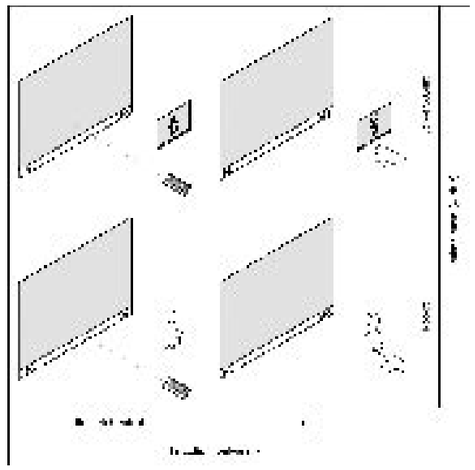
But more can emerge from these mechanic movements. With an infrared link, it is connected to an interactive movie. The toy suddenly becomes an actor: It laughs at another character in the movie; it looses its attention because nothing exciting is happening; and it looks sad when the buddy in the movie fails to get a job – it almost becomes an actor for the movie, but embedded in a physical body, with physical movements.

With this demo, we show how emotions, attentions and even narratives can come out of the mechanic movements, by simply making these movements happen at right times. Timing gives the movements meanings.

Implementation

The robot is a standalone application running on a Java Virtual Machine for Lego RCX, integrated with touch, rotation and infrared sensors, and movement, speech and lighting actuators. It receives the timely emotional events from the movie and reacts on it. The actual behaviors reacting on the events also depend on the mood of its one.





The movie, scripted in an XML based language (Interactive Play Markup Language, IPML for short), is played back by a central scheduler (called director in IPML). The director assigns actions for the distributed actors (in our demo, they are a full screen movie player, a robot, and a remote control) that are connected through a local network. Actions can be start or stop playing a video clip, showing a particular emotion or detecting an infrared signal. Actors are described in IPML scripts as requirements at an abstract level so that it can be presented in diverse environments. The director has to map these abstract requirements to available actors in a particular environment at run time.

Conclusion

No product is isolated from a context or an environment. Movements of products can be used as a new media to convey actions, emotions and even narratives in connection with other products, especially in an ambient intelligent environment. The movements can be designed for the product itself for its own sake, however, when in connecting with other products, the cooperation, especially in time, is important.

Jun Hu
Department of Industrial Design
Eindhoven University of Technology

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W. Walmink

Squabbles:
intended meaning of motion

Introduction

'Squabbles' is a design-concept which practical purpose is to display different levels of urgency using motion as mediating medium. It should be mounted to a luggage-trolley at an airport to help passenger keep track of their departure-time. I created this prototype *(image 1)* in a research project called 'Semotion' at the faculty of Industrial Design, Technical University Eindhoven. The purpose of the 'Semotion' projects is to investigate the potentials of autonomous motion in design. My personal focus in this project was to see what consequences it would have to let multiple objects work together to communicate a message.

In this document, I will describe the intended meaning of the movement. The movement itself can be viewed in two movie clips, named 'Squabbles1' and 'Squabbles2'.

Squabbles1 – first movie clip

In the first movie clip, the 'Squabbles' start of by looking around in an unfocussed way. There looking for nothing in particular, maybe a new passenger who they can help. At a certain moment (0:36) the middle Squabble begins to 'tick' with its antenna, asking attention for a new passenger who has come to their luggage-trolley. The left Squabble reacts (0:44) and turns towards the new passenger (being the viewer). It communicates to the passenger that it has noticed him/her by moving its antenna. Then, it talks enthusiastically with its neighbor about the new passenger, who in turn communicates this with its neighbor. Together they turn toward the passenger and gently regain their relaxed state, showing that they are okay with the new situation.

Squabbles2 - second movie clip

In this second movie clip, there are three urgency states, being respectively "relaxed", "activating" and "stressing". The Squabbles act a bit like traveling-companions, in the sense that they are just as concerned with the task to make it to the flight as you are. Therefore, they reflect the way you should feel/act. In state one ("relaxed"), they 'breath' slowly with their antenna. Then they look at one another (0:24) to discuss whether they should start to increase the communicated level of urgency. One of them starts to rhythmically move its antenna up and down (0:36) and the other two imitate it (state two: "activating"). They perform a kind of steady and systematic dance/walk, to emphasize the necessity to get going, but without the need for stress. At a specific moment, the right Squabble stops dancing and looks at the others (1:01). They look at the right Squabble to see why he stopped. He starts to move his antenna up and down rapidly and the other two do so too (start of state three: "stressing"). They start to move in an uncontrolled manner, with both their body and antenna. The chaotic and uncontrolled movement should simulate panic and stress, so that the passenger should become aware of the high level of urgency.

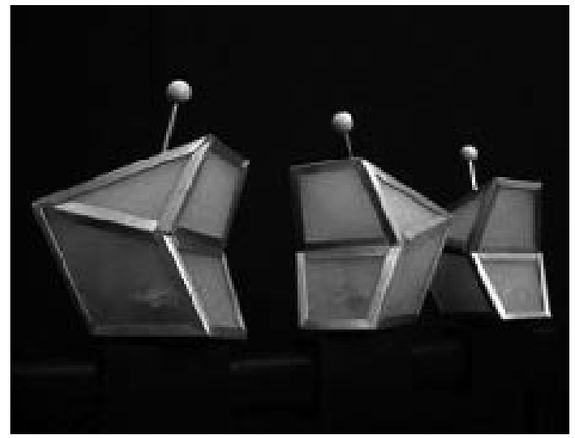


Fig. 1: Squabbles prototype

Conclusions after user test

Most test participants used the same keywords to describe the mediated message (e.g. relaxed state => "breathing" "relax") and viewed the three objects as three distinct, intelligent agents. The most commonly remarked association that I had not intended was related to state two. Most people related this motion not just to a 'regular' steady walk, but a militaristic, even dictatorial, marching army. Though the urgency level was understandable, this negative association colors the message in an unwanted way.

Bas Groenendaal, Philip Mendels, Carlijn Compen

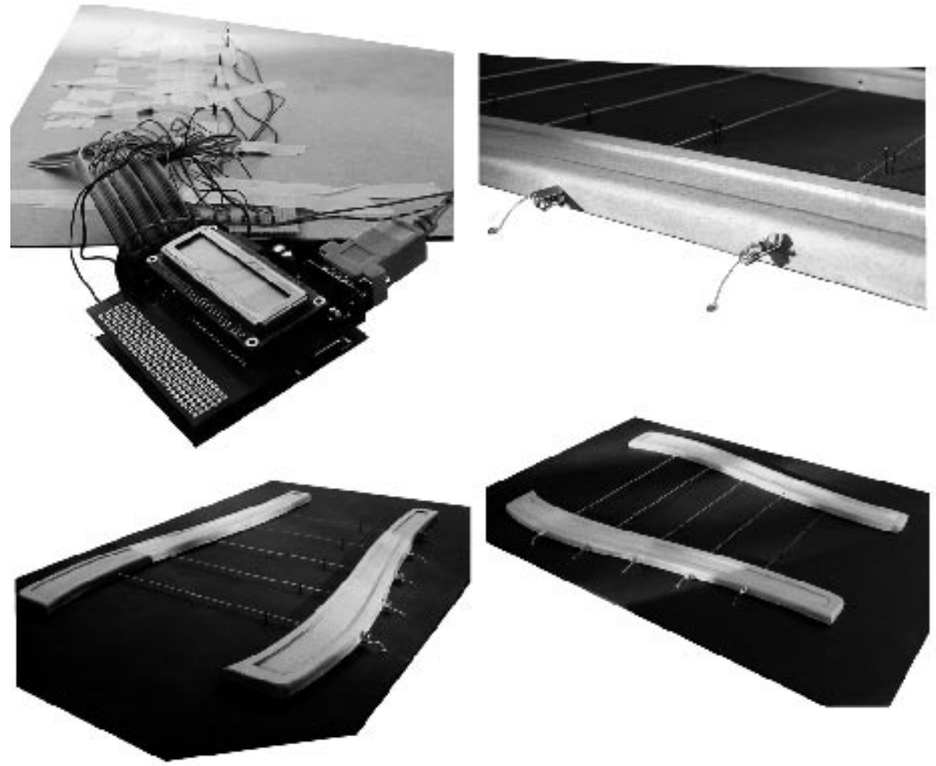
Cacophonix

Brainstorm
We started this little project by using a brainstorm. It caught our attention that there were actually two ways of coming up with a good 'multi-modal' idea. The first is to start by choosing a product, and change its current interaction model into a multimodal interaction. The purpose should be to make the product more fun, intuitive or 'rich'. The second method is to come up with an idea of an interesting interaction, independent on its application. This can be a certain movement, an interesting material etc.
We came up with the idea of using a string. A string, although pretty much limited to tactile interaction, offers an interesting richness of interaction. A string can be touched, changed of pitch, false, tight or loose.
A combination of strings can form a melody, a gamut. We chose not to redesign an existing product, but to come up with a new idea to apply this interaction model to.

Auralisation
We chose to auralise information streams going on in the domestic environment. Assuming that in the future of ambient intelligence information of all kinds of products, situations and processes is available, this information should be offered to the user using different communication channels, be it in combination (multimodal) or not. More specifically, we focused on the information that can be offered to the user while leaving or entering the house. Who doesn't recognise questions as: 'Did I turn of the gas?', 'Is mom home?', 'Did I lock all doors?', 'Did I forget something?'.

Concept.
The concept is a harp-like object that is placed nearby the front door, in the hallway. People strike the strings when they want to access certain information. The information is not literally visualized, not read up by a computer voice, but an auditory message, a melody, a gamut or sounds chosen by the user(-s). Therefore the information is subtle, and not always in display, only when the user wants to.
An auditory message is very intuitive to perceive: a false note or a wrong sound is easy to determine.

Scenarios
A mother of 3 children enters her house after a day of work. When she enters the corridor, she plays the Cacophonix hanging on the wall. She recognizes the melody, and therefore knows who is home and who is not, Also the children hear that their mother is home, because of the subtle sounds moving through the house.
An absentminded young adult, living in a dangerous neighbourhood, leaves the house. He occasionally forgets to close his doors. In his rush to get to the office, he



quickly strikes the strings of the Cacophonix and, because the third note is out of line, he knows he forgot to close the back door.

Working
As mentioned earlier, we assumed the information that is delivered to the Cacophonix is available. We therefore didn't work out this part of the working of the Cacophonix, but focused on the interaction. When the strings are triggered, the strings themselves make no sound, A sound is generated digitally. This way the Cacophonix is more flexible, users can add their own sounds, and the sounds of the Cacophonix can be adjusted more easily.

Arguments and Remarks
The way the user accesses information is subtle and intuitive. The user can decide when, while other systems often prompt information all the time. While the Cacophonix is not in use, it is a quiet artefact.
The prototype was limited to playing a sound at one loudness. Great opportunities for continuation are to make use of the strength of the string, how hard or soft it is triggered etc. This will make the interaction a lot richer and natural. The user has direct influence on the sound he produces. This would emphasize that the user uses the Cacophonix in different situations: in a rush, gently, loud etc. The variety of sounds, and therefore the variety of information that is auralised by the Cacophonix, is mainly limited by the capacity of the user to remember and hear difference. A remark has to be made that is easy to distinguish one false note in a gamut, but more difficult to distinguish more. Fully using the parameters of music, an optimal result can be reached.

Prototype
In just a few days we were able to build a prototype that communicated the basic idea of the Cacophonix. It might therefore be worth mentioning how the prototype is build. The prototype uses 5 strings, on which a voltage of 5V is put. When a string is triggered, it touches two little nails that are placed very closely to the string. The nails are attached to the ground (0V) in their turn. Touching the strings is like pushing a switch.
When the strings are triggered, a signal is sent to the PIC Microcontroller. The software program that makes the Microcontroller run is written in Jal. This program makes sure that the add-on of the Microcontroller, sends the correct signal to the serial port of the PC.
Next step is reading the string that is send to the serial port. We decided to use Macromedia Flash to build a graphical interface to control and play the type of sounds. Zinc V2 is a program that bridges the gap between this interface and the serial port. This was very handy: with the visual interface of Flash we were able to emit different sounds without changing the software, but by switching within the program.

Acknowledgements

The DeSForM workshop was held in Newcastle with the support of the Regional Development Agency, One NorthEast, Codeworks, as a part of an ambitious Regional Design Strategy with Northumbria University, also located in Newcastle. The workshop is in the amazing Baltic Centre on the banks of the Tyne. The Baltic Centre is the latest evidence of the area's growing cultural strength. Sitting in the shadow of the historic Tyne Bridge and the Millennium Eye Bridge, the towering Baltic is an international contemporary arts gallery and is the biggest such venue outside of London.

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